DISEASE CONTROL IN SOME STRAWBERRY CULTIVARS

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SUMMARY

A two year trial examined control of disease and yields in four strawberry (*Fragaria* sp) cultivars. Leaf spot (*Mycosphaerella fragariae*) was prominent on all untreated plants. Spraying at 2 weekly intervals, September-January, with benomyl plus captan reduced leaf spot. In the first season this combination was as effective as bitertanol plus iprodione and led to increases in yields and mean berry size. In the second season, benomyl alone was nearly as effective as the combination, while captan was relatively ineffective. It was concluded leaf spot resistance to benzimidazoles may not be widespread. In the first season fruit rots (mainly *Botrytis cinerea*) were reduced in incidence from 10-20% to 5-10% by either spray programme. In the second season spraying was ineffective.

INTRODUCTION

Strawberry production is affected by a number of pathogens. Grey mould (*Botrytis cinerea*) is a universal and major cause of fruit rot. For many years protection was obtained from mixtures of benzimidazole (benomyl) and protectant fungicides (captan, dichlofuanid) which principally control mycelial growth and conidial germination respectively (Beever 1973). Resistance to benzimidazoles prompted the development of the dicarboximide fungicides which are now in widespread use. However, resistance here is also on the increase (Grindle 1981; Beever and Brien 1983).

In the northern region, leaf spot (*Mycosphaerella fragariae*) is a major strawberry plant pathogen. It reduces plant vigour and yields, particularly on cv, Tioga. A number of trials on the control of leaf spot have been summarised (Hartill *et al* 1983). Early season sprays of fungicides from the new ergosterol biosynthesis inhibitor class were very effective at controlling leaf spot and enhancing yields. Prince (1983) also showed that bitertanol provided good control of leaf spot. At Pukekohe these materials were significantly better than benomyl, indicating that leaf spot resistance to benzimidazoles may be developing. However, at Rukuhia, the standard recommendation of benomyl plus captan was as effective as the bitertanol. Unpublished data from this trial also showed that a high degree of protection from botrytis was given by flowering/harvest sprays of benomyl plus captan. Control was comparable to that from the dicarboximide iprodione.

Although Tioga is still the main commercial cultivar, a number of new cultivars have been released recently. These include some day neutral types such as Hecker that offer much longer production seasons. The aim of the trials reported here were to:

- (a) compare the production and disease susceptibility characteristics of three new strawberry cultivars to that of Tioga;
- (b) compare spray programmes for disease control;
- (c) examine in more detail the effectiveness of benomyl and captan against botrytis and leaf spot.

METHODS

A trial area at Rukuhia was planted in June 1983 with runners of the cultivars Douglas, Tufts, Hecker and Tioga, using a split-plot design. Four rows at a mean spacing of 1.35 m were divided into a total of 24 plots. Plots were divided into four sub-plots each containing six plants of a cultivar at 13 cm spacing. Plots were separated by

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three plants of Tioga. The plants were grown through plastic mulch with straw between the rows. Standard MAF fertiliser and insecticide/miticide programmes were followed. Flowers were removed by hand until mid-September. The same planting was used for trials over two years of production.

In Trial 1 (1983-84) a split-plot design was employed with eight replicates of three treatments.

In Trial 2 (1984-85) the plots were re-randomised into six replicates of four treatments, balanced for previous treatment. The spray treatments for the two trials are given in Table 1.

TABLE 1: Fungicide treatments on strawberries.

Trial 1. 1983/84		Trial 2. 1984/85	
Treatment	Rate g ai/100 litres	Treatment	Rate g ai/100 litres
1. untreated	—	1. untreated	—
2. benomyl (Benlate)	12.5	2. benomyl	12.5
captan (Captan 80WP)	80	captan	80
3. bitertanol (Baycor)	12.5	3. benomyl	12.5
iprodione (Rovral 250 FL)	37		
+0.5% mineral oil		4. captan	80

10 applications at 14 day intervals, Sept - Jan.

Spray treatments were applied on a plot basis using a pressurised hand sprayer at 300 kPa and a volume rate of 900 litres/ha. Spreader-sticker (Citowett, 10 ml/100 litres) was used with all wettable powder formulations.

The following assessment techniques were employed for both trials using the four centre plants in each sub-plot. Assessments of leaf spot on mature leaves were made at monthly intervals (Oct-Feb) using the ranking system previously employed (Hartill *et al* 1983). Ripe fruit was harvested at 3-5 day intervals and counted, weighed, and examined for visible disease. Results from Trial 1 were analysed by ANOVA and those of Trial 2 by regression, including previous treatment in the model. Leaf spot assessments and disease incidence were analysed after arcsine transformation and the yields using log transformation. The means of untransformed data and average SEDs are in Tables 2-6.

