Report prepared for the
Horticultural Development Council

Protected hybrid pinks-
Control of ring spot
1993-1996

(PC 87)

Final Report (August 1996)

Title:	Protected hybrid pinks - control of ring spot caused by *Mycosphaerella dianthi* (PC 87)
Project Leader:	Dr T M O'Neill ADAS Arthur Rickwood Mepal Ely Cambridgeshire, CB6 2BA
Site Manager:	D Lockley, ADAS Starcross
Project Co-ordinator:	J Whetman, Dawlish, Devon
Location:	Commercial nurseries, Cornwall
Start date:	September 1993
Completion:	August 1996
Key words:	hybrid pinks Dianthus ring spot *Mycosphaerella dianthi* fungicides

CONTENTS

APPLICATION

1994

Seven fungicides which provide control of ring spot on protected hybrid pinks were identified. Three triazole products were more effective than carbendazim + maneb (Kombat WDG), a current standard treatment used by growers. Difenoconazole was the most effective of the triazole fungicide It became available (as Plover 250) for use on winter wheat in July 1994. Growers can use Plover on outdoor hybrid pinks **at their own risk**; an off-label approval will be required before it can be used on protected crops. The addition of Actipron or Bond to Kombat WDG did not improve control of ring spot on flower buds. Fungicides which can be used on protected crops for control of ring spot, **at growers own risk**, are Bavistin DF, Octave, Bravo 500, Topas 100 and Folicur.

1995

Sprays of Plover 250 again gave very good control of ring spot in a crop of protected hybrid pinks. Treatment at a reduced rate (0.5 ml/litre) did not result in loss of disease control in a crop with moderate disease levels on untreated plants. Addition of Agral did not improve on an already high level of disease control. Three different programmes of fungicides which provided good disease control and have potential to reduce the risk of selecting fungicide-resistant strains of ring spot were developed.

1996

Programmes consisting of two sprays of Plover 250 at 1.0 ml/litre applied between September 1995 and March 1996 gave control of ring spot. Treatment in October and December was most effective in reducing leaf infection and only slightly inferior to a programme of seven sprays applied at monthly intervals. Spray application just before flower stem elongation gave the best control of bud infection. An application for an off-label approval for use of Plover 250 EC on protected hybrid pinks has been submitted to the Pesticides Safety Directorate.

SUMMARY OF RESULTS

1994

Seven fungicides (Bavistin DF, Bravo, Folicur, Kombat, Octave, Topas and an experimental product (containing difenoconazole) were applied at 14 day intervals from September 1993 to February 1994 to a crop of protected hybrid pinks, cv. Doris. All treatments resulted in significant reductions in the occurrence of ring spot (*Mycosphaerella dianthi*) on flower buds and leaves. Difenoconazole was most effective and after application of 10 high volume sprays, only 2% of flower buds were affected compared to 100 % buds on untreated plants; the leaf area affected was reduced from 14.3% to 0.1%. Difenoconazole had no effect on flower stem length. Addition of Actipron or Bond to Kombat WDG improved control of ring spot on leaves but not on flower buds. Actipron appeared to remove leaf wax, resulting in a darker leaf colour. Control of ring spot on leaves, but not on flower buds, was still apparent 15 weeks after the final spray treatments were applied.

1995

The effect of spray interval, fungicide rate, and an adjuvant on control of ring spot in a crop of protected hybrid pinks, cv. Rose Monica Wyatt, were investigated from September 1994 to March 1995. The disease remained at a relatively low incidence for most of the period but increased rapidly during February and March, affecting 23 % of leaf area and 75 % of flower buds on untreated plants at the final assessment on 29 March 1995. All treatments resulted in significant reductions in the severity of ring spot. Plover 250 was more effective than Kombat WDG, confirming the results of last year. When Plover was applied at 14 day intervals (10 sprays in total), a high level of control was still evident 7 weeks after the final spray. The efficacy of Plover was not reduced when the application rate was reduced from 1.0 to 0.5 ml product/litre. Treatment at an extended spray interval (28 days) resulted in effective control of ring spot on leaves but persistence of control on flower buds was less effective than with treatment at 14 day intervals. Addition of Agral did not improve the already high level of disease control achieved with Plover. Three alternating programmes, each of two different products, all gave good disease control. None of the treatments reduced flower stem length.

1996

The effect of spray timing on control of ring spot was investigated in a crop of protected hybrid pinks, cvs. Doris, Joy, Monica Wyatt and Rose Monica Wyatt, from September 1995 to April 1996. Although this was the first crop of hybrid pinks grown on the nursery for several years, natural infection by ring spot occurred in December 1995 and increased to affect over 10% leaf area on untreated plants by mid-March. Programmes consisting of two sprays of Plover 250 applied at 1.0 ml/litre between September and March were evaluated. All programmes reduced infection with the October/December programme most effective (3.3% leaf area affected) and only slightly inferior to a programme consisting of seven sprays of Plover applied at monthly intervals (2.5% leaf area affected). Two-spray programmes where the first Plover spray was applied before the appearance of ring spot appeared to be more effective than programmes where the first spray coincided with the appearance of ring spot. The incidence of flower bud infection, assessed in April, was reduced by all treatments. A December/March two-spray programme reduced flower bud infection from 65% to 28%; a

seven-spray programme reduced it to 13%. An alternating programme of Plover and Kombat WDG at monthly intervals (7 sprays in total) resulted in control similar to that of the best 2 - spray programmes of Plover. No adverse effect on plant growth or flower stem height was observed.

ACTION POINTS FOR GROWERS

1. Consider using a triazole fungicide (e.g. Plover) as part of a fungicide programme for control of ring spot on outdoor hybrid pinks. Use of such fungicides is at **grower's own risk**. Use on crops under protection is not permitted at present. An application for a specific off-label approval to permit use of Plover under protection has been made.

2. In a crop with moderate disease levels, Plover applied at 0.5 ml/litre at 14 day intervals was as effective as application at 1.0 ml/litre at 14 day intervals.

3. Treatment with Plover at 28 day intervals gave effective control of ring spot on leaves in 1995 but this extended spray interval was less effective in 1996. Disease control on flower buds was reduced compared with application at 14 day intervals.

4. Carbendazim + mancozeb appears to be better than Bavistin DF, Bravo or Octave for control of ring spot on protected hybrid pinks. Kombat WDG is not recommended on any protected crops although the two active ingredients (carbendazim and mancozeb) may be applied separately. Clarification is required as to whether or not use of Kombat WDG is permitted on protected crops of hybrid pinks, at growers own risk.

5. Whilst the use of Actipron appeared to improve control of ring spot on leaves, there was no improvement in control of the disease on flower buds.

6. Plover alone gave very good control of ring spot and no improvement was detected when Agral was added.

7. A spray programme of Plover alternating with Kombat WDG every 14 days gave good disease control; this programme is recommended for outdoor crops; it should both prove effective and prevent or delay the selection of fungicide-resistant strains of *M. dianthi.*

8. A spray programme of Plover alternating with Kombat WDG every 28 days gave moderate control of both leaf and flower bud infection.

9. A comparison of two-spray programmes of Plover at different timings in 1995/96 revealed that an October/December programme gave best control of leaf infection and a December/March programme gave best control of flower bud infection. These results indicate that optimum timing for control of leaf infection is before symptoms appear; and the optimum timing for control of flower bud infection is just before stem elongation.

INTRODUCTION

Ring spot, caused by the fungus *Mycosphaerella dianthi,* can be a serious disease of hybrid pinks, carnations and sweet williams, resulting in dark-coloured ring spots on leaves, stems and flower buds. Affected flower stems are usually unmarketable. The disease on hybrid pinks is generally most common during winter as it is favoured by prolonged leaf wetness. It is found most frequently in crops grown outdoors or in unheated polythene tunnels in south-west England. The popular varieties Doris and Monica are particularly susceptible. There are no fungicides with a label recommendation for control of ring spot and products currently used by growers appear to provide only partial control. The waxy nature of the leaves of hybrid pinks makes them difficult to wet and Actipron or other wetters are often added to try and improve spray cover and disease control.

