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Final Report (September 2000)

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The results and conclusions in this report are based on an investigation conducted over one year. The conditions under which the experiment was carried out and the results obtained have been reported with detail and accuracy. However because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

I declare that this work was done under my supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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PRACTICAL SECTION FOR GROWERS

Objectives and background

Disease control is a vital part of black currant production, with yield reductions resulting from heavy infections with American gooseberry mildew (*Sphaerotheca morsurae*), leaf spot (*Drapenopeziza ribis*) and grey mould (*Botrytis cinerea*). Growers have a good range of products available to them at present for the control of these diseases but newer types of fungicides are continually being developed. For the past four years, the effects of the new group of strobilurin fungicides has been evaluated for their control of black currant diseases, and in general they are very effective. The strobilurin that has been tested for the longest period, azoxystrobin as 'Amistar', has shown good disease control. More recently, kresoxim-methyl as 'Stroby' and trifloxystrobin as 'Flint' have also given excellent control of mildew and leaf spot.

However, in the one experiment that yields were taken, in 1997, the use of Amistar resulted in lower yield than those obtained from a non-strobilurin programme. The product has been seen to cause a mild phytotoxic reaction to leaf growth - a down-curling of the leaf margins - but also to have caused a scorching of the flowers. It is this latter effect that could be related to the yield depression. In 1999, a similar leaf symptom was noticed in plots treated with Stroby and Flint, but to a lesser degree than those treated with Amistar.

The experiment reported upon here examined the effect of the three strobilurin fungicides on mildew, leaf spot and post-harvest rotting caused by *Botrytis*, when used as a full season long programme or when applied during either the flowering or post flowering periods only. The trial was also taken to yield.

Summary of results

All of the fungicide programmes reduced mildew levels compared to those developing in the unsprayed plots, but the degree of control given by the standard programme based on Systhane 6 Flo (*myclobutanil*) was disappointing. Of the three strobilurin fungicides screened, Flint and Stroby gave better control of mildew than Amistar. Leaf spot infection developed late in the season, reaching over 50% by early August in the unsprayed plots. All fungicides gave excellent control of this disease, with infection levels of only 1-2%.

The main objective of the experiment was to check for any adverse effects on yield that might result from the use of the new strobilurin group of fungicides. When compared to sprays of Bravo 500 (*chlorothalonil*) during flowering, all three strobilurin products resulted in reduced yields indicating a phytotoxic affect on the flowers. When used in place of Systhane 6 Flo post blossom, Flint and Stroby increased yields by 7.3 and 8.8% respectively, but Amistar reduced yield by 4.3%. As a full season programme only Flint out-performed the standard Bravo 500/Systhane 6 Flo programme.

All fungicide programmes reduced the low incidence of post-harvest rotting due to *B. cinerea* by 50% or more.

Good correlations were obtained between levels of mildew, leaf spot and *Botrytis* infection and yield, indicating that increasing levels of all three diseases were contributing to yield losses in the experiment.

Action points for growers

The strobilurin group of fungicides have been shown to be effective in controlling mildew and leaf spot, and some materials are likely to be Approved for use on black currants within the next few seasons. They will form a useful role as part of an alternating programme of fungicides with different modes of action and should be used in that way, rather than throughout the season.

IMPORTANT NOTE:- Systhane 6 Flo and Bravo 500 are the only products used in this experiment that are currently Approved for use on black currants. Amistar is a cereal fungicide and Stroby is Approved for use on apples; Flint is an experimental formulation and the active ingredient is not marketed in the UK at present. None of these should be used on black currants until they are Approved for use on the crop.

Practical and anticipated financial benefits

The use of strobilurin fungicides, as part of spray programme, has the potential benefit of improving disease control and increasing yield. By incorporating them into a fungicide programme with other products which have different modes of action, they could help to slow the development of resistance problems by increasing the diversity of products.

SCIENCE SECTION

INTRODUCTION

The three main diseases of black currants are American gooseberry mildew (*Sphaerotheca mors-uvae*), leaf spot (*Drapenopeziza ribis*) and grey mould (*Botrytis cinerea*). A wide range of fungicides are available for the control of these diseases, but interest has recently focused upon the new strobilurin group. In trials over the past few seasons one of these, azoxystrobin as 'Amistar', was found to be effective in controlling all three diseases. However, on the one occasion that yields were taken, in a *Botrytis* control experiment in 1997, this product was found to lead to a lower yield than that obtained from the 'standard' programme. This appeared to be due to a scorching of the flowers. Subsequently, two other strobilurin fungicides, kresoxim-methyl as 'Stroby' and trifloxystrobin as 'Flint', have been screened. These have shown very good control of mildew and leaf spot, but yield effects were not determined.

