Contract Report for the
Horticultural Development Council

CONTAINER GROWN ROSES: CONTROL OF DOWNY MILDEW 1993 & 1994 (HNS 53)

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Annual Report (October 1994)

Project Number:	HNS 53
Title:	Container-grown roses: control of downy mildew by manipulation of cultural factors and timely use of fungicides.
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APPLICATION

The objective of the project was to provide information on the efficacy, cost and crop-safety of fungicide treatments for control of downy mildew on container-grown roses. Eight fungicide treatments were identified which provided control; two treatments were very effective, enabling downy mildew to be controlled throughout the season on the susceptible variety Silver Jubilee. None of the treatments caused crop damage. Fungicide treatment before downy mildew is established in a crop appears to be essential for achieving good disease control. Increased plant spacing can reduce the risk of downy mildew.

SUMMARY OF RESULTS

The objectives of the work were: (1) to evaluate a range of fungicide sprays and drenches for efficacy and crop safety, (2) to investigate the effect of plant spacing on development of downy mildew.

1993

Experiments for evaluation of fungicides were established using container-grown plants of cvs. Silver Jubilee and Troika stood outside and cv. Hampshire stood in an unheated polythene tunnel. Plants in both experiments were watered by overhead sprinkler irrigation. Downy mildew was first confirmed in the outdoor trial on Silver Jubilee on 17 June and increased rapidly on untreated plants to cause substantial leaf spotting (10% leaf area affected) and leaf fall (21%) by 23 June. The severity of downy mildew at this time was significantly reduced by all treatments except monthly drenches of Aliette. Ripost and an experimental fungicide provided excellent season-long control and also significantly increased plant height and vigour. Application of four high volume sprays of Ripost at two week intervals to plants already severely affected by downy mildew gave no control of the disease. None of the fungicide treatments caused plant damage. It was considerably cheaper and equally effective to apply fungicides as high volume sprays than as drenches. The three varieties differed significantly in their susceptibility to downy mildew. Black spotting on cv. Hampshire was not due to downy mildew or other fungal disease.

No downy mildew developed in a plant-spacing experiment using cv. Hampshire, despite the introduction into the area of affected plants of Silver Jubilee.

1994

Seven fungicide programmes were evaluated using container-grown plants of cv. Silver Jubilee stood outside and watered by overhead irrigation. In the same experiment four products were compared applying the first sprays as soon as the disease was observed in the experiment. Downy mildew was first confirmed on 10 June, only on untreated plants. It increased slightly over the next two weeks but then disappeared during a period of continuous hot, dry weather. It had reappeared by 22 July and then increased rapidly on untreated plants. Alternating programmes of Ripost/Aliette, Ripost/fluazinam, fluazinam/Aliette and Ripost/Aliette/fluazinam all gave good control of leaf spotting and leaf fall caused by downy mildew. The three-product programme appeared to be slightly more effective than the two-product programmes. An alternating programme of Ripost/Aliette starting on 10 June, when the disease was first observed, gave control equal to that of the same programme starting on 23 April, shortly after leaf emergence. But the same programme stating on 23 June, two weeks after first symptoms had appeared, gave no disease control. The efficacy of Ripost/Aliette programme starting on 23 April was not reduced when the spray interval was extended to 28 days during June and July. Programmes of Aliette, Ripost, fluazinam and Favour starting on 10 June, at first symptoms, all gave good disease control.

In a spacing experiment using unsprayed plants of cv. Silver Jubilee, downy mildew was first observed on 10 June. At this time it only affected plants spaced at 18 cm centre to centre and not plants spaced more widely. On 22 July it was found at a low incidence (1-3% leaf area affected) in all treatments. The severity of downy mildew was reduced by increased plant spacing and by placing plants pot tight in North-South orientated rows. The prevailing wind was southerly and this may have reduced leaf wetness duration of plants in North-South rows compared to plants in East-West rows. On 28 July the % leaf fall was 25% (18 cm spacing); 14% (25 cm spacing); 4% (32 cm spacing) and 11% (pot tight in N-S rows). Differences between treatments diminished during August and there were no significant differences by early September.