The objectives of the work described here were to evaluate fungicides for control of ring spot and to devise a spray programme which provides effective control of the disease. Detailed objectives were:

1. To compare the effectiveness of fungicides currently used for control of ring spot, potentially useful alternative products and some new broad-spectrum arable crop fungicides.

2. To monitor the effect of fungicide treatment on crop growth, especially flower stem length.

3. To evaluate the effect of some stickers and wetters, when used with a current standard fungicide (Kombat) or a new fungicide (Plover) on disease control and crop growth.

4. To investigate the effectiveness of two-spray programmes of Plover applied at different timings.

MATERIALS AND METHODS

Location

Commercial nurseries in Cornwall.

Crop and site details

1994

The experiment was located in a crop of cv. Doris in an unheated polythene tunnel. The soil was treated with Basamid in November 1992 after removal of the previous crop (chrysanthemums). Hybrid pinks were planted on 4 March 1993 in beds at 30 x 25 cm spacing with 6 rows to a bed. The soil was Denbigh series with pH 6.6, P - 66 mg/l (index 4), K - 100 mg/l (index 1), Mg - 75 mg/l (index 2), NO_3 - 34 mg/l (index 1) and conductivity 2140 µs (index 0) at planting.

1995

The experiment was located at the same site, in a crop of cv. Rose Monica Wyatt in an unheated polythene tunnel. Hybrid pinks were planted in early April 1994, through black polythene. The soil had been treated with Basamid before planting. A low incidence of ring spot and stub rot (*Fusarium culmorum*) were evident when the experiment was established in September 1994.

1996

The experiment was located in a crop of cvs. Doris, Joy, Monica Wyatt and Rose Monica Wyatt in an unheated polythene tunnel. Hybrid pinks were planted in August 1995. This was the first crop of hybrid pinks grown on the nursery for three years; ring spot had been a severe problem when the crop was last grown on the site. No ring spot was evident on plants when the first treatments were applied in September 1995. The previous crop was freesias. The soil was a silty-clay loam, pH 7.6, P-37 mg/l (Index 3), K-114 mg/l (Index 1), Mg-77 mg/l (Index 2), conductivity 2080 µs and organic matter 7.8%.

Treatments

1994

The following fungicides were applied on 10 occasions at approximately 14 days intervals.

	Product	Active ingredient	Rate of use (product)
1.	Control (untreated)	-	
2.	Bavistin DF	50 % carbendazim	1.0 g/l
3.	Kombat WDG	12.4 % carbendazim + 63.3 % mancozeb	2.25 g/l
4.	Octave	50 % prochloraz Mn	1.0 g/l
5.	Bravo 500	50 % chlorothalonil	2.2 ml/l
6.	Topas 100 EC	10 % penconazole	1.0 ml/l
7.	Folicur	250 g/l tebuconazole	0.4 ml/l*
8.	Experimental (CGA 169374)	250 g/l difenoconazole	1.0 ml/l
9.	Kombat WDG + Actipron	-	2.25 g/l + 1 ml/l
10.	Kombat WDG + Bond	-	2.25 g/l + 1 ml/l
11.	Full disease control programme (Kombat + Actipron alternating with Octave; Folicur if rust appears	-	

Sprays were applied by Oxford Precision sprayer at 1500 l/ha and 250 kPa pressure using medium quality spray nozzles (Lurmark - 04 - F80).

*Increased to 1.0 ml/l for sprays 5 - 10.

1995

	Product	Rate of use	Spray interval (days)
1.	Untreated	-	-
2.	Kombat WDG	2.25 g/l	14
3.	Plover 250	1.0 ml/l	14
4.	Plover	0.5 ml/l	14
5.	Kombat WDG	2.25 g/l	28
6.	Plover	1.0 ml/l	28
7.	Plover	0.5 ml/l	28
8.	Plover + Agral	1.0 ml/l + 0.3 ml/l	14
9.	Plover + Agral	0.5 ml/l + 0.3 ml/l	14
10.	Plover alternating with Kombat	1.0 ml/l and 2.25 g/l	14
11.	Plover alternating with Kombat	1.0 ml/l and 2.25 g/l	28
12.	Plover alternating with Folicur	1.0 ml/l and 1.0 ml/l	28

1996

	Product	Time of application						
		Sept	Oct	Nov	Dec	Jan	Feb	Mar
1.	Untreated	-	-	-	-	-	-	-
2.	Plover	✓	-	-	✓	-	-	-
3.	Plover	-	✓	-	✓	-	-	-
4.	Plover	-	-	✓	✓	-	-	-
5.	Plover	-	-	-	✓	✓	-	-
7.	Plover	-	-	-	✓	-	-	✓
8.	Plover (F)	✓	-	✓	-	✓	-	✓
9.	Plover (H)	✓	-	✓	-	✓	-	✓
10.	Plover	✓	✓	✓	✓	✓	✓	✓
11.	Plover/Kombat	Plo	Kom	Plo	Kom	Plo	Kom	Plo
12.	Managed risk	Plo/Bav	Kom	_	Plo	Plo	Plo	Plo

Plover was applied at 1.0 ml/litre, except for treatment 9 (0.5 ml/litre). Treatment 12 was a managed disease programme, with product choice decided according to disease occurrence. Kombat WDG was applied at 2.25 g/l; Bavistin DF at 1.5 g/litre

Experimental design

The experiments were all of a randomised block design with four replicates. Plot size was 2 m x 1 m (2 m^2) and in 1993/94, 1.3 m x 1.2 m (1.6 ^{2}) in 1994/95 and 2m x 1m (blocks I and II) and 1m x 1m (blocks III and IV) in 1995/96. A 1 m length of crop at the end of each bed, adjacent to the tunnel doors, was excluded from the experimental area in all experiments.

Assessments

The number of terminal flower buds affected by ring spot was determined, selecting 25 buds at random for assessment and excluding buds within 20 cm of the plot edge. The leaf area affected by ring spot was assessed on a whole plot basis. Flower stem length was measured 15 weeks (1994) or 3 weeks (1995) after the final treatment on 25 stems/plot in two replicate blocks (1994) or 10 stems/plot in all four replicates (1995), selecting buds with colour just showing.

Statistical analysis

Results were analysed by analysis of variance.

Crop diary

Dates of application of fungicide treatments	Dates of assessments
1993/94	**1993/94**
14 September	12 October
29 September	26 October
12 October	9 November
26 October	24 November
9 November	6 December
24 November	2 February
7 December	3 May
21 December	
4 January	
19 January	
1994/95	**1994/95**
29 September	29 September
13 October	30 November
27 October	1 February
10 November	21 February
24 November	29 March
8 December	
24 December	
5 January	
19 January	
1 February	
1995/96	
28 September	28 December
1 November	26 January
30 November	14 March
28 December	10 April
31 January	
28 February	
28 March	

RESULTS

1993/94

A low level of ring spot (less than 1% leaf area affected and occasional buds affected) was evident when treatment commenced. No rust was found. On untreated plants the incidence of buds affected by ring spot increased steadily between September 1993 and January 1994. The disease remained at a very low level on leaves until January 1994. The effect of fungicide treatment on the occurrence of flower bud symptoms and leaf area affected is shown in Figs 1-2 and full results are given in Table 1.

At the first disease assessment, when two sprays of each treatment had been applied, the incidence of affected buds was significantly reduced by all treatments, with the experimental product most effective. Addition of Actipron or Bond to Kombat did not significantly improve disease control on flower buds.

Two weeks after the tenth and final spray had been applied, all flower buds in untreated plots were affected by ring spot. There were very high levels of ring spot (more than 75% buds affected) in all other treatments apart from the Experimental fungicide (2% affected), Folicur (35%) and Topas (49%). Fifteen weeks after the final sprays had been applied, when a new flush of flowers had developed, there was a relatively low incidence of ring spot on flower buds and no significant differences between treatments. Lesions at this time were all very small. The severity of ring spot on leaves was significantly reduced by difenoconazole, Folicur, Topas and Kombat + Actipron (Fig. 2). The addition of Actipron to Kombat improved control of ring spot on leaves.

None of the fungicides had a visible effect on stem length at any time during the experiment and four weeks after final spray no significant effects were found following treatment with difenoconazole, Topas, Folicur or Kombat (Fig. 3). The use of Actipron resulted in plants appearing a darker green, apparently due to loss of leaf bloom; this effect was visible after two sprays had been applied and become more evident with increasing number of sprays.