TABLE 2: Severity of strawberry leaf spot, Trial 1, 1983/84.

Date	Leaf spot Index* — percent								
	All cultivars				All treatments				
	Treatment	— means			Cultivar	— means			
	1	2	3	SED	Douglas	Tufts	Hecker	Tioga	SED
29/11/83	7	27	17	5.2	33	33	29	41	3.9
30/12/83	76	18	25	3.3	36	33	47	43	3.6
31/1/84	71	15	18	3.9	31	31	51	25	3.4

* Hartill *et al* (1983).

RESULTS

Leaf spot

The leaf spot severity data are summarised in Tables 2 and 3 using overall means for the treatment and cultivar effects at several assessment dates. In the first season, untreated plants of all cultivars showed a moderate to high level of leaf spot. There was more leaf spot on Tioga than the other cultivars in the early season, probably due to severely infected runners. By late season, Hecker was more affected than the other

cultivars. The benomyl plus captan spray treatment gave comparable control to that using bitertanol plus iprodione. The heavy initial infection on Tioga was well under control by late season with either spray programme. However, the severity on Hecker remained significantly higher than on the other cultivars.

On the plants untreated in their second year, there was a steady increase in leaf spot to moderate levels by January (Table 3). Hecker and Tioga were marginally more affected than Douglas or Tufts. Detailed analysis of the plot histories showed that Douglas and Tufts plants untreated in the first season were worse affected by leaf spot in the second season. The benomyl plus captan spray treatment gave moderate control of leaf spot for all cultivars, although infection levels still increased over the season. Benomyl alone also gave some control but was not as effective as the combined treatment. Captan alone was not very effective.

TABLE 3: Severity of strawberry leaf spot, Trial 2, 1984/85.

Date	All cultivars Treatment — means					All treatments Cultivar — means				
	Leaf spot Index* — percent									
	1	2	3	4	SED	Douglas	Tufts	Hecker	Tioga	SED
19/9/84	17	22	23	22	4.1	16	22	18	28	3.5
20/11/84	32	11	13	27	3.3	13	15	29	27	2.3
18/12/84	58	17	23	41	7.3	29	25	46	39	3.3
15/1/85	68	25	40	61	7.0	46	39	58	50	4.5

TABLE 4: Strawberry fruit disease incidence.

Treatment	% Affected Fruit							
	1983/84				1984/85			
	1	2	3		1	2	3	4
Douglas	10.5	7.1	7.8		10	10	9	10
Tufts	15.2	10.0	10.0		8	8	8	10
Hecker	5.4	6.3	8.5		15	13	17	14
Tioga	20.4	9.6	9.0		11	10	13	11
	SED 2.8				SED 1.8			

Diseased fruit

The data in Table 4 is that over 10-12 harvests, the only significant trend in seasonal disease incidence being an overall reduction towards the end of each season. The principal disease present was botrytis, but some black leaf spot (*Colletotrichum fragariae*) was noted. This was most apparent later in the first season (Trial 1), and appeared to be more prevalent on Hecker. No accurate classification of the types of fruit rot was undertaken.

The percentage of diseased fruit ranged from 6-21%, with an overall average of 12.9% for untreated fruit in Trial 1. It was highest in Tioga, which was significantly worse affected than the other cultivars. The disease incidence on Hecker fruit was less than 10%, dependent on treatment. There was a significant ($P < 0.05$) reduction in disease on the other three cultivars under the two spray regimes. However, there was no difference between the effectiveness of the benomyl plus captan or the iprodione treatment. Some plate testing for botrytis resistance was carried out on isolates from infected fruit (R. Beever pers comm). This revealed that some resistance to benzimidazoles was present.

In the second season (Trial 2, Table 4), the overall incidence of diseased fruit was 8-17%, similar to the first season. Hecker was now significantly more affected than the other cultivars. The spray treatments had no effect on disease incidence in any of the cultivars.

Yields

The mean total yields and berry weights (harvested December-January) for the two trials are given in Tables 5 and 6 respectively. The overall trends in production are

TABLE 5: Strawberry fruit yields.

Treatment	Tonnes/ha						
	1983/84			1984/85			
	1	2	3	1	2	3	4
Douglas	13.5	19.7	15.2	24	27	30	23
Tufts	6.0	6.3	7.7	23	29	29	29
Hecker	23.1	31.6	34.6	23	24	26	26
Tioga	6.0	14.4	15.0	31	33	36	30
	LSR* 1.33			SED 4.0			

* Least significant ratio ($P < 0.05$)

TABLE 6: Strawberry mean berry weight.

