Project title:	Protected and outdoor cut flowers: development of effective and crop-safe fungicide treatments for the control of powdery mildew diseases.
Project number:	BOF 44
Project Leader:	Dr Tim M O'Neill ADAS Arthur Rickwood
Report:	Year 1 Annual Report, December 2000
Project Consultant:	Mr David A Stokes
Project Co-ordinator:	Mr Paul Harrison
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Location of project:	Commercial nursery, Lincs.
Date project commenced:	April 2000
Date completion due:	31 March 2003
Key words:	Solidago, powdery mildew, fungicides, *Erysiphe cichoracearum*

The results and conclusion in this report are based on an investigation conducted over one year. The conditions under which the experiments were 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.

Dr T M O'Neill
Principal Research Scientist
ADAS Arthur Rickwood

Signature ..... Date .....

Report authorised by:

Dr M Heath
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PRACTICAL SECTION FOR GROWERS

Commercial benefits of the project

This work has identified several novel fungicides for effective and crop-safe control of powdery mildew (*Erysiphe cichoracearum*) on solidago, and demonstrated that a protectant programme of five sprays provides very effective control on a susceptible variety.

Background

Production of several commercially important cut flower crops can be seriously affected by powdery mildew diseases. Currently these diseases are causing increasing problems. Even slight disfigurement arising from powdery mildew infection can lead to flowers failing a supermarket specification. Cost-effective and crop-safe fungicide treatments to prevent disease are urgently required. The objectives of this work, focusing on solidago, are to: (i) determine the effectiveness of comprehensive protectant treatments, (ii) investigate the effectiveness of current and some novel fungicides applied at different timings, (iii) test the crop safety of fungicides found to be effective on the major crop species and cultivars, on both protected and outdoor crops.

Objectives for 2000

The objective in 2000 is to determine the effectiveness of comprehensive protectant treatments using a range of current and novel fungicides.

Summary of results

Trial on outdoor solidago - Summer 2000

Eleven fungicides were evaluated for their effectiveness in controlling powdery mildew (*Erysiphe cichoracearum*) in a field crop of solidago cv. Marvellous Gold in Spalding, Lincs. Natural infection occurred 5 weeks after the trial was established and increased to affect 14 % leaf area on untreated plants by harvest; no stems in untreated plots were marketable. Stem weight and height were not significantly affected by fungicide treatment. All of the fungicide treatments reduced powdery mildew disease and increased the number of marketable stems.

- Eight treatments resulted in less than 1 % mildew at harvest and no crop damage [Alto 100 SL (cyproconazole), Dorado (pyrifenox), Experimental (mepanipyrim), Flint (trifloxystrobin), Fortress (quinoxyfen), Stroby WG (kresoxim-methyl), Systhane 6W (myclobutanil, Thiovit (sulphur) and Agral]
- Five of these (Dorado, Flint, Stroby WG, Systhane 6W and Thiovit + Agral) resulted in over 90% marketable stems.
- Alto 100 SL, Experimental and Fortress resulted in 58-70% marketable stems
- Thiovit plus Agral was more effective than Bravo 500 (chlorothalonil) in preventing powdery mildew.
- Neon (spiroxamine) damaged plants, causing an obvious brown leaf spot, and it is not suitable for use on the crop.

Trial on protected solidago - Autumn 2000

Eleven fungicides were evaluated for control of powdery mildew on the second crop of a planting of cv. Tara in a glasshouse in Spalding. Fungicides tested were identical to the outdoor trial except for the following changes to comply with pesticide label conditions of approval:

- addition of Fungaflor (imazalil) (label recommendation for protected crops only)
- omission of Alto (permissible on outdoor crops only)
- replacement of Systhane 6 W (permissible on outdoor crops only) with Systhane 20 EW (myclobutanil) (permissible on protected crops only).

The first sprays were applied on 3 August. Natural infection was observed on 30 August, in one untreated plot, but failed to develop and no results were obtained on fungicide efficacy. None of the treatments had any obvious adverse effect on plant growth.