1994/95

A low level of ring spot (less than 1 % leaf area affected and occasional buds affected) was present when treatments commenced on 29 September. A low level of stub rot (*Fusarium culmorum*) was also present and this did not increase during the experiment. On untreated plants, the incidence of ring spot remained at a low level until February 1995. During February and March the disease increased rapidly, affecting 23 % leaf area and 75 % of flower buds at the final assessment (Fig 4). In contrast to the previous year, the incidence of affected flower buds was relatively low for most of the season. The effect of Kombat and Plover at full rate and at 14 and 28 day spray intervals on the development of ring spot on leaves with time is shown in Fig 5; full results are given in Table 3.

At the disease assessment on 21 February, three weeks after the final spray, and again on 29 March, seven weeks after the final spray, the severity of ring spot was reduced by all treatments. All treatments with Plover were more effective than Kombat. A comparison of products at spray intervals of 14 and 28 days, and using Plover at full and half rates, is shown

in Figs 5 and 6. Extending the spray interval for both Kombat and Plover from 14 to 28 days had little effect on the incidence of ring spot on leaves (Fig 5), but extending the spray interval to 28 days resulted in reduced control of flower bud infection at the final assessment (Fig 8). There was no significant decline in disease control using Plover at half rate (0.5 ml/l) on a 14 day spray programme, but control was consistently less than that achieved at the full rate (1.0 ml/l) on a 28 day spray programme (Table 3).

The effect of Agral on the efficacy of Plover is shown in Fig 6. Plover was very effective in the absence of Agral and no improvement was discernible on addition of Agral.

The efficacy of three different spray programmes of two products used in alternation is shown in Fig 7. All three programmes were very effective.

The effect of treatments on flower bud infection is shown in Fig 8. All of the treatments reduced infection, with Plover more effective than Kombat. Full results are given in the Table 3.

None of the treatments had a visible effect on stem length at any time during the experiment and three weeks after the final spray no significant differences were found when stem length was measured (Fig 9 and Table 4). The addition of Agral to Plover did not affect leaf colour.

1995/96

No ring spot or other disease was evident when treatments commenced on 28 September. Ring spot was first observed on 28 December (0.9% leaf area on untreated plants) and then increased steadily to affect 10.5% leaf area by 14 March. The mean leaf area affected by ring spot then declined slightly as healthy new leaves grew. Disease progress in shown in Fig 10. A flush of flowers developed in April and a high incidence of bud infection was recorded on untreated plants.

The effect of fungicide treatments on the severity of leaf infection on 14 March, two weeks after the final treatment, is shown in Fig 11 and full results are given in Table 5. The most effective of the two-spray Plover programmes was the October/December timing, which reduced disease to 3.3% leaf area affected. This timing was only slightly inferior to the programme of seven sprays applied at monthly intervals from September to March (2.5% leaf area affected). Spray programmes which commenced in December, shortly after the occurrence of ring spot on plants, appeared slightly less effective than those commencing in October or November (Fig 11) before ring spot was evident. An alternating programme of Plover (4 sprays) and Kombat (3 sprays) applied at monthly intervals gave good control.

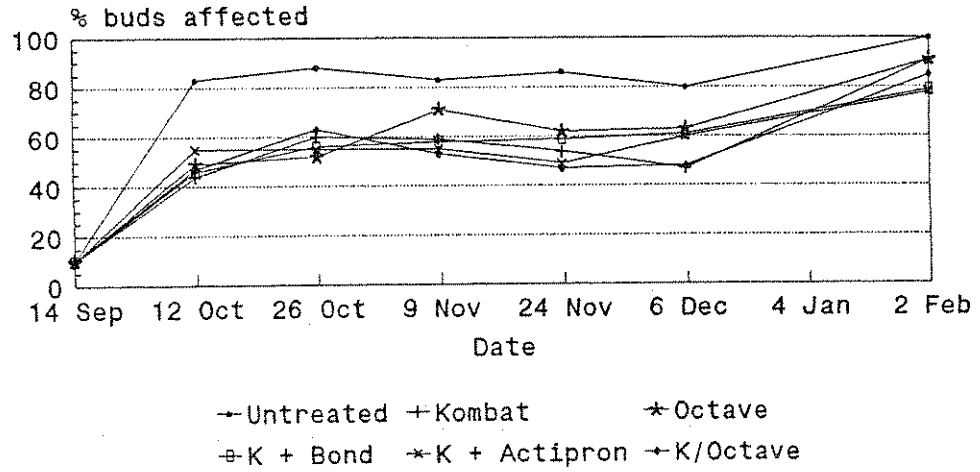
The incidence of flower bud infection on 10 April (Fig. 12) was reduced by all fungicide treatments. A December/March two-spray programme of Plover reduced the incidence of affected buds from 65% to 28%; a seven-spray programme of Plover reduced it to 13%. Interestingly, the efficacy of two-spray programmes in controlling flower bud infections increased as the timing of the second spray was delayed from December to March.

Key to abbreviations used in figures (overleaf)

