Project Title:	Evaluation of existing and novel fungicides for the control of powdery mildew and other foliage/stem pathogens of cucumber.
Project number:	HDC/HRI/SH/P/98/E509a PC 141
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Final Report:	March 2000
Previous Reports:	May 1998 (annual) March 1999 (annual)
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Date Commenced:	25 June 1999
Date Completed:	28 October 1999
Keywords:	Cucumber, fungicides, efficacy, powdery mildew, *Sphaerotheca fuliginea*, Grey Mould, *Botrytis cinerea*, Gummy Stem Blight, Black Stem Rot, *Mycosphaerella melonis, Didymella bryoniae*, Amistar, azoxystrobin, Stroby, Kresoxim-methyl, Flint, trifloxystrobin, Bravo 500, chlorothalonil, Rovral WP, iprodione, Scala, pyrimethanil, mepanipyrim, Fungaflor, Rubigan, imazalil, fenarimol.

CONTENTS

The results and conclusions in this report are based on a single experiment. The conditions under which the experiment was carried out and the results 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.

PRACTICAL SECTION FOR GROWERS

Background and Objectives

Powdery mildew (*Sphaerotheca fuliginea)* is a particularly common and troublesome disease of cucumbers in the UK. Control of the disease relies heavily on a limited range of available fungicides and the use of powdery mildew tolerant cultivars, e.g. Enigma, for the replanted crops in summer. Fungicides tend to be used prophylactically with many applications of the same products. Over several years, this has encouraged the development of tolerance to some of the more commonly used fungicides and, with pressure being placed on the limited range of products available, it is only a matter of time before widespread resistance occurs.

At the same time stem disease due to *Mycosphaerella* (*Didymella bryoniae*) *melonis* and *Botrytis cinerea* have also increased in incidence and severity and some of the mildew tolerant cultivars would appear more susceptible to these pathogens.

The work described in this Final Report is the culmination of a three year project to evaluate existing and novel fungicides for the control of *S. fuliginea* the cause of powdery mildew and foliar and stem pathogens including *B. cinerea* and *M. melonis* in cucumbers.

The objectives of the project were divided into the following areas:

a) Investigate the sensitivity of a range of isolates of *S.fuliginea* to three widely used and commercially available fungicides.

b) Determine the relative efficacy of a range of existing and novel fungicides for the control of *Botrytis cinerea* and *Mycosphaerella melonis* in *an in vitro* laboratory bioassay.

c) Determine the relative efficacy and crop safety of a range of existing and novel fungicides for the control of powdery mildew, *B. cinerea* and *M. melonis* in replicated commercial cucumber trials.

Results relating to the investigation of sensitivity of isolates of *S. fuliginea* to three fungicides were reported in the first and second year annual reports (1998 and 1999).

Fungicides were screened for their crop safety in the first year of the project (1998). Those which demonstrated phytotoxicity were excluded from the study and those which showed good crop safety and efficacy were taken forward to replicated commercial trials in the second year (1999). A number of fungicides which were particularly effective in the second year trial were selected for more detailed study in the final year in a replicated efficacy trial. The trial, described in this report, included a number of products that were either applied alone in a 6 application/14-day schedule or incorporated in three experimental integrated programmes. The activity of these selected fungicides against *B. cinerea* and *M. melonis* was also examined in an *in vitro* bioassay.

SUMMARY OF RESULTS

(i) Commercial Efficacy Evaluation

The trial conducted on cucumbers cv Jessica grown to commercial standards examined the efficacy of nine fungicide treatments with inoculated and uninoculated controls. Treatments included – Amistar (azoxystrobin), Stroby (kresoxim-methyl), Flint (trifloxystrobin), 35-35 (mepanipyrim) and Scala (pyrimethanil) as straight applications. Three Experimental Integrated (alternating) Programmes were compared to a standard Commercial Integrated (alternating) Programme of Bravo 500, Fungaflor, Rovral WP and Rubigan. The products were applied 6 times at 14-day intervals.

Powdery mildew infection established successfully in the trial plots causing significant economic crop damage in the untreated control. All the strobilurin fungicides applied in this year's trial demonstrated good control of powdery mildew. These were Amistar, Stroby and Flint with Amistar and Flint showing superior control to all other treatments including the Commercial Integrated Programme (Bravo 500, Fungaflor, Rovral & Rubigan). 35-35 (mepanipyrim) surprisingly also demonstrated good control of powdery mildew on younger leaves.

The performance of each of the three Experimental Integrated (alternating) Programmes was significantly improved by the incorporation of one or more of the strobilurin group of fungicides with 35-35 (mepanipyrim) also contributing to overall disease control. Experimental Integrated Programme 1 (Bravo 500, Fungaflor, Amistar, and 35-35) and 3 (Bravo 500, Fungaflor, Amistar, 35-35, Stroby and Scala) both showed the most effective control of powdery mildew infection with improved control compared to the standard Commercial Integrated Programme.

Following artificial inoculation, *Botrytis* established at a low to moderate level in the trial plots, though *Mycosphaerella*, which was also inoculated, did not establish to any significant level during the course of the trial conducted in 1999. Flint showed excellent early control of *Botrytis* node infections but was slightly less effective in the final stages of the trial. However, it still showed improved control compared to the Commercial Integrated Programme. In contrast, Amistar did not show effective control

until the spray programme was well established and then showed superb control for one month after the final spray application and up to harvest. 35-35 (mepanipyrim) also showed very good control of *Botrytis* throughout the duration of the trial. All the Experimental Integrated Programmes were more effective at controlling *Botrytis* than the Commercial Integrated programme.

Plant death in the final weeks of the trial were significantly reduced in all the fungicide treatments with no plant death occurring in Flint treated plots and Experimental Integrated programme – 3 (Bravo 500, Fungaflor, Amistar, 35-35, Stroby and Scala).

Yield data was collected during the course of the trial with no significant differences between the treatments during the time that the fungicide spray schedule was being applied. However there were yield differences at the end of the trial following the final application of fungicides when plant deaths in the untreated control, due to disease pressure, caused a reduction in yield. In the final harvest period all fungicide treatments showed an improvement in the percentage of Class I marketable fruit at the end of the trial compared to the untreated control. While Stroby, Flint and Experimental Integrated programme – 1 (Bravo 500, Fungaflor, Amistar, 35-35) all had significantly higher total yields in this final harvest period.

(ii) Evaluation of Novel Fungicides against *Botrytis cinerea* and *Mycosphaerella melonis* in *in vitro* Studies.

The fungicide treatments applied to the commercial trial were assessed for their efficacy in controlling *Botrytis cinerea* and *Mycosphaerella melonis* in an *in vitro* bioassay. Cucumber leaves taken from the commercial trial subsequent to spraying were inoculated with the two pathogens and the resulting leaf lesion was measured. The bioassay was repeated three times during the course of the trial. The results obtained from this bioassay provided additional information in support of the commercial efficacy trial.