Action points for growers

1. Powdery mildew on solidago often spreads quickly from lower leaves to affect the upper parts.
   Therefore a spray programme for mildew should commence soon after planting, before leaves become affected.

2. Eleven fungicides from seven different groups have been demonstrated to give significant control of solidago powdery mildew.
   Choose products from two or more different fungicide groups when devising a spray programme in order to minimise the risk of selecting fungicide resistant strains.

3. In the absence of mildew, inexpensive multi-site inhibitors (eg Thiovit, Bravo 500) are a cost-effective way of keeping the crop disease-free. The protectant fungicide Thiovit + Agral gave very effective control. There is only a low risk of powdery mildew developing resistance to this inexpensive multi-site inhibitor.
   Consider using Thiovit + Agral or Bravo 500 in alternation with other, more mildew-specific fungicides (ie fungicides with greater activity against mildew) when the disease is present. Bravo 500 may be more appropriate for use on other cut flowers, for example chrysanthemum where it would also give protection against white rust and botrytis.

4. These trials have demonstrated that a programme of 5 sprays can provide effective control of powdery mildew on solidago from planting through to harvest.
   Any programme should start early (within 7 days of planting), so that a fungicide is applied before mildew is seen. Continue with protectant materials at approximately 14 day intervals (maximum). Reduce the spray interval to 7-10 days as the crop grows providing the product label allows such a spray

interval. If mildew is seen, change to a mildew-specific fungicide for at least 2 sprays, at the shorter interval.

5. This trial has shown Dorado, Flint, Stroby WG and Systhane 6W to be the best mildew-specific fungicides to use on solidago.
Therefore include one or more of them in your programme. But please note the following comments:

-Experience has shown Dorado to be very effective against mildew on a number of ornamental crops

-There is a forthcoming limitation on use of Dorado. It is permitted until 31 July 2002 on both protected and outdoor ornamental crops. After this date, the product can only be used on outdoor crops because the manufacturers have not supported continued approval of this product on protected ornamentals - see Pesticide Monitor, August/September 2000.

-There is little experience, other than that presented here, of the effectiveness and crop-safety of Flint, Stroby WG and Systhane 6W on solidago or other outdoor cut flowers.

-Test treat a small area of outdoor solidago with one or more of these fungicides, before using them more widely.

6. Neon was phytotoxic to solidago 'Marvellous Gold', even when tested at half rate.
It is recommended that the product is not used on the crop.

7. The cost of fungicide only (ie excluding labour) for treating 1,000 m^2 with a programme of five sprays ranged from 14p (Thiovit + Agral) to £5.71 (Nimrod T), according to product.
It is extremely economically worthwhile to prevent powdery mildew by using an integrated programme of sprays starting from planting.

8. Check the approval status and conditions of use before you use a new fungicide on solidago. ***Of the fungicides we tested, it is permissible to use on solidago the products shown below. See treatment lists (page 6) for further details:***

Outdoor crops		**Protected crops**	
Alto	Nimrod T	Bravo	Systhane 20 EW
Bravo 500	Stroby WG	Dorado*	Thiovit + Agral
Dorado	Systhane 6W	Fungaflor	
Flint	Thiovit + Agral	Nimrod T	
Fortress			

*Approval on protected crops expires 31/7/02.

Anticipated practical and financial benefits

Discussion with the industry and examination of MAFF Basic Horticultural Statistics (1998) indicate the total area of perennial herbaceous cut flower crops is around 60 ha (20 ha protected; 40 ha outdoor) valued at £6.8m. Key growers have indicated that losses to powdery mildew on susceptible species average around 10 %. Assuming 50 % of the perennial herbaceous cut flower crop is susceptible to powdery mildew, and the losses on these is 10 %, the potential financial loss is estimated at £340,000 per annum. Several cases of complete crop loss to powdery mildew have occurred in recent years. We believe that the effective and crop safe treatments demonstrated here will significantly reduce or eliminate the problem. Practical information resulting from this project will also be of benefit to nursery stock growers, many of whom produce the young plants for perennial cut flower production.