Kom -Kombat
Plo -Plover
Fol -Folicur
Ag -Agral

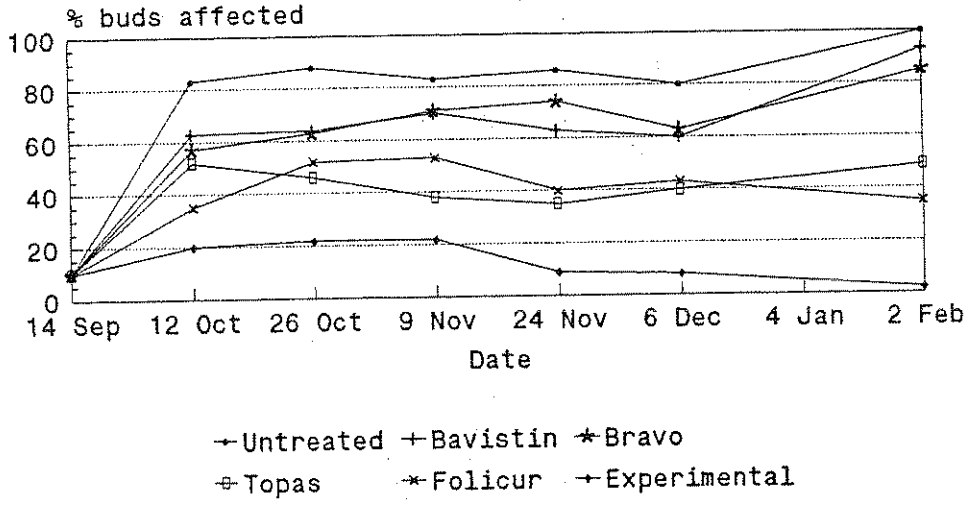
F -Full rate
H -Half rate

Fig 1a. Control of ring spot on flower buds - 1994



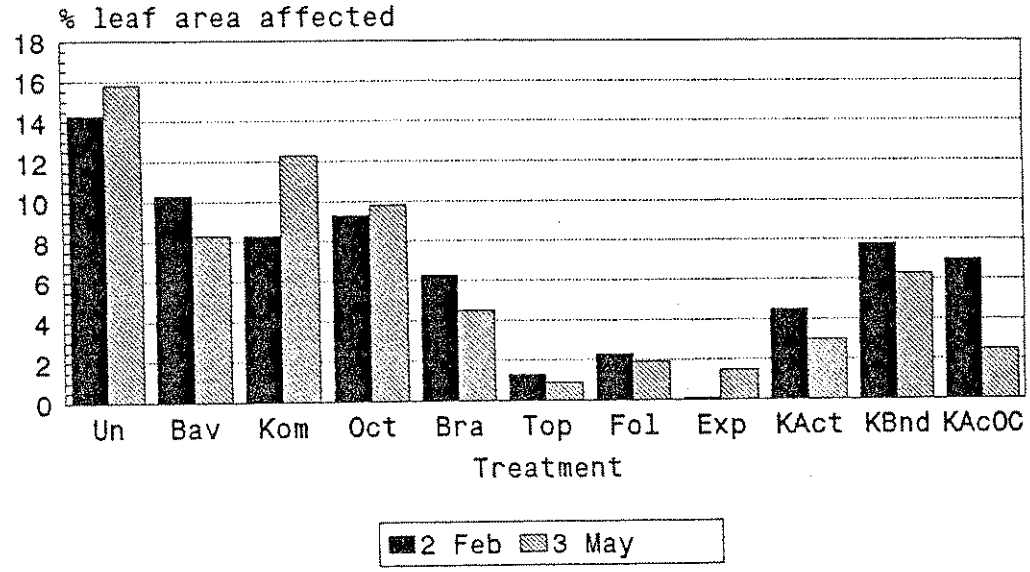
Pink2a

Fig 1b. Control of ring spot on flower buds - 1994



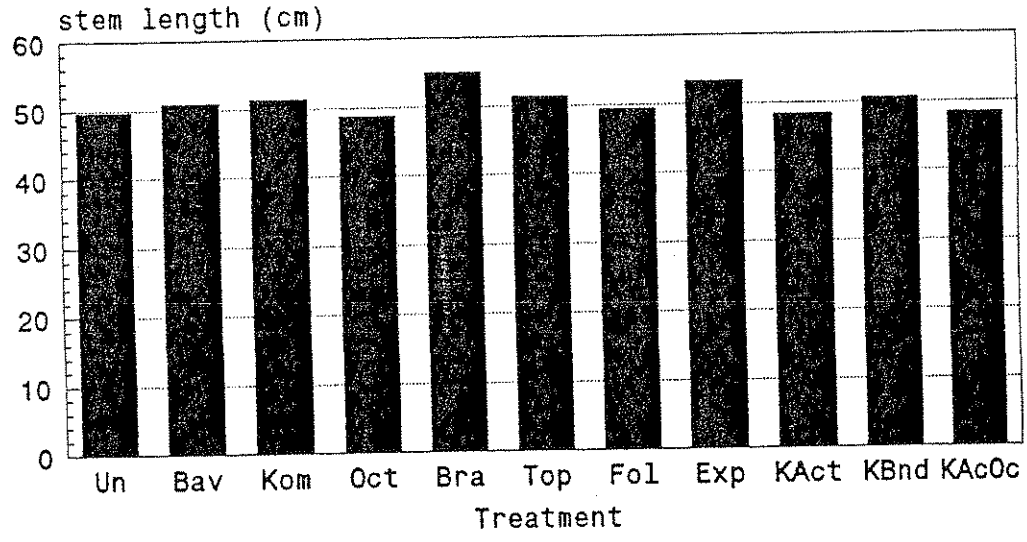
Pink3a

Fig 2. Control of ring spot on leaves - 1994



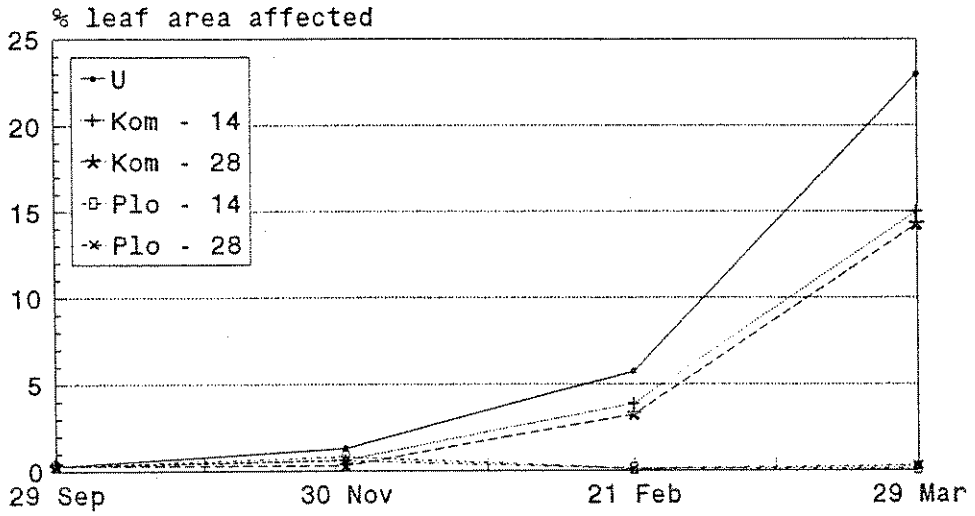
Pink2

Fig 3. Effect of fungicides on flower stem length - 1994



Pink3

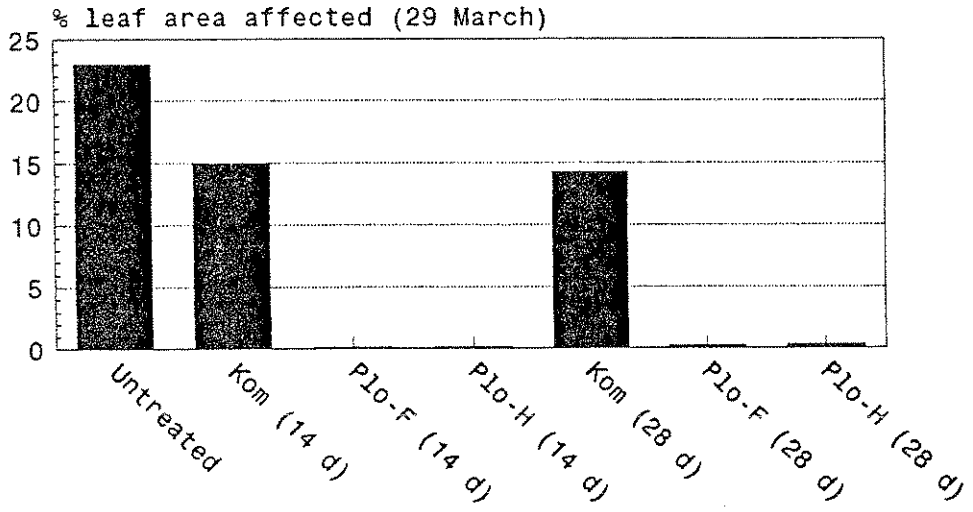
Fig 4. Development of ring spot - 1995



rs4

Fig 5. Effect of fungicides on ring spot - 1995

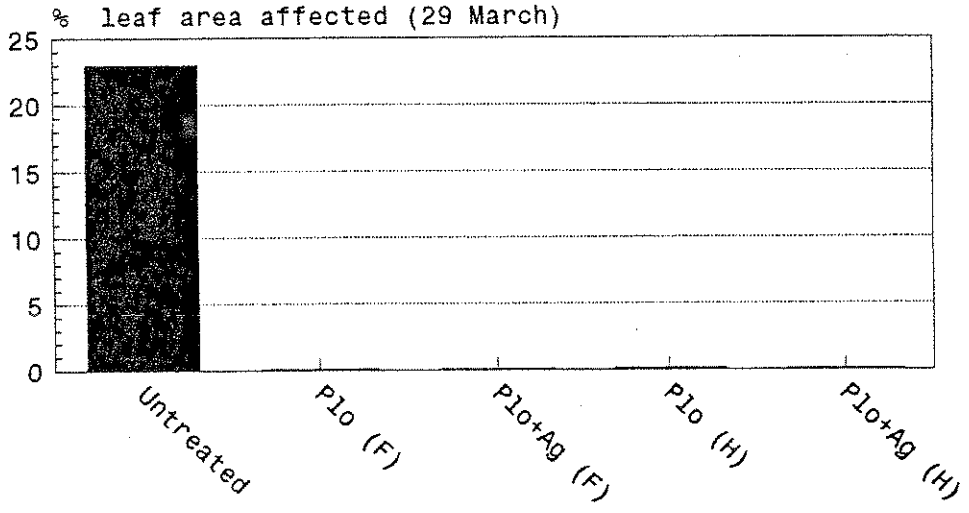
Comparison of products and spray interval