ACTION POINTS FOR GROWERS

1. Confirm the cause of any red-brown spotting found on rose leaves.

2. Note which varieties are susceptible to by downy mildew on your nursery and ensure they receive priority treatment.

3. Apply sprays as soon as, or before, the first symptoms of downy mildew occur. Delaying by only two weeks can prevent control.

4. High volume sprays of Aliette, Curzate M, Favour, Filex, fluazinam, Fubol 75 or Ripost, or drenches of Fongarid provided control of downy mildew. Fluazinam is now available from Zeneca as Shirlan, with a label recommendation for use on potatoes to control blight. It can be used on outdoor roses **at grower's own risk**. Of the sprays evaluated, Aliette, Favour, fluazinam, Fubol 75 and Ripost were most effective. Aliette, Favour and Filex can be used on protected roses, **at grower's own risk**, under the long term extension of use arrangements for pesticides on minor crops.

5. An alternating programme should be used rather than repeated sprays of a single product. Programmes of Ripost/Aliette, Ripost/fluazinam, fluazinam/Aliette and Ripost/Aliette/fluazinam starting on 23 April 1994 all gave good disease control.

6. Increased plant spacing can reduce the risk of downy mildew occurring in a crop and slow epidemic development. However, this effect is likely to be of short duration if no fungicides are applied.

INTRODUCTION

Downy mildew of rose caused by *Peronospora sparsa* was first described in England in 1862 (Francis, 1981) and has now been described in many countries throughout the world. The fungus causes a reddish-brown leaf spot and premature leaf fall. Sporulation on leaf spots occurs on the underside of leaves but it is often very sparse or absent and it is not easy to confirm the disease (Stahl, 1973). It is currently proving difficult to control downy mildew during spring and summer in container-grown roses and during winter and spring in protected crops. These crops are commonly irrigated by overhead sprinklers, creating conditions favourable to development of the disease (Gill, 1977).

Many growers currently use a range of fungicides with different active ingredients in intensive spray programmes aimed at preventing the disease. Phenylamide-based products are usually included. Following reports of resistance to phenylamide fungicides in lettuce downy mildew (*Bremia lactucae*) (Crute, 1987) the effectiveness of these fungicides on rose downy mildew has been questioned. It was therefore proposed to compare the effectiveness of a range of fungicides, applied as high volume sprays or drenches, for control of downy mildew on container-grown roses.

It has been reported that downy mildew is often worse during periods of high humidity (Baker, 1953), in crops stood in shady and poorly drained areas (Gill, 1977), and in glasshouse crops grown wet (Baker, 1953). The density at which plants are stood is likely to affect relative humidity around them and the speed at which they dry after wetting. It was therefore decided to investigate whether the simple non-chemical measure of placing container-plants at wider spacings than is conventional affected the development of rose downy mildew.

MATERIALS AND METHODS

Plants

The groundcover variety Hampshire and the large flowered bush varieties Silver Jubilee and Troika were used; all three varieties were believed to be susceptible to downy mildew. Bare root plants were obtained from Notcutts Nurseries (cvs. Hampshire and Troika) and HRI Efford (cv. Silver Jubilee) and potted in 3 l (Hampshire) or 4 l containers. The potted plants were stood on Mypex-type matting outside or on a gravel floor in a polythene tunnel and irrigated by overhead sprinklers (irrigation around midnight). Plants were placed pot-tight initially, or as required (spacing trial). In 1993 the large flowered bush roses were spaced to 22 cm (centre to centre) on 3 June. Sprays of Systhane and Nimrod-T were applied for control of powdery mildew, rust and black spot.

Experiments

Three experiments were undertaken in 1993:

1. Evaluation of fungicide treatments on protected rose, cv. Hampshire.
2. Evaluation of fungicide treatments on outdoor roses, cvs. Silver Jubilee and Troika.
3. Effect of plant spacing on development of downy mildew in outdoor rose, cv. Hampshire.