Results showed that all of the strobilurin fungicides controlled *Botrytis* with Amistar and Flint showing effective and superior control of *Botrytis* leaf infections for the duration of the trial when compared to the untreated control and Commercial Integrated Programme. The three Experimental Integrated Programmes all reduced *Botrytis* leaf infections. While Scala and 35-35 (mepanipyrim) gave effective control of *Botrytis* in the early stages of the bioassay but control deteriorated as the trial progressed.

All treatments with the exception of the Commercial Integrated Programme were effective in suppressing the growth of *Mycosphaerella.* 35-35 (mepanipyrim) gave effective control not only when applied alone but also when combined in the Experimental Integrated Programmes with the strobilurins (azoxystrobin, kresoxim-methyl and trifloxystrobin). Experimental Integrated Programmes – 1, combining Amistar and 35-35 in the final spray applications was particularly effective in controlling *Mycosphaerella.* These results support the results obtained in the second year trials (1998) where good control of *Mycosphaerella* stem and node infections was achieved in the commercial efficacy trial with Amistar and 35-35 (mepanipyrim).

Action Points for Growers

- Continue to utilise tolerant cucumber cultivars to minimise pressure on available fungicides.

- Review spray application procedures to optimise delivery of fungicides to the plants.

- Plan disease control programmes carefully, alternating products from different chemical groups to minimise the risks of disease resistance occurring.

- Continue to use good hygiene practices and cultural techniques to delay or minimise the need for fungicide application.

- Keep abreast of fungicide approvals as legislative issues continue to put pressure on their continued availability

- Do not use any of the experimental products listed in this report until such time as a new On or Off-Label Approval Notice is issued and you have a copy for your records.

Note on approval status of the fungicides used in this trial for use on protected cucumbers

- **Fungicides with on-label approval for use on protected cucumber crops**

Product	Approved Use
Bravo 500 (chlorothalonil)	Botrytis, powdery mildew
Fungaflor (imazalil)	Powdery mildew
Rovral WP (iprodione)	Botrytis
Rubigan (fenarimol)	Powdery mildew [Rubigan is subject to a phased revokation]

- **Fungicides <u>not permitted for use</u> on protected cucumbers**

Amistar (azoxystrobin) [HDC have made an application to PSD for specific off label approval (SOLA) for the use of Amistar on protected cucumbers. Approval is expected in 2000].

Flint (trifloxystrobin)
Scala (pyrimethanil)
Stroby WG (Kresoxim-methyl)

- **Fungicides awaiting registration by the Pesticides Safety Directorate (PSD). <u>Use is not permitted</u> on protected cucumbers**

35-35 (mepanipyrim)

Practical and Financial Anticipated Benefits

The promising performance of the strobilurin fungicides - Amistar (azoxystrobin), Stroby (kresoxim-methyl) and Flint (trifloxystrobin) and the anilino pyrimidine – 35-35 (mepanipyrim) in controlling powdery mildew, *Botrytis* and *Mycosphaerella* in this years trials indicates that their inclusion in an alternating fungicide programme will provide improved disease control for cucumber growers. This will allow the grower to build an anti-resistance strategy thereby reducing disease pressure on the existing products.

It is highly recommended that one or more of these products are secured for On or Off-Label Approval for use on cucumbers. Every effort is being made in this regard via the HDC funded SOLA programme.

EXPERIMENTAL SECTION

Introduction

A limited range of fungicide sprays are used routinely for the control of powdery mildew and other diseases with increasing reliance on these products to control often severe infections. Sprays are being applied with increasing frequency over the season as the disease develops, with the result that there is a strong pressure on the powdery mildew pathogen to develop tolerance/resistance to the fungicides. It is therefore imperative to increase the portfolio of products available to the cucumber grower to reduce the pressure on available fungicides.

The three fungicides most widely used for powdery mildew control belong to the following chemical groups: imazalil and fenarimol (DMI's) and bupirimate (Pyrimidines). It is important in planning a future strategy to effectively and sustainably control powdery mildew and to select novel fungicides for use within powdery mildew control programmes that have different modes of action to those currently used. Novel fungicides could therefore complement those already in use and be used in a rotating programme to reduce the pressure on the few products now available.

There is presently a range of new powdery mildew control products currently available to the arable sector, which could effectively be used on cucumber crops assuming efficacy, crop environment, operator (under protection) and consumer safety, can be demonstrated and the product subsequently approved On or Off-Label. Until now, none of these new products have been further developed on protected cucumbers in the UK. Included amongst these new additions are the Strobilurins which, from earlier studies, would appear to have some activity against other diseases on cucumbers including *Botrytis cinerea* and *Mycosphaerella melonis* (syn. *Didymella bryoniae*).

Following results from the second year of the project the following objectives were set for the third year:

a) Evaluate the efficacy and crop safety of a selected range of fungicides in a fully replicated trial conducted under 'commercial' cucumber crop conditions. The activity of these fungicides was examined when applied alone in a 6 application/14-day schedule and when incorporated into Experimental Integrated Programmes. They were compared to untreated control and a Commercial Integrated Programme.

b) The selected range were also evaluated in an *in vitro* laboratory bioassay to determine their relative efficacy in the control of *B. cinerea* and *M. melonis*.

Materials and Methods

(i) Commercial Efficacy Evaluation

Crop and Cultivar

Cucumber cv. Jessica.

Trial Design

The trial was comprised of 2 randomised blocks (one per glasshouse unit) with each block containing 2 complete replicates of the treatments. The inoculated and uninoculated control treatments were replicated 6 times with all the fungicide treatments replicated 4 times. The 2 blocks were contained in 2 separate units of a multi-factorial unit glasshouse, which experiences the same conditions of temperature and humidity.

Each plot was comprised of 4 rockwool slabs with 2 plants per slab. The outer edges (east and west elevations) of both blocks were planted with untreated guard rows. The crop was grown to a commercial standard utilising a run to waste rockwool system of culture with plants being grown until they reached the overhead wire. The shoot apex of each plant was subsequently removed and three lateral shoots allowed to develop and the crop was then trimmed according to normal commercial practice.

Inoculum Production and Inoculation

Powdery Mildew

A natural infection of powdery mildew established in the crop before the plants reached the overhead wires.

Botrytis cinerea

A *Botrytis* infection was established artificially in the crop by introducing an actively growing and virulent isolate of the fungus to the cut petioles of plants. An isolate of *Botrytis cinerea* selected for inoculation into the trial was grown for 5 days in sterile specimen tubes containing an agar medium. One tube containing the culture was then placed over the stump of an excised cucumber leaf petiole. The first plant in each plot was inoculated with petioles in the upper part of the plant selected for inoculation.

Mycosphaerella melonis

Mycosphaerella was introduced to the crop in the same manner as for *Botrytis* except that petioles near the base of the plant were selected for inoculation to closely mimic the start of a natural *Mycosphaerella* infection. The *Mycosphaerella* isolate used for inoculation was cultured for 7 days prior to introduction to the plant petioles.