Treatment	Mean weight g						
	1983/84			1984/85			
	1	2	3	1	2	3	4
Douglas	11.3	13.8	13.7	8.2	8.8	8.6	8.6
Tufts	10.9	12.2	12.6	8.5	8.9	8.8	8.8
Hecker	8.6	10.5	10.4	7.1	7.3	7.2	7.2
Tioga	6.0	8.1	8.3	7.3	7.3	7.3	7.5
	SED 0.77			SED 0.43			

typical for the crop with the first season giving larger fruit than the second, but tonnages being higher in the second season.

Both the treatments in Trial 1 significantly affected mean berry weight and, generally, yield. The yield increases were approximately 40% and 140% for Hecker and Tioga respectively. There was no difference between the yields from either spray treatment. Yields from Tufts were poor, principally due to very slow establishment. This also affected Douglas to some extent. Yields from Hecker were outstanding, particularly under spraying. The fruiting continued for at least 8 weeks past the end of January, so the reported yields are very conservative.

In the second season all the cultivars gave good yields with Tioga being the most productive. Again, Hecker continued to crop well past January. Berry size and tonnage were increased by the fungicide treatments only for Douglas and Hecker, and the increases were small. There was no significant difference between the fungicide combinations in their effects on yield.

DISCUSSION

The first trial confirmed previous work (Hartill *et al* 1983) showing that benomyl plus captan was as effective as bitertanol in reducing leaf spot on strawberries in the Waikato and that control of this disease can lead to large yield increases. The second trial demonstrated that benomyl is more effective than captan against leaf spot, although there is some additive effect. This indicates leaf spot resistance to benzimidazoles may not be widespread at present. The four cultivars tested were all quite susceptible to leaf spot. In the first season, fungicide sprays resulted in large yield increases, particularly in Tioga. For this cultivar the effect was largely on fruit numbers and this was attributed to untreated fruiting laterals being directly affected by leaf spot (W. Hartill pers comm).

Both benomyl plus captan and iprodione were effective at reducing botrytis on fruit to an incidence of less than 10% in Trial 1. However, in Trial 2, benomyl plus captan was not effective against botrytis, even though disease pressure was lower in all except Hecker. The poorer performance of sprays in the second season against both botrytis and leaf spot may be due to denser foliage hindering spray penetration during flowering (Jordan 1978). The limited testing of botrytis isolates indicated that some benzimidazole resistance was present. This may not be of great commercial consequence

in the Waikato as in Trial 1 benomyl plus captan gave effective control. However, captan may have contributed to the control, in the first season and resistance increased in the second.

The data on black leaf spot is limited but it is of interest to note that on Hecker, which was the cultivar worst affected, the incidence of diseased fruit, under the bitertonal plus iprodione spray regime, was higher than in untreated plots ($P < 0.01$, Table 4).

In conclusion, benomyl plus captan is still an effective fungicide combination for strawberries in the Waikato region. However, to minimise the problem of resistance, spray programmes should alternate fungicides from the dicarboximide and triazole classes. The day-neutral cultivar Hecker showed a high production potential. Once established, Douglas and Tufts also produced well and gave excellent berry size. The new cultivars are susceptible to leaf spot, similar to the present preferred main season cultivar Tioga.

ACKNOWLEDGEMENTS

R.E. Beever, Plant Diseases Division, DSIR, Mt Albert, carried out agar plate assessment of resistance on botrytis isolates. Helen Grinlinton, Glenys Sands and Colin Malcolm provided field assistance.

REFERENCES

- Beever, D.J., 1973. Control of botrytis on strawberries. *N.Z. J. Exp. Agric.* 1: 227-279.
- Beever, R.E. and Brien, H.M.R., 1983. A survey of resistance to dicarboximide fungicides in *Botrytis cinerea*. *N.Z. J. Agric. Res.* 26: 391-400.
- Grindle, M., 1981. Variations among field isolates of *Botrytis cinerea* in their sensitivity to antifungal compounds. *Pestic. Sci.* 12: 305-312.
- Hartill, W.F., Holland, P.T. and Eden, M.A., 1983. Control of leaf spot in strawberries. *Proc. 36th N.Z. Weed and Pest Control Conf.*: 74-78.
- Jordan, V.W.L., 1978. Epidemiology and control of fruit rot *Botrytis cinerea* in strawberries. *Pflanzenschutz-Nachrichten Bayer* 31: 1-10.
- Prince, R.W., 1983. Control of strawberry leaf spot. *Proc. 36th N.Z. Weed and Pest Control Conf.*: 71-73.