rs5

Fig 6. Effect of fungicides on ring spot - 1995

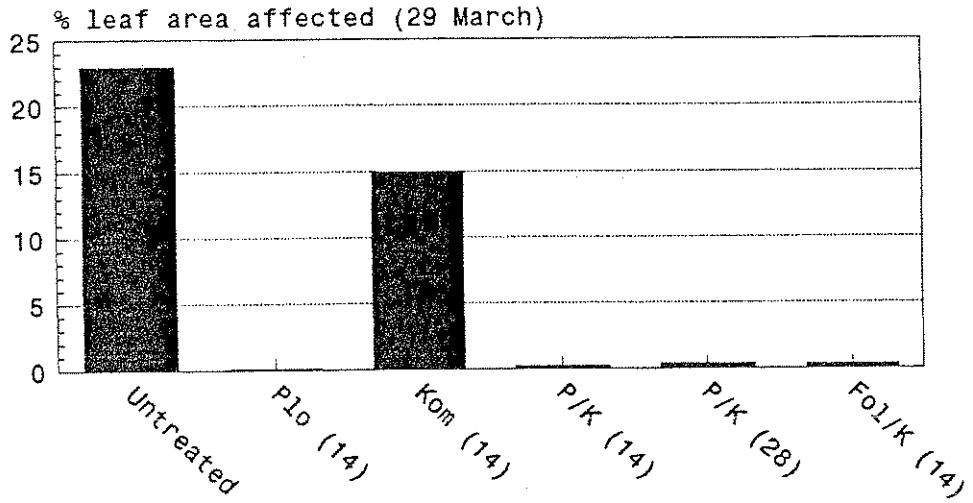
Effect of Agral



rs6

Fig 7. Effect of fungicides on ring spot - 1995

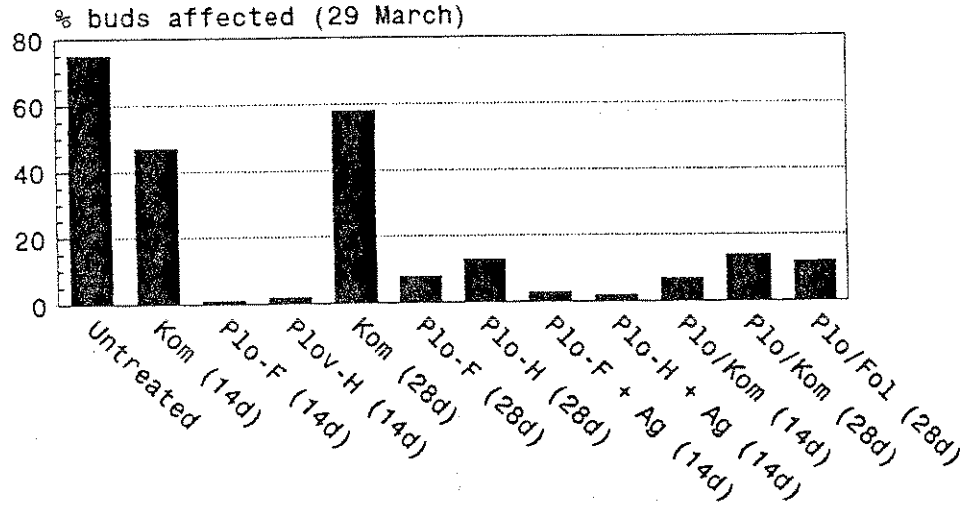
Spray programmes



rs7

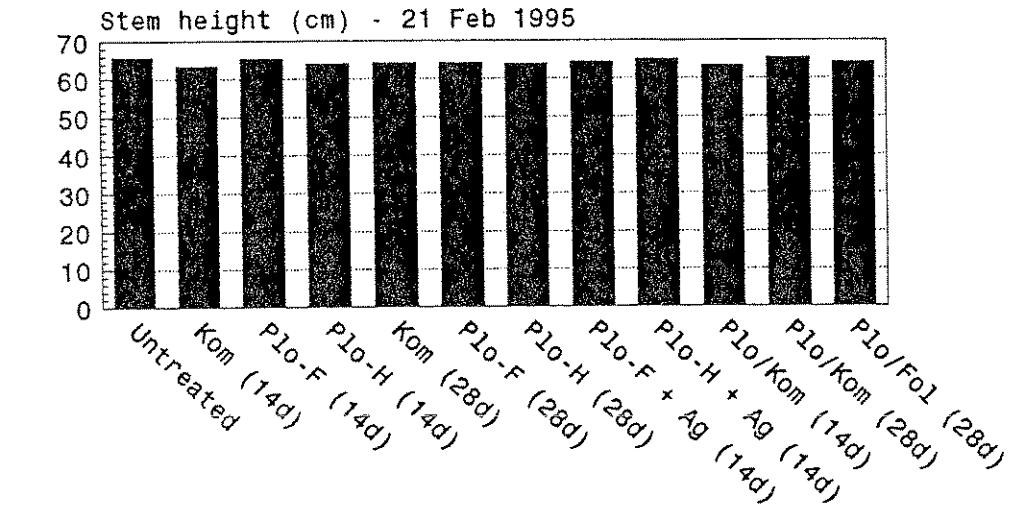
Fig.8 Effect of fungicides on ring spot - 1995