Treatment

No	Fungicides treatment and rate of application	Approval Status
1	**Uninoculated untreated** (water) control.	-
2	**Inoculated untreated** (water) control	-
3	**Amistar** (Azoxystrobin) 80ml/100l water.	Not approved for use
4	**Stroby** (Kresoxim-methyl) 50g/100l water.	Not approved for use
5	**Flint** (Trifloxystrobin) 200ml/100l water.	Not approved for use
6	**35-**35 (Mepanipyrim) 80g/100l water.	Not approved for use
7	**Scala** (Pyrimethanil) 132ml product/100l water	Not approved for use
8	**Commercial Integrated Programme (alternating)**	
	i) Bravo 500 (Chlorothalonil) 200ml product/100l water;	On label approval
	ii) Fungaflor (Imazalil) 50ml product/100l water;	On label approval
	iii) Rovral WP (Iprodione) 100g product/100l water;	On label approval
	iv) Rubigan (Fenarimol) 9ml product/100l water.	On label approval
9	**Experimental Integrated Programme (alternating) 1 –**	
	i) Bravo 500 (Chlorothalonil) 200ml product/100l water;	On label approval
	ii) Fungaflor (Imazalil) 50ml product/100l water;	On label approval
	iii) Amistar (Azoxystrobin) 80ml product/100l water;	Not approved for use
	iv) Amistar (Azoxystrobin) 80ml product/100l water;	Not approved for use
	v) 35-35 (Mepanipyrim) 80g product/100l water;	Not approved for use
	vi) 35-35 (Mepanipyrim) 80g product/100l water.	Not approved for use
10	**Experimental Integrated Programme (alternating) 2 –**	
	i) Bravo 500 (Chlorothalonil) 200ml product/100l water;	On label approval
	ii) Fungaflor (Imazalil) 50ml product/100l water;	On label approval
	iii) Stroby (Kresoxim-methyl) 50g product/100l water;	Not approved for use
	iv) Stroby (Kresoxim-methyl) 50g product/100l water;	Not approved for use
	v) Scala (Pyrimethanil) 132ml product/100l water;	Not approved for use
	vi) Scala (Pyrimethanil) 132ml product/100l water.	Not approved for use
11	**Experimental Integrated Programme (alternating) 3 –**	
	i) Bravo 500 (Chlorothalonil) 200ml product/100l water;	On label approval
	ii) Fungaflor (Imazalil) 50ml product/100l water;	On label approval
	iii) Amistar (Azoxystrobin) 80ml product/100l water;	Not approved for use
	iv) 35-35 (Mepanipyrim) 80g product/100l water;	Not approved for use
	v) Stroby (Kresoxim-methyl) 50g product/100l water;	Not approved for use
	vi) Scala (Pyrimethanil) 132ml product/100l water.	Not approved for use

Application of Spray Treatments

The spray treatments were applied on 6 occasions at 14-day intervals. Fungicides were applied using a lance attachment on an Oxford Precision Sprayer modified to operate with compressed air at a pressure of 2 bars. To determine the precise volume required for even delivery of the target dose a water spray was applied to run-off to the control plots (T2) and the resulting volume was used as the basis of all spray calculations.

The commercial integrated commercial (alternating) programme was selected using currently approved products with activity against *Botrytis* (Bravo 500, Rovral WP) and powdery mildew (Rubigan, Fungaflor). Whilst there are no fungicides specifically approved for the control of *Mycosphaerella*, some of those listed are known to have some activity against this pathogen. They were applied in a rolling programme in the order specified in the treatment table above.

In the table below is a list of the treatments used in the trial and the chemical group to which they belong.

Table 1: A list of the Active Ingredients used in the Efficacy Evaluation and their Associated Chemical Grouping.

Chemical Group	Active Ingredient	Product Name	Target Diseases
Phthalimide	Chlorothalonil	Bravo 500	broad spectrum – *Mycosphaerella*, *Botrytis* and powdery mildew
DMI: Imidazoles	Imazalil	Fungaflor	powdery mildew
Pyrimidinyl Carbinol	Fenarimol	Rubigan	powdery mildew
Dicarboximide	Iprodione	Rovral WP	*Botrytis*
Anilino-Pyrimidine:	Pyrimethanil	Scala	*Botrytis*
	Mypanipyrim	35-35	
Strobilurins:	Azoxystrobin	Amistar	broad spectrum fungal diseases and powdery mildew
	Kresoxim-methyl	Stroby	powdery mildew
	Trifloxystrobin	Flint	broad spectrum fungal diseases and powdery mildew

Crop Diary

Crop planted out: 25 June 1999

Final cucumber harvest: 28 October 1999

Inoculation Schedule: Plots inoculated with *Mycosphaerella* and *Botrytis* on 21 July 1999

Spray Schedule	
Spray Number	Spray Date
1	17 July 1999
2	2 August 1999
3	16 August 1999
4	31 August 1999
5	13 September 1999
6	28 September 1999

Sample Date for *In-Vitro* Bioassay	
1	3 August 1999
2	1 September 1999
3	1 October 1999

In-Crop Disease Assessment Dates	
Number	Assessment Date
1	4 August 1999
2	17 August 1999
3	1 September 1999
4	14 September 1999
5	29 September 1999
6	13 October 1999

Disease Assessments – In Crop

Powdery Mildew

The crop was monitored regularly for the first occurrence of a powdery mildew infection and following its first appearance a disease assessment was conducted by selecting 3 leaves from each plant from the lower, central and upper portions of the crop canopy. The assessment was conducted on the 4 central plants in each plot according to the following schedule:

0 = No mildew present

1 = 1-4% leaf area affected

2 = 5-9% leaf area affected

3 = 10-24% leaf area affected

4 = 25-49% leaf area affected

5 = 50-100% leaf area affected

Botrytis* and *Mycosphaerella

Following inoculation with these two pathogens the crop was monitored for the development of disease. Once the crop had established and reached the cropping wire (2m), the mean number of nodes from the stem base to the cropping wire was determined on 4 central plants in each plot. Subsequently, at intervals during the trial, observations on the occurrence of *Botrytis* and *Mycosphaerella* could then be made on the stem bases and nodes of these four plants. The infected stem bases and nodes were also scored for severity of infection using the following schedule:

0 = No infection.

1 = slight infection.

2 = Moderate infection progressing to main stem but not girdling the stem.

3 = Severe infection girdling the stem, plant death anticipated.

In the later stages of the trial assessment of dead plants was also carried out. Where possible the cause of death was determined.

Agronomic Assessments – Yield

Fruit was harvest from the plots and counted, weighed and graded. There were 2 to 3 harvests per week and the results from these harvests were totalled to give the yield for three harvest periods. The dates covered by these harvest periods are as follows:

1) 21 July – 17 August 1999,
2) 19 August – 17 September 1999,
3) 20 September – 28 October 1999.

The crop was monitored regularly after each spray application for the presence of phytotoxicity symptoms.