SCIENCE SECTION

INTRODUCTION

Aster, cornflower, delphinium, gypsophila, scabious, solidago, and phlox are becoming more widely grown both outdoors and under protection (heated and unheated crops) to fulfil an increasing supermarket demand for a greater variety of flowers. Unfortunately, experience has shown that all of these popular crop species are very susceptible to powdery mildew diseases. For example, crops of solidago and delphinium were badly affected in both 1998 and 1999; gypsophila was badly affected in 1999. The fungal species involved include *Erysiphe cichoracearum* var. *cichoracearum* (on aster, cornflower, chrysanthemum and solidago); *Erysiphe aquilegia* (on aquilegia and larkspur); *Erysiphe knautiae* and *Sphaerotheca dipsacearum* on scabious; *Sphaerotheca fusca* on phlox; and a species on gypsophila (probably *Erysiphe buhrii*). *Erysiphe cichoracearum* is the most important pathogen. The diseases mark and deform the foliage and with severe attacks, premature leaf fall results. Attacks on the upper stem and foliage generally make the stem unmarketable even with a slight infection. Another serious effect with a slight to moderate attack is a reduction in size of flower stem (both weight and stem length are reduced) and consequently the very tight supermarket specifications may not be so easily met. For example, where the stem length is present but stems are thinner due to powdery mildew, more stems will be needed to make a saleable bunch.

Powdery mildew diseases tend to be most troublesome in the late summer and early autumn, and are often worse in protected crops. Most of these crops are herbaceous multi-stem plants which inevitably form a dense canopy when grown in beds, creating the right environment (high humidity) for powdery mildew disease to establish, thereby increasing disease risk. Because of the dense growth, fungicides need to be applied as the crop is developing, to maintain cover on the new growth.

Currently growers generally apply sprays only when powdery mildew is seen and this often proves to be only partially effective, or completely ineffective. Some growers have tried a protectant spray programme but with limited success.

The **commercial objective** of this project is to develop effective and crop safe fungicide treatment for representative species of the three major cut flower families susceptible to powdery mildew (Compositae, Caryophyllaceae, Ranunculaceae).

In this first project year, experiments were conducted to evaluate a range of current and novel fungicides as individual treatments for their effectiveness in controlling powdery mildew on field and protected crops of solidago, an important commercial species in the Compositae family.

MATERIALS AND METHODS

Site and crop details

Trials were undertaken on a commercial nursery at Spalding, Lincolnshire, using two varieties (Marvellous Gold - field trial; Tara - glasshouse trial) reported to be susceptible to powdery mildew. Plants were grown in a 2-row bed system at 10 cm spacing.

The glasshouse trial was conducted on a second-cut crop; this trial was inoculated with mildew on 29 September by scattering leaves bearing fresh mildew in each plot.

Treatments

Outdoor crop

Sprays were applied at 1,000 l/ha using a single, medium flat fan nozzle operating at 2 bar pressure. Initially spraying was from overhead, with a 3-nozzle boom. Once the crop reached 50 cm, a single nozzle was used to apply spray both from the top and sides of beds.

Product	Active Ingredient (a.i.)	Rate	Approval status
1. Untreated	(control)	-	-
2. Bravo 500	50% chlorothalonil	2.2 ml/litre	Label
3. Dorado	20% pyrifenox	0.25 ml/litre	Label
4. Nimrod T	6.25% bupirimate + 6.25% triforine	3.2 ml/litre	Label
5. Thiovit + Agral	80% sulphur + wetter	2 g/litre+0.06 ml/litre	GOR[a]
6. Stroby WG	50% kresoxim-methyl	200 g/ha	GOR
7. Fortress	50% quinoxyfen	150 ml/ha	GOR
8. Flint	5% trifloxystrobin	150 g/ha	GOR
9. Neon	50% spiroxamine	1.5 l/ha	GOR[b]
10.Alto 100 SL	10% cyproconazole	0.8 l/ha	GOR
11.Experimental	50 % mepanipyrim	800 g/ha	Not approved
12.Systhane 6W	6% myclobutanil	1 g/litre	GOR

[a] GOR - At growers own risk under the Revised Long Term Arrangements for Extension of Use-2000.