Bud infection



rs8

Fig. 9 Effect of fungicides on plant growth



rs9

Fig 10a. Development of ring spot in hybrid pinks - 1995/96

Two-spray programmes

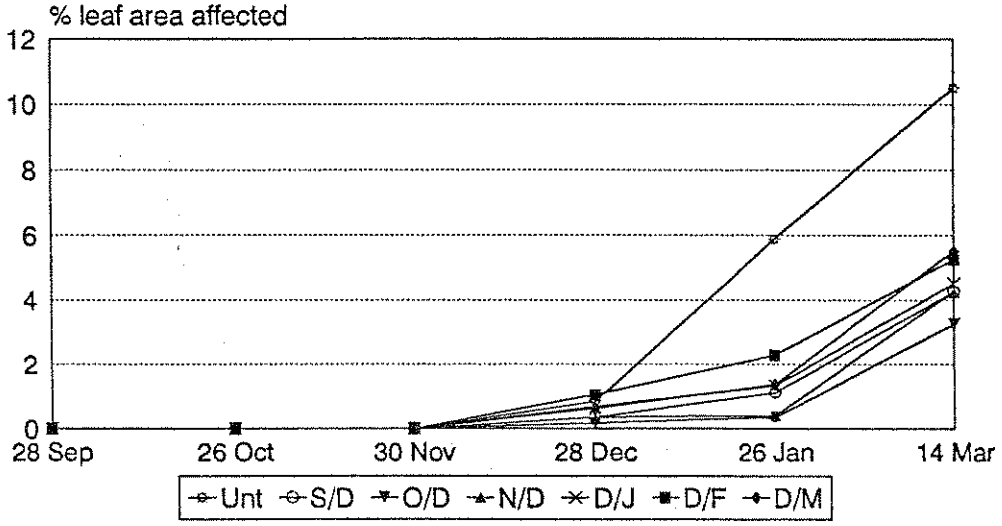


Fig 10b. Development of ring spot in hybrid pinks - 1995/96

Multi-spray programmes

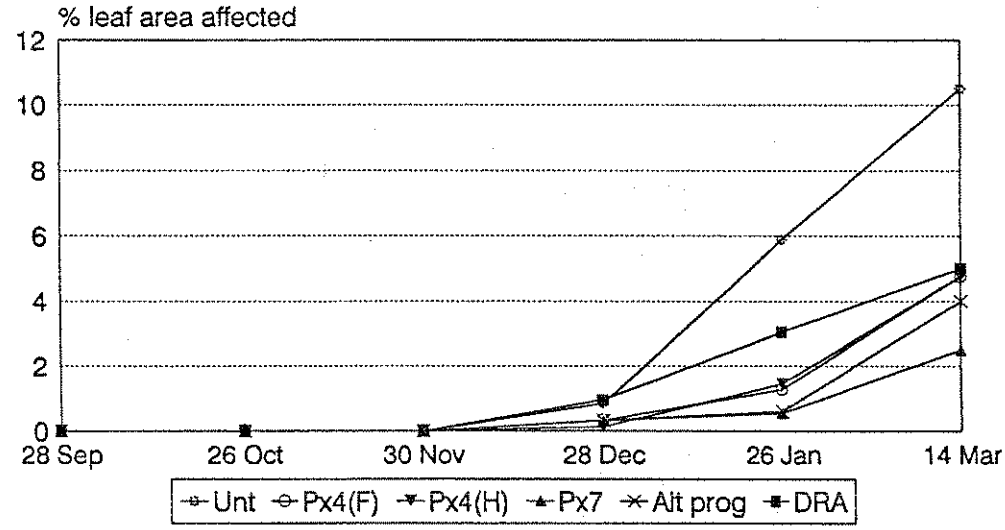


Fig 11. Control of ring spot on leaves of protected hybrid pinks-14 March 1996

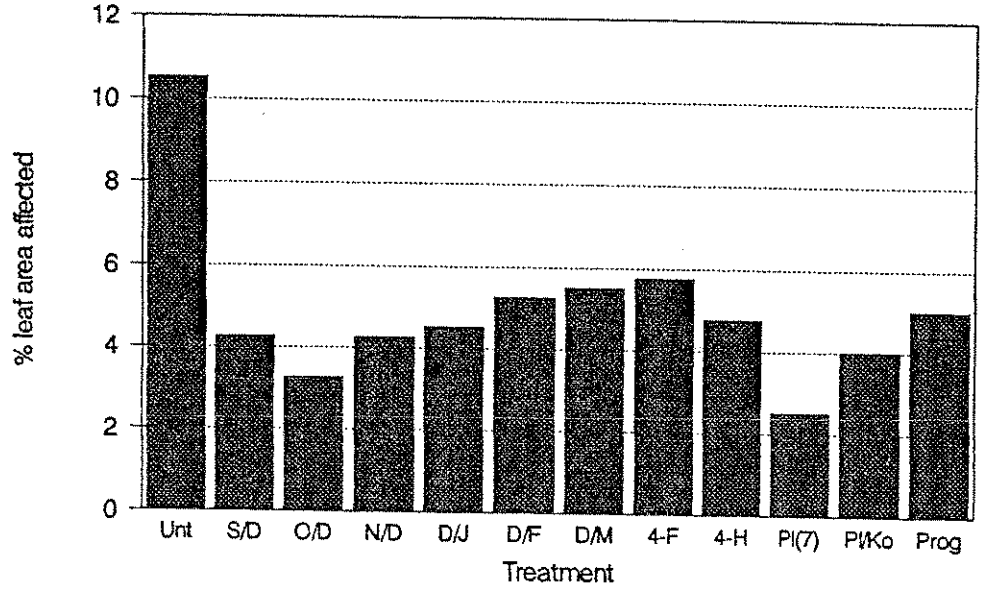
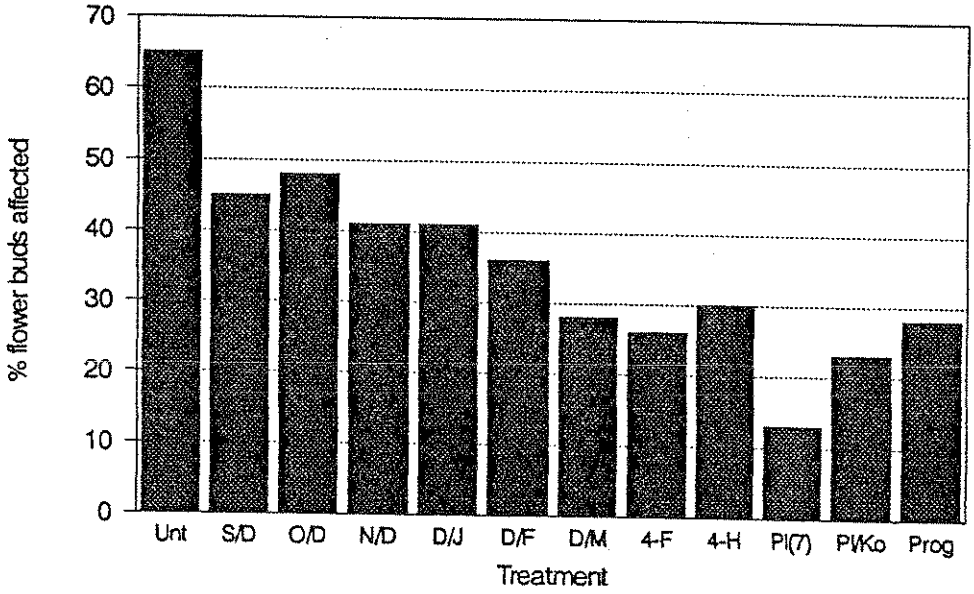


Fig 12. Control of ring spot on flower buds of protected hybrid pinks-10 April 1996



DISCUSSION

1993/94

This experiment identified difenoconazole as a very effective fungicide for control of ring spot on hybrid pinks with no detrimental effect on plant growth. It offers significant improvement over the control achieved with Kombat, Bavistin DF or Bravo. Further work is planned to confirm these results and to investigate how effective it is at a lower rate (0.5 ml/l) and at a more extended spraying interval (28 days).

Folicur and Topas also gave better control of ring spot than Kombat, Bavistin or Bravo. However, as difenoconazole, Folicur and Topas are all in the same fungicide group (triazoles), and none of them is currently permitted for use on protected crops, it would seem sensible to pursue development of the most effective product (i.e. difenoconazole).

Previous studies on the control of ring spot on carnation indicated that Actipron alone inhibits spore germination of *Mycosphaerella dianthi* and its use at 0.5% improved control of Delsene M (carbendazim + maneb) (N. Nathaniels, pers. comm.). In the experiment reported here, Actipron added to Kombat did not improve the control of ring spot on flower stems, but it did improve control of the disease on leaves. The addition of Bond to Kombat did not improve disease control on either stems or leaves.

1994/95

This experiment confirmed difenoconazole as a very effective treatment for control of ring spot with no detrimental effect on plant growth. In a crop with relatively low disease pressure, treatment at 0.5 ml/litre at 14 day intervals gave acceptable control of both leaf and flower bud symptoms. Seven weeks after the final spray, the leaf area affected by ring spot was still less than 0.5 % in all plots treated with Plover, compared to 23 % area affected in untreated plots. A programme of Plover alternating with Kombat every 28 days (3 sprays of Plover and 2 of Kombat in total) was only slightly less effective in controlling leaf symptoms than Plover applied every 14 days (10 sprays in total), although control of flower bud symptoms was less persistent. The former programme has the advantage of minimising fungicide treatment costs, reduces the risk of ring spot developing resistance to Plover and provides some protection against stub rot, leaf rot *(Heteropatella valtellinensis)* and rust (*Uromyces dianthi*).

Because of the very effective control provided by Plover, even at a reduced rate in this experiment, no information was gained on the possible benefit of adding the adjuvant Agral to the spray. It is suggested that the effect of Agral on the efficacy on less effective fungicides is investigated.

It is interesting that the development of ring spot in the two experiments differed. In 1993/94 on cv. Doris, infection was predominantly on flower buds and relatively little disease occurred on the leaves; in 1994/95 on cv. Rose Monica Wyatt the reverse was true; for most of the season infection developed on leaves with very little evident on flower buds.

1995/96

This experiment indicated that two sprays of Plover at 1.0 ml/litre applied over the winter period (September-March) resulted in approximately a 50% reduction in leaf area affected by ring spot. There was relatively little difference in programme efficacy according to timing, although the results suggest slightly better control of leaf infection when the first spray was applied before symptoms appeared. The best control of flower bud symptoms was achieved when the second spray was applied in March, just before flower stem elongation; earlier treatments were less effective.

A programme of seven sprays of Plover (1.0 ml/litre) applied at monthly intervals from September to March reduced leaf area affected from 10.5% to 2.5% (14 March) and the incidence of flower buds affected from 65% to 13% (10 April). This was slightly better than an alternating programme of Plover (1.9 ml/litre) and Kombat WDG (2.25 g/litre), applied at monthly intervals, where leaf and bud infection was 4% and 23% respectively, at the same assessment date. The latter programme is to be preferred in that it carries a lower risk of selecting fungicide-resistant strains of *M. dianthi*.

In the experiment in 1994/95, a programme of five sprays of Plover (1.0 ml/litre) applied at monthly intervals from September to January reduced leaf area affected from 23% (untreated plants) to 0.3%, and the incidence of flower buds affected from 75% to 8%. The degree of control of leaf infection achieved with Plover applied at monthly intervals was thus better than that in the current experiment, whereas the degree of control of flower bud infection was similar. Application of Plover at 14 day intervals in 1994/95 reduced leaf area affected to 0.1% and the incidence of flower bud infection to 1.0%. These results indicate that a shorter spray interval (eg 14 days) is required in order to contain ring spot to very low levels, when the environment is favourable to disease development.