A further two experiments were undertaken in 1994:

4. Evaluation of fungicides programmes and products on outdoor roses, cv. Silver Jubilee.
5. Effect of plant spacing on development of downy mildew in outdoor roses, cv. Silver Jubilee.

Experiment design and statistical analysis

All experiments were of randomised block design with fourfold replication. For Experiments 1, 2 and 4 there was double replication of the untreated control. The number of plants per plot was 20 (Experiments 1,3 and 5), 10 (Experiment 2, Silver Jubilee), 9 (Experiment 4) and 5 (Experiment 2, Troika). Results were analysed by analysis of variance.

Treatments - 1993

The fungicide treatments used in **Experiments 1 and 2** were:

1. Water (control treatment) (double replication)
2. Dithane DF (80% mancozeb) spray applied at 200g/100 l
3. Curzate M (4.5% cymoxanil + 68% mancozeb) spray applied at 200g/100 l
4. Filex (72.2% propamocarb hydrochloride) spray applied at 150ml/100 l
5. Fubol 75 (67.5% mancozeb + 7.5% metalaxyl) spray applied at 200g/100 l
6. Ripost (56% mancozeb + 8% oxadixyl + 3.2% cymoxanil) spray applied at 250g/100 l
7. Aliette (80% fosetyl - Al) spray applied at 500g/100 l
8. Fongarid (25% furalaxyl) drench applied at 400g/100 l
9. Aliette (80% fosetyl-Al) drench applied at 200g/100 l
10. Experimental (ASC 66825) (50% fluazinam) spray applied at 100ml/100 l
11. Programme: Aliette drench (200g/100 l) then alternating sprays of Fubol 75 and Aliette (rates as in treatments 5 and 7).
12. Ripost (rate as above) with the first spray applied when downy mildew was well established.

Treatments 1 - 11 were first applied before symptoms of downy mildew were evident.

From 26 July four replicates of the control treatment were treated with Ripost (treatment 12), reducing the number of control replicates to four. Fungicide sprays were applied at high volume (900 l/ha) by knapsack sprayer at 2.5 bar with a medium nozzle (03) every 10-14 days. Plants were sprayed from overhead and from around the sides of plots to achieve good leaf cover. Drenches were applied to the pot surface at 300ml/plant using a watering can. Drench treatments were repeated monthly.

The spacing treatments used in **Experiment 3** were:

1. Standard spacing (22 cm centres)
2. 27 cm centres
3. 32 cm centres
4. 37 cm centres
5. 42 cm centres
6. Pot tight in rows; 22 cm between rows

No fungicides were applied for control of downy mildew.

Treatments - 1994

The fungicide programmes used in **Experiment 4** were:

1. Water sprays every 14 days (double replication)
2. Ripost (250 g/ 100 l) alternating with Aliette (500 g/100 l) approximately every 14 days * from first new leaf.
3. Ripost (250 g/100 l) alternating with fluazinam (200 ml 100 l) approximately every 14 days * from first new leaf.
4. Fluazinam (200 ml/100 l) alternating with Aliette (500 g/100 l) approximately every 14 days * from first new leaf.
5. Ripost (250 g/100 l), alternating with Aliette (500 g/100 l) and fluazinam (100 ml/ 100 l) every 14 days from first new leaf.
6. Ripost (250 g/100 l) alternating with Aliette (500 g/100 l) every 14 days from the first recorded blight risk period in the area.
7. Ripost (250 g/100 l) alternating with Aliette (500 g/100 l) every 14 days from the first occurrence of leaf spotting in the experiment.
8. Ripost (250 g/100 l) alternating with Aliette (500 g/100 l), first spray at first new leaf; subsequent sprays at 14-28 day intervals according to weather.+
9. Aliette (500 g/100 l) every 14 days from first occurrence of leaf spoting.
10. Ripost (250 g 100 l) every 14 days from first occurrence of leaf spotting.
11. Fluazinam (200 ml/100 l) every 14 days from first occurrence of leaf spotting.
12. Favour (300 ml/100 l) every 14 days from first occurrence of leaf spotting.