[b] Proved phytotoxic when tested. See results section.

Glasshouse crop

Spray volume was initially 1,000 l/ha (100 ml/m^2) and increased to 2,667 l/ha to maintain good coverage.

Product	Active Ingredient (a.i.)	Rate	Approval status
1. Untreated	(control)	-	-
2. Bravo 500	50% chlorothalonil	2.2 ml/litre	Label
3. Dorado	20% pyrifenox	0.25 ml/litre	Label[a]
4. Nimrod T	6.25% bupirimate + 6.25% triforine	3.2 ml/litre	Label
5. Thiovit + Agral	80% sulphur + wetter	2 g/litre + 0.06 ml/litre	GOR[b]
6. Stroby WG	50% kresoxim-methyl	200 g/ha	Not approved
7. Fortress	50% quinoxyfen	150 ml/ha	Not approved
8. Flint	5% trifloxystrobin	150 g/ha	Not approved
9. Programme*	-	-	-
10.Alto 100 SL	10% cyproconazole	0.8 l/ha	Not approved
11.Fungaflor	20% imazalil	0.5 ml/litre	Label
12.Systhane 20 EW	20.6% myclobutanil	0.45 litre/ha	GOR[c]

* Neon proved phytotoxic in the first trial and was therefore not included in the second trial. Instead, a programme of Thiovit + Agral (x2), followed by Dorado (x2) was tested.

[a] Approval on protected crops expires 31/7/02.

[b]GOR - At growers own risk under the Revised Long Term Arrangements for Extension of Use-2000. Extrapolation from SOLA 2080/98

[c] Extrapolation from SOLA 1881/99.

Treatments were applied every 14 days starting within 2 weeks of planting/re-growth. Treatment interval was reduced to 7-10 days when mildew occurred in the trial.

Experiment design and analysis

Each trial comprised a randomised block design with four replicate blocks. There was double replication of the untreated control. Plot size for the outdoor trial was 1.7 m lengths of 1.2 m wide bed (2.04 m^2). Plot size for the glasshouse trial was 1.5 m lengths of 1.2 m wide bed (1.80 m^2). Disease control and crop yield assessment were conducted on stems within the central 1 m of the plot length. Results were initially examined by ANOVA, but as the data sets were skewed with many values close to zero or 100, even after transformation, ANOVA was not suitable. Friedman`s test was therefore conducted. Results are shown as NS-no significant difference between treatments or ***-significant difference at $P<0.001$.

Assessments

During Growth

1. Estimate of % leaf area affected by powdery mildew (average of 3 positions in each plot, when plants were viewed from the side, near the base).
2. Record of any leaf scorch, yellowing or stunting.

At harvest

The 10 stems selected for cutting were ones at the normal marketing stage (the lowest flowers on the stem just opening) or just past this stage.

1. Estimate of % leaf area affected by powdery mildew on 10 stems per plot (prior to any normal leaf removal). Trace values of less than 1% were recorded as 0.1%
2. Length of stem from soil.
3. Number of stems (of 10) affected by powdery mildew after the normal removal of leaves on the basal 20 cm of stem. These would be deemed unmarketable because of the mildew.
4. Weight of each of 10 stems/plot, after usual preparation for marketing.
5. Marketability. Plants deemed marketable were free from powdery mildew, or had only 1-2 small leaves affected which could be removed without detriment to appearance; had no chemical scorch or other pesticide damage; were within size and weight grades (minimum of 55 cm and 15 g); and were of good appearance (not thin or misshapen).