CONCLUSIONS

1993/94

1. In an unheated protected crop of hybrid pinks, cv. Doris, a high incidence of flower buds developed ring spot symptoms; the disease was less common on leaves.

2. Seven fungicides (Bavistin DF, Bravo, Folicur, Kombat, Octave, Topas and difenoconazole) were identified which at the rates and frequency used, gave good control of ring spot.

3. None of the treatments affected flower stem length.

4. Addition of Actipron or Bond to Kombat improved control of ring spot on leaves but not on flower buds.

5. Actipron appeared to remove leaf wax resulting in a darker leaf colour.

1994/95

1. In an unheated protected crop of hybrid pinks, cv. Rose Monica Wyatt, a moderate level of ring spot developed on leaves; symptoms on flower buds were generally less common.

2. Plover (difenoconazole) was more effective than Kombat in controlling both leaf and flower bud symptoms.

3. The efficacy of Plover was not reduced when the application rate was reduced from 1.0 to 0.5 ml/l.

4. The efficacy of Plover was reduced when the spray interval was extended from 14 to 28 days; a reduction in persistence of control on flower buds was most obvious.

5. Addition of Agral to Plover did not improve an already high level of disease control.

6. Alternating programmes of Plover with Kombat and Plover with Folicur gave good disease control.

1995/96

1. In an unheated protected crop of hybrid pinks, cvs. Doris, Joy, Monica Wyatt and Rose Monica Wyatt, a moderate level of ring spot developed on leaves and flowers buds of all four varieties.

2. Two-spray programme of Plover with the first spray applied in December and the second between September and March, controlled both leaf and flower bud symptoms. The two-spray programmes were only slightly inferior to a seven-spray programme of Plover applied monthly.

3. An October and December programme of Plover was the best two-spray timing for control of leaf symptoms; a December and March programme was the best two-spray timing for control of bud symptoms.

4. A four-spray programme of Plover (September, November, January and March) was less effective in controlling ring spot on leaves than a seven-spray monthly programme using the same product and no better than any of the two-spray programme.

5. A four-spray programme of Plover (September, November, January and March) gave control of flower bud infection similar to that of the best two-spray programme (December and March). The March timing was probably critical for good control of flower bud symptoms.

6. An alternating programme of Plover with Kombat WDG (7 sprays in total) gave good control of leaf and flower bud infection.

ACKNOWLEDGEMENTS

The help and co-operation of the growers who provided the sites for this work are gratefully acknowledged. We also thank John Whetman, project co-ordinator, for helpful discussion throughout the project.

Table 1. Effect of fungicides on ring spot (*Mycosphaerella dianthi*) on hybrid pinks-1993/94

Treatment		% flower buds affected							% leaf area affected	
		12 Oct	26 Oct	9 Nov	24 Nov	6 Dec	2 Feb	3 May	2 Feb	3 May
1.	Untreated	83	88	83	86	80	100	27	14.3	15.8
2.	Bavistin DF	63	64	70	63	60	93	17	10.3	8.3
3.	Kombat	44	60	59	54	47	91	21	8.3	12.3
4.	Octave	49	52	71	62	63	91	26	9.3	9.8
5.	Bravo	57	63	71	74	63	85	16	6.3	4.5
6.	Topas	52	46	38	35	40	49	16	1.3	0.9
7.	Folicur	35	52	53	40	43	35	22	2.3	1.9
8.	Experimental	20	22	22	9	8	2	17	0.1	1.5
9.	Kombat + Actipron	55	55	55	49	60	78	23	4.5	3.0
10.	Kombat + Bond	46	56	58	59	61	79	23	7.8	6.3
11.	Programme	47	63	53	47	48	85	25	7.0	2.5
	Significance	***	***	***	***	***	***	NS	***	***
	SED (30 d.f.)	7.18	9.14	9.17	10.43	9.91	6.76	2.02	1.49	2.46

*** - significant at P = 0.001 ; NS - not significant

Table 2. Effect of fungicides on flower stem length - 3 May 1994

Treatment		Mean stem length (cm)
1.	Untreated	49.7
2.	Bavistin DF	50.9
3.	Kombat	51.4
4.	Octave	48.8
5.	Bravo	55.0
6.	Topas	51.4
7.	Folicur	49.4
8.	Experimental	53.3
9.	Kombat + Actipron	48.4
10.	Kombat + Bond	50.6
11.	Programme	48.4
	Significance	NS
	SED (9 d.f.)	2.16

NS - not significant

Table 3. Effect of fungicides on ring spot-1994/95

Treatment	% leaf area affected			% flower buds affected	
	30 Nov	21 Feb	29 Mar	21 Feb	29 Mar
1. Untreated	1.3	5.8	23.0	18.2	75.0
2. Kombat (14 d)	0.6	3.9	15.0	13.0	47.0
3. Plover-F (14 d)	0.8	<0.1	0.1	0.0	1.0
4. Plover-H (14 d)	0.7	0.3	0.2	1.7	2.0
5. Kombat (28 d)	0.3	3.3	14.3	12.5	58.0
6. Plover-F (28 d)	0.6	0.1	0.3	0.0	8.0
7. Plover-H (28 d)	0.9	0.5	0.3	2.5	13.0
8. Plover-F + Agral (14 d)	0.3	<0.1	0.1	0.0	3.0
9. Plover-H + Agral (14 d)	0.8	0.2	0.1	8.2	2.0
10. Plover/Kombat (14 d)	0.8	0.3	0.2	5.0	7.0
11. Plover/Kombat (28 d)	0.4	0.6	0.4	0.0	14.0
12. Folicur/Kombat (14 d)	0.7	0.5	0.3	4.2	12.0
SED (33 d.f.)	0.39	0.36	2.15	5.45	3.65
Significance	NS	***	***	*	***

F-full rate; H-half rate
NS-not significant
* Significant at P<0.05
*** Significant at P<0.001

Table 4. Effect of fungicides on flower stem length-21 February 1995

Treatment	Mean stem length (cm)
1. Untreated	65.7
2. Kombat (14 d)	65.9
3. Plover-F (14 d)	65.4
4. Plover-H (14 d)	64.1
5. Kombat (28 d)	64.2
6. Plover-F (28 d)	64.3
7. Plover-H (28 d)	63.9
8. Plover-F + Agral (14 d)	64.5
9. Plover-H + Agral (14 d)	65.1
10. Plover/Kombat (14 d)	63.4
11. Plover/Kombat (28 d)	65.5
12. Folicur/Kombat (14 d)	64.2
SED (33 d.f.)	1.52
Significance	NS

F-full rate; H-half rate
NS-not significant

Table 5. Effect of fungicide timing on ring spot of hybrid pinks - 1995/96.

Treatment		% leaf area affected							
		28 Dec		26 Jan		14 Mar		10 Apr	
1.	Untreated	0.9	(0.55)	5.9	(-0.63)	10.5	(2.41)	10.0	(2.39)
2.	Plover - Sept/Dec	0.4	(0.29)	1.1	(-1.67)	4.3	(1.62)	5.0	(1.70)
3.	Plover - Oct/Dec	0.2	(0.16)	0.4	(-1.76)	3.3	(1.40)	2.8	(1.24)
4.	Plover - Nov/Dec	0.4	(0.29)	0.4	(-2.06)	4.3	(1.60)	4.1	(1.44)
5.	Plover - Dec/Jan	0.7	(0.48)	1.3	(-1.15)	4.5	(1.69)	3.1	(1.30)
6.	Plover - Dec/Feb	1.1	(0.59)	2.3	(-1.72)	5.3	(1.69)	2.3	(1.05)
7.	Plover - Dec/Mar	0.6	(0.44)	1.4	(-1.21)	5.5	(1.77)	4.8	(1.60)
8.	Plover (F) x 4	0.3	(0.27)	1.3	(-1.29)	5.7	(1.76)	2.8	(1.22)
9.	Plover (H) x 4	0.1	(0.12)	1.5	(-1.41)	4.8	(1.59)	3.9	(1.52)
10.	Plover monthly	0.3	(0.25)	0.6	(-1.78)	2.5	(1.20)	1.0	(0.65)
11.	Plover/Kombat alternating	0.3	(0.25)	0.6	(-1.62)	4.0	(1.50)	2.9	(1.29)
12.	Managed disease prog.	1.0	(0.62)	3.1	(-0.87)	4.9	(1.76)	2.4	(1.16)
SED (33 d.f.)		-	(0.202)	-	(0.476)	-	(0.33)	-	(0.273)
Significance		NS	(NS)	-	(NS)	-	(NS)	-	(***)

NS - not significant
*** - significant at P =0.001
Transformed data is shown in parenthesis

Table 6. Effect of fungicide timing on infection of flower buds by ring spot 10 April 1996.