Statistical Analysis

A statistical analysis of variance was performed on raw data using a Genstat 5 programme. The disease assessment data for *Mycosphaerella* and *Botrytis* node infections was transformed from the severity scores used for assessment to 'weighted scores' by using a weighted score calculation. This enabled severity scores for plants to be reduced to a single percentage infection score, which was then analysed by Analysis of Variance. The weighted scores were calculated using the following formula:

$$\text{Weighted Score} = \frac{[(\text{Nodes with}) + (\text{Nodes with}) \times 2 + (\text{Nodes with}) \times 3]}{[(\text{Severity 1}) \quad (\text{Severity 2}) \quad (\text{Severity 3})]} \times \frac{100}{3}$$

$$19$$

Hence each weighted score is a 'percentage' on the range 0-100

The assessment data for the number of dead plants per plot was analysed using a Binomial Analysis of the number of surviving plants on the final two assessment dates.
Within the tables of results are comments on the significance of data, these comments are based on the comparison between the untreated control and all other treaments (Significance Untreated) and the comparison between all treatments except the control (Significance Treated). The notation of significance in the tables is based on the following:

NS = Result not significant

* = Significant result (P at 5 %)

** = Highly significant result (P at 1%)

*** = Very highly significant result (P at 0.1%)

Official Recognition

The study described was undertaken in accordance with the guidelines for Official Recognition of Efficacy Testing Organisations.
Certificate No. ORETO 020;
Date of Issue: 13 January 1998,
Expiry Date: 31 December 2002.

(ii) Evaluation of Novel Fungicides against *Botrytis cinerea* and *Mycosphaerella melonis* in *in vitro* studies

Leaves used in the *in vitro* bioassay were selected from fungicide treated plots in the replicated commercial efficacy trial. The treatments applied to the plots are given in the treatment list for the commercial efficacy evaluation.

Leaves were sampled randomly from the trial plots 24-48hrs after the application of fungicide sprays. Leaves were selected from a range of representative age categories within the plant canopy - from the bottom (near to stem base) representing older leaves; from the middle, representing intermediate aged leaves and from the top of the plant, representing the youngest leaves. A total of 10 leaves were sampled from each treatment.

The leaves were returned to the laboratory and leaf discs measuring 7.5cm diameter (44.0cm^2) were cut from the sampled leaves using a sharp core. The excised discs were placed inside humid chambers containing moist blotting paper. A 3mm-diameter agar plug from a 7–day old culture of either *Botrytis cinerea* or *Mycosphaerella melonis* was inoculated into the centre of the incubated leaf discs. The inoculation site immediately beneath the agar plug was wounded to aid infection by inserting a sterile scalpel or needle through the leaf surface to create a wound. The inoculated leaf discs were kept in humid chambers and out of direct light at ambient room temperature for up to 7 days and then the diameter of the resulting leaf lesion was measured.

Results

(i) Commercial Efficacy Evaluation

Powdery mildew

Powdery mildew infection established naturally in the crop causing significant economic crop damage in the untreated control plots during the course of the trial.

Good control of powdery mildew was demonstrated by all of the strobilurin fungicide treatments including - Amistar (azoxystrobin), Stroby (kresoxim-methyl) and Flint (trifloxystrobin) throughout the trial. These treatments showed significantly lower levels of infection compared to the untreated control throughout the trial period. Amistar was particularly effective and at the first assessment on 4 August showed excellent control of infection on each of the levels of the canopy assessed (Table 2). Flint showed a level of control not significantly different to Amistar but was slightly less effective in the early stages of the trial. It was only after the application of the 5th spray in the programme that Flint showed control equal to Amistar. However Flint surpassed Amistar in the later stages of the trial showing superb control of powdery mildew on the younger leaves (only remaining leaves on the plants) at the end of powdery mildew assessments. Stroby, although not significantly different to the two other Strobilurins, was the least effective of this group of fungicides showing improved efficacy with increasing numbers of spray applications until after the 5th spray application on 14 September (Table 5) when it showed poor control of new infection on young leaves during a period of high disease pressure.

At the first assessment on 4 August (Table 2) all of the Strobilurin treatments - Amistar, Stroby and Flint had significantly less powdery mildew infection on the lower (older) leaves than Treatment 8 – the Commercial Integrated Programme comprised of Bravo 500 (chlorothalonil), Fungaflor (imazalil), Rovral WP (iprodione) and Rubigan (fenarimol). Following the first assessment and throughout the trial Amistar and Flint showed significantly better control of powdery mildew than the Commercial Integrated Programme at all levels in the canopy with Stroby being comparable to the Commercial Integrated Programme in its control of powdery mildew at all levels in the canopy.

The anilino-pyrimidine 'Botrytis' fungicide 35-35 (mepanipyrim) surprisingly was effective throughout the trial in controlling new infections of powdery mildew on young leaves in the top of the canopy with significantly less infection than the untreated control on the younger leaves at each assessment. However it showed poor control of infection on the older leaves in the bottom of the canopy with results not significantly different to the untreated control throughout the trial. Control of infection in the middle of the canopy was good in the earlier assessments (4 August – 1 September) (Tables 2 to 4) when infection levels were significantly less than the untreated control. However 35-35 (mepanipyrim) was less effective on older infections on middle leaves as the trial progressed with no differences between this treatment and the untreated control at the 4th assessment on 14 September.

Scala (Pyrimethanil, another anilino-pyrimidene fungicide) was also included in the treatment list for its activity against *Botrytis.* Yet this also showed some activity against powdery mildew with disease severity scores consistently lower than the untreated control throughout the trial although these results were not significant.

The Experimental Integrated Programmes (Treatments 9-11) all showed poor control of powdery mildew at the first assessment on 4 August (Table 2) in the lower levels of the canopy. Infection levels on lower and middle leaves were not significantly different to the untreated control. The Commercial Integrated Programme also showed poor control of infection at this first assessment and was comparable to the three Experimental Integrated Programmes in control on the lower and middle leaves at this time. Treatment 10 – Experimental Integrated Programme 2, comprised of an alternating programme of Bravo 500, Fungaflor, Stroby and Scala showed some improved control of infection on younger (top) leaves in this first assessment. This improved control of powdery mildew on the younger leaves with this treatment continued on to the 2nd assessment on 17 August (Table 3) where infection levels again were lower on this treatment compared to the other two Experimental Programmes. At the 2nd assessment on 17th August (Table 3) all three Experimental Integrated Programmes showed improved control of infection on middle leaves compared to the untreated control and slightly better control than the Commercial Integrated Programme, although this result was not significant. Following the 4th spray application (Table 4) the Experimental Integrated Programmes showed improved control with Treatment 9 comprised of an alternating

programme of Bravo 500, Fungaflor, Amistar and 35-35 (mepanipyrim) and Treatment 11 comprised of Bravo 500, Fungaflor, Amistar, 35-35 (mepanipyrim), Stroby and Scala both showing improved control of powdery mildew at all levels in the canopy compared to the untreated control.

The improved performance of Treatments 9 and 11 at the 3rd assessment on 1 September (Table 4) appeared to be related to the order of the products in the alternating programme with Amistar being applied as part of the alternating integrated programme in these treatments. Treatment 9 – Experimental Integrated Programme 1 (Bravo 500, Fungaflor, Amistar and 35-35) had received Amistar as two consecutive applications (16 August and 31 August) prior to this assessment. While Treatment 11 – Experimental Integrated Programme 3 (Bravo 500, Fungaflor, Amistar, 35-35, Stroby and Scala), had received one application of Amistar by this time (16 August).