Crop diary

	Field trial (first crop)	Glasshouse trial (second cut)
Crop planted/cut down	29 May	end July
Spray 1	5 June	3 August
Spray 2	16 June	17 August
Spray 3	30 June	31 August
Spray 4	12 July	14 September
Spray 5	20 July	28 September
Assessment 1	26 July	12 October
Assessment 2	2/3 August	-

RESULTS

Field trial

Powdery mildew was first observed in the crop on 12 July, 12 days after spray 3 and increased to affect 14 % leaf area on untreated plants (Table 1). Both leaves and stems were affected. The disease was initially restricted to leaves on the basal 30 cm of stem, but in the final 2 weeks it also appeared on leaves and stems near the tops of plants. All fungicide treatments reduced the disease and nine of them (Alto 100 SL, Dorado, Experimental, Flint, Fortress, Neon, Stroby WG, Systhane 6W and Thiovit + Agral) resulted in less than 1 % leaf area affected by powdery mildew at harvest. No *Sclerotinia* or other diseases were observed in the crop.

- Treatment with Dorado (100%), Flint (98%), Stroby WG (90%), Systhane 6W (93%) and Thiovit+Agral (90%) resulted in a very high % of marketable stems.

- Plants treated with Flint remained completely free of visible mildew through to the final assessment.

- Although neither stem length nor weight were statistically significantly affected by fungicide treatment, it is interesting to note that the shortest stems (76.2 cm) occurred following treatment with a triazole fungicide (Alto 100 SL), a type which has previously been shown to reduce stem length (e.g. Tilt on chrysanthemum and Sweet William).

- Plants treated with Nimrod T, Bravo 500 and the untreated control all had less than 20% marketable stems due to the presence of powdery mildew

- Neon caused a brown spotting on leaves. Damage was first noticed on 20 June and continued to occur on new growth even though the treatment rate was reduced from 1.5 to 0.75 litres/ha after spotting was first observed. None of the stems from this treatment were suitable for marketing.

Cost of fungicide (excluding labour) to treat 1,000 m^2 of solidago with a programme of 5 sprays ranged from 14p to £5.71 at the rates and volumes used (Table 3). An approximate sale value for 1,000 m^2 of crop is £10,500 (assumes 70 stems/m^2 and 15p/stem). Given that failure to apply fungicide treatment resulted in complete loss of marketable crop, an expenditure of less than £6 per 1000 m^2 (plus labour) to control powdery mildew appears well justified.

Glasshouse trial

Although the trial was inoculated with mildew, and an isolated spot of mildew was found in one plot partway through the trial, and mildew was present at a low level on plants elsewhere in the same glasshouse, the disease failed to develop in the trial area. A total of five sprays were applied of each of the fungicides. None of the treatments caused phytotoxicity, or had an obvious effect on plant size or flowering date. The crop was harvested from 12 October. Observation during harvesting indicated that plants which had been treated with Stroby WG were at a more advanced stage of flowering than other treatments. Further work is needed to confirm this.

Identity of solidago powdery mildew

The powdery mildew on solidago was identified as *Oidium* subgen. *Reticuloidium* (anamorph) compatible with the teleomorph *Golvinomyces cichoracearum*, formerly known as *Erysiphe cichoracearum*. This fungus is restricted to the family Compositae.

Table 1. Effect of fungicide treatments on Solidago powdery mildew - outdoor crop, Summer 2000

Treatment		% leaf area affected	
		26 July[a]	2 Aug[b]
1.	Untreated	5.7	14.2
2.	Bravo 500	2.9	6.7
3.	Dorado	0.3	0.1
4.	Nimrod T	1.1	3.0
5.	Thiovit + Agral	0.02	0.1
6.	Stroby WG	0	0.1
7.	Fortress	0.1	0.1
8.	Flint	0	0
9.	Neon	0.02	0
10.	Alto 100 SL	0	0.1
11.	Experimental	0.2	0.4
12.	Systhane 6W	0.02	0.6
Significance (11 df)		***	***