	Treatment	% flower buds affected	
1.	Untreated	65.0	(54.4)
2.	Plover - Sept/Dec	45.0	(42.2)
3.	Plover - Oct/Dec	48.0	(43.4)
4.	Plover - Nov/Dec	41.0	(39.8)
5.	Plover - Dec/Jan	41.0	(39.6)
6.	Plover - Dec/Feb	36.0	(36.1)
7.	Plover - Dec/Mar	28.0	(31.4)
8.	Plover (F) x 4	26.0	(26.9)
9.	Plover (H) x 4	30.0	(29.3)
10.	Plover monthly	13.0	(18.4)
11.	Plover/Kombat alternating	23.0	(27.5)
12.	Managed disease prog.	28.0	(31.5)
SED (33 d.f.)		-	(***)
Significance		-	(4.76)

*** - significance at P = 0.001
Transformed date is shown in parenthesis

Contract between ADAS (hereinafter called the "Contractor") and the Horticultural Development Council (hereinafter called the "Council") for research/development project.

PROPOSAL

1. TITLE OF PROJECT

Contract No: PC/87
Contract date: 29.3.93

CONTROL OF RINGSPOT ON PROTECTED HYBRID PINKS

2. BACKGROUND AND COMMERCIAL OBJECTIVE

The recent HDC Review of outdoor flower production (BOF18) and subsequent consultation with growers producing hybrid pinks under protection, have identified ringspot as a disease which is difficult to control and of primary concern to growers. Ringspot is caused by the fungus *Mycosphaerella dianthi* and infection results in dark ringspots on leaves, stem and calyces, making flowers unmarketable. The disease is generally most common in the spring and autumn periods being favoured by leaf wetness. Current fungicide spray treatments offer only partial control. This may be due to incorrect use of appropriate products in spray programmes, relatively poor control offered by current products, or possibly fungicide resistance.

The commercial objective is to improve control of ringspot in pinks by evaluation of fungicide spray programmes using a range of fungicide products and wetters. Effectiveness of treatments on other diseases (eg. stub rot, rust) would also be monitored, if these diseases occurred in the trials.

Results from the study would also have application to crops of hybrid pinks grown outdoors.

3. POTENTIAL BENEFIT TO THE INDUSTRY

While it is not possible to obtain accurate figures for pinks production, a best estimate is that 60 ha are grown under protection (glass or polythene) and a further 35-40 ha grown outdoors. About one third of protected crop is grown in South West England, while most of the outdoor crop is in Eastern England.

Ringspot is the only uncontrollable disease of hybrid pinks, with no fungicide or mixture with a label recommendation. Fungicides applied in the early 1980s (to spray carnations) gave some control in trials but no commercial recommendations were ever made. Some of these products are no longer available for horticultural use.

The disease can be a major problem from autumn to spring, depending on weather conditions. As ringspot is favoured by wetness and high humidity, it is frequently severe in many pink crops as the majority are grown with no heat or minimal heat.

Over the normal two-year cycle of the crop, the value of a normal crop of 50,000 bunches per 0.1 ha is about £15,000. As the disease infects flowers as well as leaves, infected flower flushes can be completely unsaleable. In discussion with local

producers, losses of 10% are frequent but this can be 20% in some seasons in the South West.

With a crop value of £150,000 per hectare, a 10% loss of crop over 60 ha would be £900,000 over a two year period. With the potential of higher losses in some instances (20%) together with similar losses in the outdoor crop, annual losses to the industry from this disease is in the region of £750,000.

Varieties

Doris is still the most commonly grown variety, and is very susceptible to ringspot. Any trial work should be done on this variety. If a second variety is needed, one of the Monica sports should be used - a popular variety, but very susceptible to ringspot.

4. SCIENTIFIC/TECHNICAL TARGET OF THE WORK

To evaluate fungicides currently used for control of ringspot (eg. Benlate), potentially useful alternative products (eg. Octave, Bavistin) and some of the newer broad spectrum arable crop fungicides (eg. Folicur). Products would be examined for efficacy of disease control and phytotoxicity. The advantage of adding wetters (eg. Actipron and some new products) would also be evaluated. Effect of products on diseases other than ringspot (eg. stub rot and rust) would also be noted if these diseases occur in the trial. The work would be undertaken as replicated trials in a polythene tunnel crop on a nursery where ringspot has occurred. If natural infection did not occur, the pathogen would be introduced into the crop on affected debris.

5. CLOSELY RELATED WORK - COMPLETED OR IN PROGRESS

To the best of my knowledge there is no work in progress, or recently completed, on control of this disease. MAFF-funded work in 1983 and 1984 investigated the use of Actipron wetter together with Delsene M for control of ringspot in protected carnations. The use of 0.5% and 2% Actipron improved the control of ringspot given by Delsene M, and Delsene M was found to be superior to chlorothalonil. Delsene M (carbendazim + maneb) is no longer marketed. Kombat WDG (carbendazim + mancozeb) with 0.5% Actipron is proposed as a treatment in this experiment.

A MAFF-funded experiment on control of ringspot at Rosewarne EHS was established in 1989/90 but there was no epidemic disease development, despite inoculating the trial with affected leaves. The trial was concluded early due to the closure of the station.

6. DESCRIPTION OF THE WORK

First year

The trial will be on cv. Doris in a polythene tunnel, with planting in August. The crop will be established and initial spray treatments applied. Leaves affected with ringspot would be introduced into the trial and irrigation and ventilation adjusted to

try and encourage disease development. Spray treatment would be continued at 14-21 day intervals. Fungicide treatments applied would include:

	Product (rate)	Active ingredient
1.	Control (untreated)	-
2.	Bavistin DF (1 g/l)	50% carbendazim
3.	Kombat WDG (2.25 g/l)	12.4% carbendazim + 63.3% mancozeb
4.	Octave (1 g/l)	50% prochloraz Mn
5.	Bravo 500 (2.2 ml/l)	50% chlorothalonil
6.	Topas 100 EC (1 ml/l)	10% penconazole
7.	Folicur	tebuconazole
8.	Kombat WDG + Actipron (2.25 g/l + 5 ml/l)	-
9.	Kombat WDG + Bond (2.25 g/l + 1 ml/l)	-
10.	Full disease control programme (Kombat + Actipron alternating with Octove; Folicur if rust appears.)	

New candidate fungicides being developed for arable or other crops and with evidence of activity against species of *Mycosphaerella* would be sought for inclusion in the trial.

Disease assessments would be carried out as appropriate and plants would also be examined for evidence of phytotoxicity.

Second and third years

Trials in years 2 and 3 will be used to confirm initial results, to evaluate any further new products available, and to incorporate the best treatments from the initial trial into a programme of alternating products to try and maximise disease control while minimising the risk of fungicide resistance.

7. COMMENCEMENT DATE & DURATION

01.10.93; duration 3 years

8. STAFF RESPONSIBILITIES

Project Leader: Dr T M O'Neill
ADAS Cambridge
Tel: 0223-455852
Fax: 0223-455911

Contract No: PC/87

TERMS AND CONDITIONS

The Council's standard terms and conditions of contract shall apply.

Signed for the Contractor(s)

Signature.....

Position.....R2D Manager.....

Date.....15/4/93.....

Signed for the Contractor(s)

Signature.....

Position.....

Date.....

Signed for the Council

Signature.....

Position.....CHIEF EXECUTIVE.....

Date.....29.3.93.....