A phytotoxic leaf symptom, in the form of a downward curling of the leaf margin, had been observed in the Amistar plots in the 1997 experiment. The same symptom was noted in the plots treated by all three strobilurin fungicides in a trial in 1999. It was therefore decided that all three products should be re-examined for their disease control efficacy and effects on yield in a new trial in 2000. As the deleterious effect on yield was thought to be due to damage incurred at the flowering stage the trial was designed to include treatments with each of the strobilurins applied as a full season long programme, applied only during flowering or applied only post flowering. Assessments would be made on the levels of mildew and leaf spot. A post harvest check on fruit rots would give an indication of the suppression of *Botrytis* infection that occurs during flowering.

MATERIALS AND METHODS

Site and crop details

The experiment was carried out at Bradenham Hall Farm, Bradenham, Norfolk on a black currant plantation of cv. Ben Lomond.

Treatments

	Flowering sprays (x2)	Post flowering sprays (x4)
1.	Untreated	Untreated
2.	Bravo 500 at 5.0 l/ha	Systhane 6 Flo at 1.5 l/ha
3.	Amistar at 1.0 l/ha	Amistar at 1.0 l/ha
4.	Bravo 500 at 5.0 l/ha	Amistar at 1.0 l/ha
5.	Amistar at 1.0 l/ha	Systhane 6 Flo at 1.5 l/ha
6.	Flint at 0.15 kg/ha	Flint at 0.15 kg/ha
7.	Bravo 500 at 5.0 l/ha	Flint at 0.15 kg/ha
8.	Flint at 0.15 kg/ha	Systhane 6 Flo at 1.5 l/ha
9.	Stroby at 0.2 kg/ha	Stroby at 0.2 kg/ha
10.	Bravo 500 at 5.0 l/ha	Stroby at 0.2 kg/ha
11.	Stroby at 0.2 kg/ha	Systhane 6 Flo at 1.5 l/ha

All sprays were applied in water volumes equivalent to 1000 l/ha. Applications were made by ADAS staff using a pressurised knapsack sprayer.

Assessments

American gooseberry mildew was assessed according to a standard key, shown below.

Category	Disease Incidence Description
0	No mildew visible
1	Trace. Mildew seen on only one leaf per bush
2	Mildew seen on up to six leaves per bush. No leaf curling or distortion.
3	Mildew frequent on leaves. Slight curling but no browning or necrosis of leaves.
4	Mildew frequent on leaves with moderate curling and leaf distortion and/or mildew on stems. Slight leaf browning and necrosis present, but no shoot tip death.
5	As for No 4, but with a little shoot tip death. No obvious retardation of shoot growth.
6	As for No 5, but with moderate killing of shoot tips. Some obvious retardation of shoot growth, and leaf browning common.
7	As for No 6, but with much shoot tip death and some severe retardation of shoot growth.

Six bushes per plot were assessed individually and a mean score calculated for the plot.

Leaf spot was assessed using a standard key by Clarke and Corke (1955) which takes into account both the level of leaf infection and defoliation. The key is presented in the Appendix. Three bushes were assessed in each plot and a mean percentage infection calculated for the plot.

Plot yield were taken and 100 fruit per plot were randomly selected and incubated at ambient temperatures for 3 days. They were then assessed for post-harvest rotting.

Experimental design and analysis

The experiment was arranged in randomised blocks with 4 replicates of each treatment and eight replicates of the untreated plots. Plot size was 10m length of row. Results were analysed by analysis of variance and Duncan's multiple range test.

Crop diary

Sprays were applied on the following dates:- 6 April
18 April
12 May
6 June
23 June
7 July

Assessments were made on the following dates:- 25 May
5 June
20 June
4 July
18 July
2 August

The trial was harvested and yield taken on 27 July.

Post harvest fruit rot assessments were done on 30 July.

RESULTS

(a) Mildew

At the time of the first visit to carry out assessments, on 25 May, mildew was appearing at trace levels in the untreated plots. The first full mildew assessment was therefore undertaken on 5 June. The results of the five assessments made between 5 June and 2 August are shown in Table 1.