Treatment 9 – Experimental Integrated Programme 1 (Bravo 500, Fungaflor, Amistar and 35-35) performed particularly well at the 3rd assessment on 1 September (Table 4) showing improved control when compared to the Commercial Integrated Programme (Treatment 8).

The Experimental Programmes continued to show effective control of powdery mildew up to the end of the trial with the exception of Treatment 10 – Experimental Programmed 2 (Bravo 500, Fungaflor, Stroby and Scala) which showed a decline in efficacy on older (bottom) leaves by the 4th assessment on 14 September (Table 5). This results is likely to be related to the inclusion of Scala as the last two spray applications in this Experimental Programme.

Botrytis cinerea

Following artificial inoculation, *Botrytis* established slowly in the Inoculated and Uninoculated untreated control plots. Throughout the trial the uninoculated untreated control was more severely affected by *Botrytis* infection than the inoculated untreated control. At the termination of the trial on 13 October infection had successfully established across the trial area causing node infections, however, the levels of infection were very low and did not cause significant crop losses.

In the final week of the trial, two weeks after the final spray application, infection from *Botrytis* caused the girdling of nodes in some treatments which resulted in the death of those plants (Table 8).

In the first two assessments (Table 8 - 1 and 14 September) there were no significant differences between the treatments in the severity of *Botrytis* node infection. At the third assessment on 29 September there were significant differences between the severity of infection on the Uninoculated Untreated Control and certain other treatments. At this assessment excellent control of node infection was demonstrated by Treatment 3 –Amistar, Treatment 5 – Flint and Treatment 6 – 35-35 (mepanipyrim). Amistar and 35-35 (mepanipyrim) continued to demonstrate excellent control of *Botrytis* to the final assessment on 13 October which was two weeks after the final spray application. These two treatments had significantly less *Botrytis* than the Uninoculated Untreated Control and showed improved control of infection compared to the Commercial Integrated Programme.

At the last assessment on 13 October (Table 8) Treatment 9 – Experimental Integrated Programme 1 (Bravo 500, Fungaflor, Amistar and 35-35) and Treatment 11 - Experimental Integrated Programme 3 (Bravo 500, Fungaflor, Amistar, 35-35, Stroby and Scala) both demonstrated excellent control of *Botrytis* with levels of infection significantly lower than the untreated control.

Treatment 7 - Scala performed well in controlling *Botrytis* during the course of the trial but its efficacy decreased in the two weeks after the final spray.

Mycosphaerella melonis

Mycosphaerella was inoculated into the trial plots and infection established in the petioles where inoculum was introduced. However infection did not spread to any great extent from the inoculation sites and there were very few basal and node lesions in the crop caused by *Mycosphaerella*. The infection sites therefore recorded for this pathogen during the course of the trial were too few to analyse and this data has not been displayed in the result tables.

Plant deaths were recorded at the final assessment on 13 October (Table 9). In most cases plants that died had lost many leaves due to powdery mildew infection but in most instances it was a *Botrytis* node infection girdling the stem that caused the death of the plant. All fungicide treatments reduced the number of plant deaths with no plant deaths occurring in Treatment 5 – Flint and Treatment 11 – Experimental Integrated Programme (Bravo 500, Fungaflor, Amistar, 35-35, Stroby and Scala).

The results for total yield, total number and percentage of marketable Class I cucumbers show no improvement in yield with fungicide treatments compared to the untreated control in the first two harvest periods (Table 10). The results for yield however in the final harvest period (20 September –28 October) show significant differences between treatments. In the final harvest period disease pressure was causing plant deaths in the untreated control and therefore reducing the yield. It can be seen that the effects of reduced plant death in some treatments has allowed an increase in yield in this final harvest period. Treatment 4 –Stroby, Treatment 5 - Flint, Treatment 9 – Experimental Integrated Programme 1 and Treatment 11 Experimental Integrated Programme 3 all had significantly higher total yields in this final harvest period than the untreated control. The same improvement in yield in these treatments was shown for total number of marketable cucumbers in the final harvest period.

All fungicide treatments showed a yield improvement for percentage marketable Class I cucumbers with Treatment 4 –Stroby, Treatment 5 - Flint, Treatment 10 Experimental Integrated Programme 2 and Treatment 11 Experimental Integrated Programme 3 performing particularly well in boosting Class I marketable yield in this final harvest period.

Observations on crop safety were made at every assessment during the course of the trial with no evidence of phytotoxicity occurring on any of the treatments.

(ii) Evaluation of Novel Fungicides against *Botrytis cinerea* and *Mycosphaerella melonis* in an *in vitro* study

In an *in vitro* inoculation study using excised leaf discs from fungicide treated leaves the range of novel and standard fungicide treatments listed in the treatment list were evaluated for their efficacy against both *Botrytis* and *Mycosphaerella* (Table 11). The bioassay provided additional supporting data on *Botrytis* and *Mycosphaerella* control to the in-crop assessments conducted in the commercial efficacy trial.

Botrytis cinerea

All of the strobilurin fungicides completely controlled *Botrytis* in the first assessment on 3 August, which followed two spray applications. Treatments 3 – Amistar and Treatment 5 – Flint continued to show significantly reduced *Botrytis* infection for the remainder of the bioassay assessments. The consistent performance of Amistar and Flint contrasted to the poor control shown by the Treatment 8 – Commercial Integrated Programme where the *Botrytis* lesions were larger than the untreated control throughout the period of the bioassay. Each of the Experimental Integrated Programmes reduced leaf lesion size at each assessment compared to the untreated control. At the final assessment on 1 October, after all spray applications had been applied, the Experimental Integrated Programmes (Treatments 9 to 11) had significantly smaller *Botrytis* leaf lesions than the untreated control.

Treatment 7 - Scala showed significant control of *Botrytis* in the first assessment on 3 August but showed poor control during the subsequent assessments. Treatment 6 - 35-35 (mepanipyrim) also showed some small reduction in lesion size in the early stages of the bioassay but then showed very poor control for the remainder of the trial period.

Mycosphaerella melonis

Treatment 6 - mepanipyrim (35-35) and each of the three Experiment Integrated Programmes showed significant reduction in the size of *Mycosphaerella* lesions in the first assessment. Mepanipyrim (35-35) continued to reduce lesion size for the rest of the period of the bioassay but the result was not significantly different to the untreated control. All of the Experiment Integrated Programmes significantly reduced *Mycosphaerella* lesions size at the second assessment but only Treatment 9 - Experiment Integrated Programme 1 (Bravo 500, Fungaflor, Amistar and 35-35) controlled the growth of *Mycosphaerella* leaf lesions throughout the trial period.