[a] Estimated cover at 0-50 cm, 3 positions/plot.
[b] Estimated whole stem cover, 10 stems/plot

Table 2. Effect of fungicides on growth and quality of Solidago - outdoor crop, 2000

Treatment	Stem length (cm)	Stem weight (g)	% stems marketable[a]
1. Untreated	78.4	61.3	0
2. Bravo 500	80.0	68.2	5
3. Dorado	82.3	71.2	100
4. Nimrod T	78.3	55.8	13
5. Thiovit + Agral	78.3	68.8	90
6. Stroby WG	77.9	65.0	90
7. Fortress	81.6	71.4	70
8. Flint	78.4	60.7	98
9. Neon	78.0	54.1	0
10. Alto 100 SL	76.2	57.6	68
11. Experimental	78.2	59.6	58
12. Systhane 6W	77.5	55.2	93
Significance (11 df)	NS	NS	***

[a] After removal of lower leaves, as normally practised; up to 1-2 small leaflets with a trace of mildew also removed if required.

Table 3. Approximate cost of fungicides (excluding application cost) to treat 1000 m^2 of crop (5 sprays)

Treatment	Rate	Unit cost (£/kg or litre)	Cost for 5 sprays[a] (£)
1. Untreated	-	-	-
2. Bravo 500	2.2 ml/l	3.50	0.77
3. Dorado	0.25 ml/l	86.47	2.16
4. Nimrod T	3.2 ml/l	17.85	5.71
5. Thiovit + Agral	2g + 0.06 ml/l	0.63 + 1.78	0.14
6. Stroby WG	200 g/ha	140.00	2.80
7. Fortress	150 ml/ha	62.00	0.93
8. Flint	150 g/ha	N/A	-
9. Neon	1.5 l/ha	16.67	2.50
10. Alto 100SL	0.8 l/ha	43.90	3.51
11. Experimental	0.8 kg/ha	N/A	-
12. Systhane 6W	1 g/litre	22.43	2.24

[a] 5 sprays at 1000 l/ha, excluding cost of application.

DISCUSSION

This work has clearly shown that a programme of five protectant fungicide sprays applied from soon after planting, or early re-growth, through to 13 days before harvest, can provide extremely good control of powdery mildew.

Older, multi-site fungicides

The good control achieved with Thiovit + Agral was interesting and mirrors the generally good control of tomato powdery mildew (*Erysiphe* sp.*)* achieved with this fungicide. It would be useful to examine the persistence of control from a single Thiovit spray (especially in a glasshouse crop), as a relatively long control period (4-6 weeks) is often reported in tomato crops.

Bravo 500 (chlorothalonil) gave moderate control. This chemical can be useful in fungicide programmes because it has a broad spectrum of activity (e.g. against botrytis, downy mildew). Also, because it is a multi-site inhibitor, it is useful to intersperse such chemicals between treatments with mildew-specific fungicides (e.g. Dorado, Fungaflor) in order to reduce the risk of selecting fungicide resistant strains. However, due to the superior control achieved with other chemicals, it should not be the major component in spray programmes for control of powdery mildew.

Older, single-site fungicide mixture

Nimrod T (bupirimate + triforine) gave moderate control of mildew on solidago but was not as effective as some other treatments. It is reported, on the other crops, to have relatively short persistence of control though on some crops (e.g. cucumber) it is useful at halting development of established infections (i.e. as a curative treatment).

Newer, single-site (DMI) fungicides

The three DMI fungicides (Dorado, Alto 100 SL and Systhane 6W) all gave extremely good control of solidago powdery mildew. Dorado has a label recommendation for control of powdery mildew diseases on both outdoor and protected ornamentals (now valid until July 2002 (see Action Point 5). Alto is only permitted on outdoor crops, again at growers own risk. Systhane 6W is permitted on outdoor ornamental crops at growers own risk, whilst Systhane 20EW is permitted on protected ornamentals at growers own risk (extrapolation from SOLA 1881/99).