Table 1. Mildew index

Treatment (flowering / post-flowering)	Mean mildew index				
	5 June	20 June	4 July	18 July	2 August
1. Unsprayed	2.2 d	4.1 d	4.5 f	4.3 c	4.2 e
2. Bravo 500 / Systhane 6 Flo	1.5 bc	3.6 c	3.7 de	3.5 b	3.6 bcd
3. Amistar / Amistar	1.1 abc	3.3 c	3.7 de	3.9 b	3.9 de
4. Bravo 500 / Amistar	0.8 ab	3.2 bc	3.5 cde	3.5 b	3.7 cd
5. Amistar / Systhane 6 Flo	1.4 bc	3.5 c	3.7 de	3.5 b	4.0 de
6. Flint / Flint	0.6 a	2.8 ab	2.8 a	2.9 a	3.2 ab
7. Bravo 500 / Flint	1.0 abc	2.8 ab	3.0 abc	2.8 a	3.0 a
8. Flint / Systhane 6 Flo	1.3 abc	3.5 c	3.9 e	3.6 b	4.0 de
9. Stroby / Stroby	0.9 abc	2.7 a	3.0 ab	2.9 a	3.1 a
10. Bravo 500 / Stroby	1.3 abc	3.2 bc	3.4 bcd	3.0 a	3.4 abc
11. Stroby / Systhane 6 Flo	1.5 cd	3.4 c	3.6 de	3.6 b	3.8 cde
Days after last treatment	11	14	11	11	26
sed (df =30)	0.328	0.196	0.206	0.199	0.202
cv%	38.2	8.5	8.2	8.2	7.9

Duncan's multiple range test: figures in the same column followed by a common letter are not significantly different ($P \leq 0.05$).

All treatments were effective in significantly reducing the mildew levels found in the untreated plots, until the time of the last assessment, 26 days after the final spray had been applied.

(b) Leaf spot

Leaf spot did not appear in the trial at assessable levels until the time of the visit on 20 June. The results of the 4 assessments made from this date until 2 August are shown in Table 2. In estimating the effects of leaf spot infection on the bushes, the assessment method used combines the percentage area of the bush affected by leaf spotting and defoliation due to the disease.

Table 2. Percentage leaf spot infection.

	Mean % leaf spot infection			
Treatment (flowering / post-flowering)	20 June	4 July	18 July	2 August
1. Unsprayed	0.7 b	1.1 b	10.2 b	52.5 b
2. Bravo 500 / Systhane 6 Flo	0.1 a	0.3 a	0.3 a	1.7 a
3. Amistar / Amistar	0.3 ab	0.4 a	0.8 a	1.9 a
4. Bravo 500 / Amistar	0.4 ab	0.2 a	0.8 a	1.8 a
5. Amistar / Systhane 6 Flo	0.4 ab	0.5 a	1.7 a	2.1 a
6. Flint / Flint	0.4 ab	0.4 a	1.1 a	1.5 a
7. Bravo 500 / Flint	0.3 ab	0.3 a	0.4 a	1.5 a
8. Flint / Systhane 6 Flo	0.2 a	0.4 a	0.8 a	1.6 a
9. Stroby / Stroby	0.3 ab	0.3 a	0.6 a	1.3 a
10. Bravo 500 / Stroby	0.3 ab	0.5 a	0.4 a	1.1 a
11. Stroby / Systhane 6 Flo	0.2 a	0.3 a	1.0 a	1.6 a
Days after last treatment	14	11	11	26
sed (df =30)	0.199	0.163	0.822	0.650
cv%	92.2	57.1	71.3	14.8

Duncan’s multiple range test: figures in the same column followed by a common letter are not significantly different ($P \leq 0.05$).

All fungicide treatment programmes gave excellent control of leaf spot, even where a long interval occurred between the final spray application and the last assessment. During this period, leaf spot developed rapidly in the unsprayed plots, but the fungicides keep infection at a very low level.

(c) Yield and post-harvest rots

The plot yields and post-harvest rot assessments are shown in Table 3. Plot yields were taken using the farm harvester. The rots were assessed 3 days after harvest and are divided into those due to *Botrytis cinerea* and those caused by other fungi consisting mainly of *Penicillium* spp. and some *Mucor* sp.