Table 2: Powdery Mildew Assessment – 4 August 1999#

Treatments		0-100 Disease Severity Index		
		Young leaves	Middle leaves	Old Leaves
1&2	Untreated control	16.93	34.67	46.77
3	Amistar (Azoxystrobin)	0.31	7.59	18.83
4	Stroby (Kresoxim-methyl)	1.09	14.20	23.15
5	Flint (Trifloxystrobin)	2.80	3.74	24.36
6	35-35 (Mepanipyrim)	0.26	12.92	32.55
7	Scala (Pyrimethanil)	12.59	23.43	39.73
8	Commercial Integrated Programme (alternating)	9.31	25.08	46.93
9	Experimental Integrated Programme -1 (alternating)	6.12	25.71	50.09
10	Experimental Integrated Programme - 2 (alternating)	4.37	21.72	55.84
11	Experimental Integrated Programme - 3 (alternating)	5.29	22.87	55.46
Significance Untreated		***	***	* (6% level)
Significance Treated		NS	**	***
LSD 5% (34 df)*		12.39	13.17	16.93

Mildew infection scores expressed as 0-100 disease Index, this data has been transformed using the angular transformation. Analysis based on actual leaves present, dead leaves are not included in the analysis.

Please refer to the treatment list on page 11 for details of the Commercial Integrated Programme (alternating) and the three Experimental Integrated Programmes (alternating).

Table 3: Powdery Mildew Assessment – 17 August 1999#

Treatments		0-100 Disease Severity Index		
		Young leaves	Middle leaves	Old leaves
1&2	Untreated control	38.36	44.7	50.93
3	Amistar (Azoxystrobin)	0.35	3.58	5.95
4	Stroby (Kresoxim-methyl)	17.73	22.18	22.22
5	Flint (Trifloxystrobin)	5.17	5.37	11.99
6	35-35 (Mepanipyrim)	5.57	18.27	38.25
7	Scala (Pyrimethanil)	21.69	33.33	37.33
8	Commercial Integrated Programme (alternating)	22.34	25.13	49.04
9	Experimental Integrated Programme -1 (alternating)	14.58	23.14	37.70
10	Experimental Integrated Programme - 2 (alternating)	25.67	24.92	44.08
11	Experimental Integrated Programme - 3 (alternating)	23.94	29.70	50.95
Significance Untreated		***	***	***
Significance Treated		**	**	***
LSD 5% (34 df)*		15.47	16.50	17.23

Mildew infection scores expressed as 0-100 disease Index, this data has been transformed using the angular transformation. Analysis based on actual leaves present, dead leaves are included in the analysis.

Please refer to the treatment list on page 11 for details of the Commercial Integrated Programme (alternating) and the three Experimental Integrated Programmes (alternating).

Table 4: Powdery Mildew Assessment – 1 September 1999#

Treatments		0-100 Disease Severity Index		
		Young leaves	Middle leaves	Old leaves
1&2	Untreated control	52.7	55.03	54.78
3	Amistar (Azoxystrobin)	0.2	1.85	5.47
4	Stroby (Kresoxim-methyl)	21.7	20.14	25.59
5	Flint (Trifloxystrobin)	5.4	6.27	10.33
6	35-35 (Mepanipyrim)	1.6	14.48	39.52
7	Scala (Pyrimethanil)	32.7	43.07	45.54
8	Commercial Integrated Programme (alternating)	33.5	33.47	43.19
9	Experimental Integrated Programme -1 (alternating)	1.5	6.52	16.83
10	Experimental Integrated Programme - 2 (alternating)	31.0	28.90	41.42
11	Experimental Integrated Programme - 3 (alternating)	23.2	22.91	31.14
Significance Untreated		***	***	***
Significance Treated		***	***	***
LSD 5% (34 df)*		16.15	16.18	20.92

Mildew infection scores expressed as 0-100 disease Index, this data has been transformed using the angular transformation. Analysis based on actual leaves present, dead leaves are not included in the analysis.

Please refer to the treatment list on page 11 for details of the Commercial Integrated Programme (alternating) and the three Experimental Integrated Programmes (alternating).

Table 5: Powdery Mildew Assessment – 14 September 1999#

Treatments		0-100 Disease Severity Index		
		Young leaves	Middle leaves	Old leaves
1&2	Untreated control	71.6	64.0	54.65
3	Amistar (Azoxystrobin)	25.0	8.6	5.8
4	Stroby (Kresoxim-methyl)	40.0	22.6	13.4
5	Flint (Trifloxystrobin)	5.9	5.2	4.9
6	35-35 (Mepanipyrim)	22.2	42.5	58.9
7	Scala (Pyrimethanil)	55.3	50.3	36.8
8	Commercial Integrated Programme (alternating)	36.8	44.6	36.0
9	Experimental Integrated Programme -1 (alternating)	37.4	12.8	6.2
10	Experimental Integrated Programme – 2 (alternating)	35.7	33.1	42.1
11	Experimental Integrated Programme - 3 (alternating)	42.7	30.9	23.4
Significance Untreated		***	***	***
Significance Treated		**	**	***
LSD 5% (34 df)*		22.54	22.54	40.04

Mildew infection scores expressed as 0-100 disease Index, this data has been transformed using the angular transformation. Analysis based on actual leaves present, dead leaves are not included in the analysis.

Please refer to the treatment list on page 11 for details of the Commercial Integrated Programme (alternating) and the three Experimental Integrated Programmes (alternating).

Table 6: Powdery Mildew Assessment – 29 September 1999#

Treatments		0-100 Disease Severity Index		
		Young leaves	Middle leaves	Old leaves
1&2	Untreated control	59.0	59.75	+
3	Amistar (Azoxystrobin)	15.6	3.5	+
4	Stroby (Kresoxim-methyl)	24.1	13.6	+
5	Flint (Trifloxystrobin)	4.1	2.4	+
6	35-35 (Mepanipyrim)	23.8	40.4	+
7	Scala (Pyrimethanil)	39.0	42.4	+
8	Commercial Integrated Programme (alternating)	33.3	42.5	+
9	Experimental Integrated Programme -1 (alternating)	33.4	27.5	+
10	Experimental Integrated Programme - 2 (alternating)	45.5	25.2	+
11	Experimental Integrated Programme - 3 (alternating)	32.2	32.9	+
Significance Untreated		***	***	-
Significance Treated		**	**	-
LSD 5% (34 df)*		23.17	56.67	-

Mildew infection scores expressed as 0-100 disease Index, this data has been transformed using the angular transformation. Analysis based on actual leaves present, dead leaves are not included in the analysis.

\+ All lower leaves were dead at this assessment

Please refer to the treatment list on page 11 for details of the Commercial Integrated Programme (alternating) and the three Experimental Integrated Programmes (alternating).

Table 7: Powdery Mildew Assessment – 13 October 1999#

Treatments		0-100 Disease Severity Index		
		Young leaves	Middle leaves	Old leaves
1&2	Untreated control	74.5	+	+
3	Amistar (Azoxystrobin)	32.2	+	+
4	Stroby (Kresoxim-methyl)	59.6	+	+
5	Flint (Trifloxystrobin)	6.4	+	+
6	35-35 (Mepanipyrim)	38.0	+	+
7	Scala (Pyrimethanil)	55.3	+	+
8	Commercial Integrated Programme (alternating)	35.9	+	+
9	Experimental Integrated Programme -1 (alternating)	42.5	+	+
10	Experimental Integrated Programme – 2 (alternating)	50.3	+	+
11	Experimental Integrated Programme - 3 (alternating)	31.5	+	+
Significance Untreated		***	-	-
Significance Treated		**	-	-
LSD 5% (34 df)*		22.48	-	-

Mildew infection scores expressed as 0-100 disease Index, this data has been transformed using the angular transformation. Analysis based on actual leaves present, dead leaves are not included in the analysis.