Newer, single-site (strobilurin) fungicides

The two strobilurin fungicides (Stroby and Flint) both gave excellent control with no obvious detrimental effects on the solidago varieties used. Stroby WG appeared to advance plant flowering, in the outdoor trial, but this was not confirmed in the glasshouse trial. Both products are permitted on outdoor crops only, and at growers own risk. Neither product is strongly systemic (they are described as being 'quasi-systemic') and they should be used as protectant treatments. The strobilurin group of fungicides are single-site inhibitors and there is a real risk than resistant powdery mildew strains could develop. This has recently happened with wheat powdery mildew on the Continent and in the UK, and with cucumber powdery mildew in Japan (Heaney *et al.,* 2000). In order to prevent this, the following guidelines, issued by the Fungicide Resistance Action Committee (FRAC) should be followed.

Avoiding resistance to strobilurin fungicides

The Fungicide Resistance Action Committee (FRAC) have issued the following guidelines to minimise the risk of resistance arising to Stroby, Flint and similar strobilurin fungicides:

1. Strobilurins should be used where possible as preventative treatments.
2. Strobilurins should be applied at the manufacturers' recommended rates.
3. Strobilurins should not constitute more than 30% to 50% of the total number of fungicide applications made to the crop in one season (strobilurin spray numbers should move to the lower limit when the total number of fungicide sprays made to the crop exceeds 8).
4. Strobilurins should be used in blocks of 1 to 3 consecutive applications.
5. Where blocks of 2 or 3 strobilurins are applied, they should be separated by a minimum of 2 applications of a fungicide from a different cross-resistance group.
6. For perennial crops or where crops are grown successively, alternation of programmes should continue between seasons and between crops respectively.
7. These recommendations apply to strobilurins used alone or in formulated or mixture with chemicals from other fungicide groups designed to increase the level or spectrum disease efficacy.

Newer, single-site (various groups) fungicides

The new fungicides Fortress (quinoxyfen) and Neon (spiroxamine) are both wax absorbed and reported to redistribute to new growth in the vapour phase. Extremely good and persistent control of cereal powdery mildew has been observed with these products. On solidago, both products gave good control of mildew though Neon proved phytotoxic and should not be considered for commercial use on this crop. The persistence of control with Fortress, and crop-safety on different varieties and under different conditions would require further investigation.

Experimental single-site (anilinopyrimidine) fungicide

The experimental fungicide mepanipyrim is known primarily for its good control of grey mould (*Botrytis cinerea)*. In these trials we have demonstrated that it also has good activity against solidago powdery mildew. Recently it has been reported to have good activity against cucumber and grapevine powdery mildews also.

The reason for mildew failing to develop on the glasshouse crop of solidago, cv. Tara, during August and September 2000 is puzzling. Possibly it is less susceptible to the disease than cv. Marvellous Gold.

In future work it is planned to devise spray programmes, based on the products which performed well in this work, and to test their effectiveness.

CONCLUSIONS

- A programme of five protectant fungicide sprays applied from soon after planting, or early re-growth, through to 13 days before harvest, can provide very good control of powdery mildew.

- There are several new, single-site fungicides which are suitable for use in an integrated programme for control of mildew on solidago

TECHNOLOGY TRANSFER

1. Presentation to growers by T M O'Neill at the HDC Cut Flower Walk, HRI Kirton, 21 September 2000.

2. Written summary of year 1 progress - Fungicide treatments for control of powdery mildew on cut flowers (BOF 44) - 21 September 2000.

3. Powdery mildew: an increasing problem. *HDC News* **68**, p 21.

ACKNOWLEDGEMENTS

We are grateful to Paul Harrison and family for hosting these trials, and to Dr Roger Cook, CSL York, for confirmation of the powdery mildew species.

REFERENCE

Heaney SP, Hall AA, Davies SA & Olaya G (2000). Resistance to fungicides in the QoI-STAR cross-resistance group: current perspectives. *Proceedings BCPC Conference, Pests and Diseases-2000*, **2**, 755-762.