Table 3. Crop yield and post-harvest rot assessments

Treatment (flowering / post-flowering)	Yield (kg/plot)	% yield increase over untreated	% yield increase over standard programme*	% fruit rotted by *B. cinerea*	% fruit rotted by other fungi
1. Unsprayed	21.29	-	-	4.4 c	75.6 b
2. Bravo 500 / Systhane 6 Flo	23.35	9.7	-	2.0 b	28.5 a
3. Amistar / Amistar	22.25	4.5	-4.7	0.2 a	4.4 a
4. Bravo 500 / Amistar	22.35	5.0	-4.3	1.4 ab	4.7 a
5. Amistar / Systhane 6 Flo	21.48	0.9	-8.0	1.3 ab	32.5 a
6. Flint / Flint	26.23	23.2	12.3	0.6 ab	12.3 a
7. Bravo 500 / Flint	25.05	17.7	7.3	0.9 ab	8.5 a
8. Flint / Systhane 6 Flo	22.60	6.1	-3.2	1.6 ab	38.7 a
9. Stroby / Stroby	22.52	5.8	-3.6	1.5 ab	76.3 b
10. Bravo 500 / Stroby	25.40	19.3	8.8	0.5 ab	24.5 a
11. Stroby / Systhane 6 Flo	22.67	6.5	-2.9	1.4 ab	73.7 b
	NS				
sed (df =30)	2.466	-	-	0.659	16.65
cv%	15.0	-	-	65.1	68.2

*Treatment 2

Duncan's multiple range test: figures in the same column followed by a common letter are not significantly different ($P \leq 0.05$). NS - no significant differences at ($P \leq 0.05$).

There were no statistically significant differences between the yields at the 5% significance level. This was due to plot to plot variation within treatments, that may have been due to the presence of reversion within the plantation.

DISCUSSION

Mildew levels steadily increased from the end of May, but the cool summer weather held back disease development in July. Although all fungicides significantly reduced mildew levels for most of the season, compared to the unsprayed plots, control with Systhane 6 Flo was poor. By the time of the final assessment most of the programmes which included Systhane post-flowering did not have a mildew index lower than the unsprayed control. Of the three strobilurin fungicides, Amistar was consistently out-performed by Flint and Stroby.

Leaf spot was present in the crop from early June, but did not develop significantly until mid-July. By the time of the assessment on 18 July, the unsprayed plots had over 10% infection whilst all of fungicides kept levels to below 2%. In the second half of July leaf spot infection developed rapidly, with some defoliation occurring, and reached 52.5% in the unsprayed plots by early August. All fungicide programmes maintained very effective control, with only 1-2% infection levels being recorded.

In earlier projects, a downward curling of leaf margins had been noted following the use of strobilurin fungicides, particularly Amistar. There was little sign of such phyotoxicity as a result of the fungicide programmes applied in this experiment, possibly because of the generally cooler weather conditions this year.

Although differences between yields were not statistically significantly, the effects of the strobilurin fungicides can be examined by looking at the consequences of using them to replace either Bravo 500, Systhane 6 Flo, or both of these fungicides in the spray programme.

(a) Net effect of substituting a strobilurin for Bravo 500 during flowering:-

	Yield difference
(i) Amistar	-8.0%
(ii) Flint	-3.2%
(iii) Stroby	-2.9%

(b) Net effect of substituting a strobilurin for Systhane 6 Flo post-flowering:-

	Yield difference
(i) Amistar	-4.3%
(ii) Flint	+7.3%
(iii) Stroby	+8.8%

(c) Net effect of substituting a strobilurin for both Bravo 500 and Systhane 6 Flo:-