\+ All lower and middle leaves were dead at this assessment

Please refer to the treatment list on page 11 for details of the Commercial Integrated Programme (alternating) and the three Experimental Integrated Programmes (alternating).

Table 8: Assessment of *Botrytis* Node infection at Four Intervals#

Treatment		0-100 Disease Severity Index			
		1 September 1999	14 September 1999	29 September 1999	13 October 1999
1	Uninoculated untreated control.	0.0	0.07	1.90	4.31
2	Inoculated untreated control	0.0	0.00	1.83	3.58
3	Amistar (Azoxystrobin)	0.46	0.48	0.02	0.07
4	Stroby (Kresoxim-methyl)	0.29	0.45	0.30	1.29
5	Flint (Trifloxystrobin)	0.01	0.01	0.09	1.78
6	35-35 (Mepanipyrim)	0.00	0.06	0.01	0.54
7	Scala (Pyrimethanil)	0.04	0.03	0.62	2.67
8	Commercial Integrated Programme (alternating)	0.18	0.67	0.52	2.06
9	Experimental Integrated Programme -1 (alternating)	0.28	0.64	0.39	1.04
10	Experimental Integrated Programme - 2 (alternating)	0.22	1.04	1.00	1.52
11	Experimental Integrated Programme - 3 (alternating)	0.35	1.03	1.01	0.59
Significance Untreated		NS	NS	**	**
Significance Treated		NS	NS	NS	NS
LSD 5% (34 df)*		0.58	1.28	2.02	3.20

Angular transformation of node disease severity score

Please refer to the treatment list on page 11 for details of the Commercial Integrated Programme (alternating) and the three Experimental Integrated Programmes (alternating).

Table 9: The number of plants killed by infection from *Botrytis* and assessed as dead at the last assessment date (assessment based on 4 plants per plot).

Treatment		% dead plants at final assessment ◆	
		13 October 1999	
		% Dead Plants	Standard Error
1	Uninoculated untreated control.	18.75	6.0
2	Inoculated untreated control	16.66	5.8
3	Amistar (Azoxystrobin)	6.25	4.6
4	Stroby (Kresoxim-methyl)	6.25	4.6
5	Flint (Trifloxystrobin)	0.00	0.00
6	35-35 (Mepanipyrim)	3.12	3.3
7	Scala (Pyrimethanil)	6.25	4.6
8	Commercial Integrated Programme (alternating)	6.25	4.6
9	Experimental Integrated Programme -1 (alternating)	6.25	4.6
10	Experimental Integrated Programme - 2 (alternating)	6.25	4.6
11	Experimental Integrated Programme - 3 (alternating)	0.00	0.00

◆ Significance tests of differences based on deviance χ^2 test.

Please refer to the treatment list on page 11 for details of the Commercial Integrated Programme (alternating) and the three Experimental Integrated Programmes (alternating).

Table 10: Yield Assessments – The Total Weight, Total Number and % Class I cucumbers at Three Harvest Periods[a]

Treatments		Assessment of Different Yield Factors in 3 harvest periods								
		Total Yield of Cucumbers (Kg per m^2) in each Harvest Period			Mean Total Number of Marketable Cucumbers Per m^2			% of Marketable Class I Cucumbers		
		1	2	3	1	2	3	1	2	3
1	Uninoculated untreated control.	9.82	7.15	4.91	20.63	14.76	10.47	97.55	91.31	83.46
2	Inoculated untreated control	9.99	7.33	5.77	20.72	15.08	12.18	98.04	94.02	82.06
3	Amistar (Azoxystrobin)	8.77	6.17	5.69	18.19	13.18	12.49	97.94	91.55	84.78
4	Stroby (Kresoxim-methyl)	9.41	7.01	6.14	19.82	15.17	13.34	98.70	95.64	85.25
5	Flint (Trifloxystrobin)	9.70	6.94	6.41	19.65	14.38	14.29	97.45	92.89	89.99
6	35-35 (Mepanipyrim)	9.06	6.85	5.83	18.32	14.58	12.80	97.45	94.16	84.84
7	Scala (Pyrimethanil)	9.50	6.83	5.82	19.91	14.92	12.65	97.74	92.16	83.88
8	Commercial Integrated Programme (alternating)	9.77	6.97	5.81	20.78	14.82	12.26	97.30	94.66	85.67
9	Experimental Integrated Programme -1 (alternating)	9.83	7.04	6.44	20.38	14.84	13.33	98.26	89.68	87.42
10	Experimental Integrated Programme - 2 (alternating)	9.74	7.30	5.67	19.41	15.18	12.84	97.79	95.10	88.49
11	Experimental Integrated Programme - 3 (alternating)	9.31	7.32	6.18	19.84	15.31	13.27	98.34	91.80	89.93
Significance Untreated		NS	NS	*	NS	NS	**	NS	NS	*
Significance Treated		NS	NS	NS	NS	NS	NS	NS	NS	NS
LSD 5% (34df)		1.00	1.11	1.15	1.95	2.31	2.42	2.84	4.91	1.75

a. Harvest Periods
1) 21/7/99 – 17/8/99
2) 19/8/99 – 17/9/99
3) 20/9/99 – 28/10/99

Please refer to the treatment list on page 11 for details of the Commercial Integrated Programme (alternating) and the three Experimental Integrated Programmes (alternating).

Table 11: ***In-Vitro*** **bioassay – the relative growth of isolates of** ***Mycosphaerella*** **and** ***Botrytis*** **on leaf discs taken from the crop after application of fungicide sprays at three assessment intervals**

		Mean Lesion Length at Three Assessment Dates					
		Botrytis			*Mycosphaerella*		
		3/8/99	1/9/99	1/10/99	3/8/99	1/9/99	1/10/99
1&2	Untreated Control	1.37	3.87	5.69	5.21	1.76	2.60
3	Amistar (Azoxystrobin)	0.0	1.12	2.90	4.40	1.65	1.65
4	Stroby (Kresoxim-methyl)	0.0	3.08	4.97	4.87	1.21	1.49
5	Flint (Trifloxystrobin)	0.0	2.58	3.08	4.68	1.58	2.04
6	35-35 (Mepanipyrim)	1.00	4.40	4.66	3.38	1.23	1.56
7	Scala (Pyrimethanil)	0.22	4.08	4.67	4.63	1.94	1.63
8	Commercial Integrated Programme (alternating)	0.54	4.34	5.88	3.43	1.81	3.79
9	Experimental Integrated Programme -1 (alternating)	0.49	0.24	4.02	3.14	0.26	0.77
10	Experimental Integrated Programme - 2 (alternating)	0.56	2.64	3.51	1.72	0.00	1.33
11	Experimental Integrated Programme - 3 (alternating)	0.0	2.78	1.94	3.76	0.32	2.20
Significance Untreated		*	*	***	**	NS	NS
Significance Treated		NS	***	***	***	*	*
LSD 5% (90 df)		0.90	1.19	1.02	1.40	1.26	1.48

[a] Lesion lengths are square root transformed.

Please refer to the treatment list on page 11 for details of the Commercial Integrated Programme (alternating) and the three Experimental Integrated Programmes (alternating).

Conclusions

In the commercial efficacy evaluation powdery mildew infection established naturally in the trial plots causing significant economic crop damage.

All of the strobilurin fungicides treatments which included Amistar (azoxystrobin), Stroby (kresoxim-methyl) and Flint (trifloxystrobin) showed good control of powdery mildew throughout the duration of the trial and it is quite clear that one or more of these novel fungicides would be extremely valuable for disease control in the UK cucumber industry. Amistar was effective from the early stages and throughout the whole of the trial period while Flint was slightly less effective in the early stages becoming more effective with the increasing number of spray applications. By the end of the trial Flint showed excellent control of powdery mildew on the young leaves. Stroby although not significantly different was the least effective of the Strobilurin group. Throughout the trial Amistar and Flint showed significantly better control of powdery mildew than the Commercial Integrated Programme (Bravo 500, Fungaflor, Rovral WP and Rubigan). Stroby was comparable to the Commercial Integrated Programme in its control of powdery mildew.

The anilino-pyrimidine fungicides evaluated were included primarily for their expected efficacy against *Botrytis*. However, 35-35 (mepanipyrim) showed effective control of powdery mildew infection of young leaves throughout the trial but did not control infection on the lower leaves in the canopy. Scala (Pyrimethanil) which was also included in the trial showed some suppression of powdery mildew although results were not significant.

The schedules for each of the Experimental Integrated Programmes and the Commercial Integrated Programme all began with the same two fungicide applications (see Treatment List) which were firstly Bravo 500 (chlorothalonil) and secondly Fungaflor (imazalil). The initial control of powdery mildew demonstrated by these four treatments in the lower leaves of the canopy was poor with some improvement shown in one of the Experimental Programmes (Treatment 10) following the application of Fungaflor as the second spray application in the schedule. Each of the three experimental programmes showed improved control of powdery mildew as the third fungicide application in each schedule was applied. In each case this was a member of the strobilurin group with Amistar

applied as the third spray in Experimental Integrated Programmes - 1 and 2, and Stroby applied as the third spray in Experimental Integrated Programme - 2. As treatment application progressed Experimental Integrated Programmes - 1 and 3, showed the most effective control of powdery mildew infection, (Experimental Programme – 1, contained Amistar as the 3rd and 4th and 35-35 (mepanipyrim) as the 5th and 6th fungicide applications in the spray schedule; Experimental Programme 3 contained Amistar as the 3rd, 35-35 (mepanipyrim) as the 4th, Stroby as the 5th and Scala as the 6th application in the spray schedule). The combination therefore of Amistar and 35-35 (mepanipyrim) used in the middle of Experimental Programmes 1 and 3 significantly improved the effective control of powdery mildew.

Following artificial inoculation *Botrytis* infections established slowly in the crop with only a low level of node infections appearing in the trial plants as compared to those seen in the second year of the project in 1998. *Botrytis* infection did however cause the girdling of the stems of plants in the untreated control and some treatments that encouraged plant death in the final weeks of the trial. Amistar, Flint and 35-35 (mepanipyrim) showed the best control of *Botrytis* node infections following the establishment of the spray programme. Both Amistar and 35-35 (mepanipyrim) continued to show effective control to the termination of the trial. Scala showed effective control of *Botrytis* during the course of the trial when spray applications were being regularly applied however its control did not persist after sprays had ceased with a decline in efficacy in this treatment in the weeks following the final application. In view of the relatively high risk of fungicide resistance with the strobilurins, it would be appropriate to also seek approval for one of the anilino-pyrimidine fungicides to ensure growers can 'ring the changes' and use alternative fungicides with contrasting modes of action.

All three Experimental Integrated Programmes showed effective control of *Botrytis* node infections in the final weeks of the trial when disease pressure was at its greatest. Each of these Experimental Programmes was significantly better than the Commercial Integrated Programme.

Plant deaths at the end of the trial were primarily caused by *Botrytis* node infections but powdery mildew infection also contributed to premature plant losses. All of the fungicide treatments significantly reduced the number of plant deaths in the final weeks of the trial with no plant losses occurring in the plots treated with Flint and Experimental Integrated Programme – 3.

Mycosphaerella although successfully inoculated into trial plants did not establish in the crop and results for infection sites were too low to be recorded. Results for control of *Mycosphaerella* leaf lesions were obtained from the *in vitro* bioassay.

Yield data showed no differences in treatments for any of the criteria measured during the trial (total yield, number of cucumbers and percentage class I cucumbers). However in the final harvest period when disease pressure was causing plant losses in the untreated control Stroby, Flint, Experimental Integrated Programme - 1 and 3 all had significantly higher total yields in this final harvest period than the untreated control. All fungicide treatments showed an improvement in the percentage of Class I marketable fruit at the end of the trial compared to the untreated control. None of the fungicide treatments caused any problems with phytotoxicity.

Where fungicides were evaluated in the *in vitro* bioassay for their activity against *Botrytis* and *Mycosphaerella* there were some clear differences between treatments. These results provided additional information on the performance of the treatments in controlling these two pathogens which were particularly relevant to *Mycosphaerella* following its failure to establish in the commercial efficacy trial plots in this years experiment. In the bioassay all of the Strobilurin fungicides controlled *Botrytis* with Amistar and Flint showing effective and superior control of *Botrytis* leaf infections for the duration of the trial when compared to the untreated control and Commercial Integrated Programme. The three Experimental Integrated Programmes all reduced *Botrytis* leaf infections. While Scala and 35-35 (mepanipyrim) gave effective control of *Botrytis* in the early stages of the bioassay but poor control as the trial progressed.

All treatments with the exception of the Commercial Integrated Programme were effective in suppressing the growth of *Mycosphaerella.* With Mepanipyrim (35-35) giving effective control not only when applied alone but also when combined in the Experimental Integrated Programmes with the Strobilurins (azoxystrobin, kresoxim-methyl and trifloxystrobin). Experimental Integrated Programmes – 1, combining azoxystrobin (Amistar) and mepanipyrim (35-35) in the final spray applications was particularly effective in controlling *Mycosphaerella.*

In summary therefore, every effort should be made to secure On or Off-Label Approval of a strobilurin fungicide (eg Amistar (azoxystrobin) or Flint (trifloxystrobin)) and an anilio-pyrimidine product (eg mepanipyrim).

Acknowledgements

This project was sponsored by the Horticultural Development Council and their financial support to the work is acknowledged.

Thankyou to Derek Hargreaves and members of the Cucumber Technology Group (CTG) for valuable technical discussion during the time course of the project. Thankyou to Feli Pomares, Cathryn Lambourne and Nick Hall for technical support in all aspects of the work and to David Varley, Carol Rockcliff and Julie Lane for assistance in applying spray treatments.