	Yield difference
(i) Amistar	-4.7%
(ii) Flint	+12.3%
(iii) Stroby	-3.6%

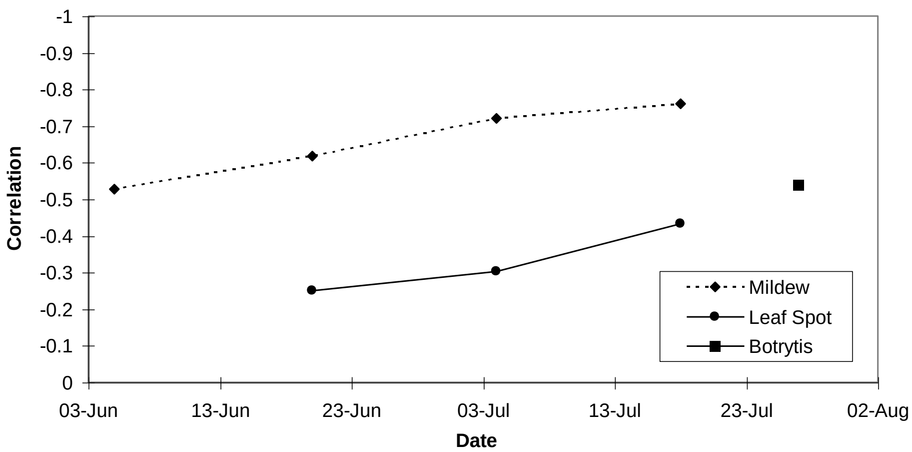
These results indicate that all three strobilurin fungicides were having a detrimental effect on yield, compared to Bravo 500, when applied during flowering. Flint and Stroby used post-flowering instead of Systhane 6 Flo resulted in increased yield, whereas Amistar resulted in a lower yield. This may be a reflection of the performance of the fungicides in controlling mildew, where Flint and Stroby were more effective then Amistar or Systhane 6 Flo. With full season use, Flint was the only strobilurin to result in a higher yield than that obtained with the standard Bravo 500/Systhane 6 Flo programme.

Fruit rot assessments were carried out 3 days after harvest, following incubation of samples at ambient temperatures. Fruit from the unsprayed plots had 4.4% affected by *B. cinerea*, and all fungicide programmes significantly reduced such infection to 2% or less. Although these levels were low, all of the programmes containing a strobilurin fungicide resulted in less infection than that recorded from the standard Bravo 500/Systhane 6 Flo programme. The only programme to do so to a statistically significant degree was where Amistar was used throughout the season, a result confirming a similar finding in an earlier year's experiment

More fruit rotted due to other pathogen e.g. *Penicillium* and *Mucor* spp.; Amistar and Flint, used post-flowering, gave the greatest control of these fungi.

There were good negative correlation coefficients between increasing mildew and leaf spot levels and crop yield. These relationships strengthened, for both diseases, approaching harvest (Figure 1).

Figure 1 : Relationship of Disease Control to Yield



There was also a good correlation between yield and amount of post-harvest fruit affected by *Botrytis*. This may indicate that where losses due to *Botrytis*-induced 'run-off' of flowers were controlled earlier in the season, a positive yield benefit accrued.

CONCLUSIONS

This experiment has confirmed the efficacy of strobilurin fungicides in controlling mildew, leaf spot and post-harvest Botrytis fruit rot. In general, Flint and Stroby appear to be more effective than Amistar in controlling mildew, but all three products gave excellent leaf spot control. The level of mildew control exhibited by Systhane 6 Flo was poor and appears to have declined over recent seasons. If the results from this experiment are a true reflection of its present mildew activity, its use in controlling the disease would be very limited in commercial practice. It is still very effective in controlling leaf spot.

The good correlations obtained between levels of mildew, leaf spot and *Botrytis* infection and yield, indicated that increasing levels of all three diseases were contributing to yield losses in the experiment.

The use of strobilurin fungicides during flowering was detrimental, in terms of yield, when compared to the use of Bravo 500 and the products would appear to be somewhat phytotoxic to flowers. Of the three products, Flint gave the best yield results overall.

In other crops the number of recommended sprays of strobilurins is limited on the product label, e.g. 3 consecutive sprays of Stroby on apples and a maximum of 3 sprays at full dose rate of Amistar on cereals. In this experiment up to 6 consecutive sprays were applied in some treatments, to check for adverse yield effects. If any of these or similar products are eventually marketed for use on black currants they are likely to be restricted in a similar way, to reduce the risk of resistance. The yield depressions recorded, when compared to the standard Bravo 500/Systhane 6 Flo programme are therefore likely to be the worst that can occur. However, it does seem clear that the use of strobilurin fungicides during flowering should be avoided, and any future label recommendations should take notice of this finding.

Strobilurin fungicides would be useful to black currant growers for their efficacy and as materials with an alternative mode of action for use in anti-resistance strategies in a crop where many fungicide applications are made in a season.

REFERENCE

Clarke, G.M. and Corke, A.T.K. (1955) Rep. agric. hort. Res. Sta. Bristol, pp 196-200.

ACKNOWLEDGEMENTS

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