* Spray interval varied from 11-16 days dependent on weather, shorter intervals in wet weather.
\+ Long interval in dry weather; short interval in wet weather.

Alongside Experiment 1 were four single plots of 9 plants sprayed every 14 days from first leaf with:

1. Invader (dimethomorph + mancozeb) applied at 200 g/100 l (from 28 May)
2. Favour 600 SC (metalaxyl + thiram) applied at 300 ml/100 l.
3. Folio 575 SC (metalaxyl + chlorothalonil) applied at 200 ml/100 l.
4. Tattoo (propamocarb HCl + mancozeb) applied at 400 ml/100 l.

There was no statistical analysis of information from these plots as there was no plot replication.

The spacing treatments used in **Experiment 5** were:

1. Standard spacing (18 cm centres)
2. 25cm centre to centre
3. 32cm centre to centre
4. Pot tight in north-south orientated rows (18cm between rows)
5. Pot tight in east-west rows (18cm between rows)
6. Staggered placement at 18cm centres.

Infector plants

Twelve Silver Jubilee plants affected by downy mildew were placed between plots within the trial area of Experiments 1 and 3 on 29 June 1993.

Disease assessments

In all experiments plants were examined every two weeks for evidence of leaf spotting or leaf loss. Leaves with symptoms suggestive of downy mildew were examined microscopically for conidiophores characteristic of *P. sparsa*. If no downy mildew was found on immediate examination, leaves were incubated in a damp chamber for 7 days and re-examined. When downy mildew was confirmed plants were examined and for each plot an estimate was made of the % leaf area affected by black spotting typical of downy mildew and the % leaf loss judged by the sparseness of leaf cover on branches. Full disease assessments were made in Experiment 2 on 23 June, 14 July, 10 August and 29 September 1993 and in Experiments 4 and 5 on 22 July, 25 July, 5 August, 11 August, 16 August, 31 August and 13 September1994. At the final assessment in 1993, plant vigour was also determined, by placing each plant into one of five categories according to a visual assement of plant size, leaf cover and stem thickness.

Plant vigour key

0 - plant dead
1 - very poor plant (unsaleable; severe defoliation & stunting)
2 - poor plant (unsaleable; defoliation & stunting)
3 - moderately good plant (slight defoliation)
4 - good plant (very slight defoliation)
5 - excellent plant

Where downy mildew was not found (Experiments 1 and 3), assessments were made of general leaf spotting, leaf yellowing and the proportion of pot surface area covered by leaves when plants were viewed from directly overhead (30 April and 24 June 1993 for Experiment 1; 14 July 1993 for Experiment 3).

Crop diary

Dates of fungicide treatment in **1993** were as follows:

Fungicide sprays	Fungicide drenches
30 April	30 April
11 May	--
21 May	--
3 June	3 June
17 June	--
29 June	29 June
14 July	--
26 July	26 July
10 August	--
24 August	24 August
6 September	--

Treatment 12 (Experiment 2) was started on 26 July 1993.

Dates of fungicide treatments in **1994** were:

Treatment	**Date sprays applied**										Total no. of
	29 Apr	13 May	28 May	10 June	23 June	9 July	22 July	5 Aug	16 Aug	30 Aug	sprays
1.	-	-	-	-	-	-	-	-	-	-	0
2.	Ripost	Aliette	Ripost	Aliette	Ripost	Aliette	Ripost	Aliette	Ripost	Aliette	10
3.	Ripost	Fluaz.	Ripost	Fluaz.	Ripost	Fluaz.	Ripost	Fluaz.	Ripost	Fluaz.	10
4.	Fluaz.	Aliette	Fluaz.	Aliette	Fluaz.	Aliette	Fluaz.	Aliette	Fluaz.	Aliette	10
5.	Ripost	Aliette	Fluaz	Ripost	Aliette	Fluaz.	Ripost	Aliette	Fluaz.	Ripost	10
6.	-	-	-	-	Ripost	Aliette	Ripost	Aliette	Ripost	Aliette	6
7.	-	-	-	Ripost	Aliette	Ripost	Aliette	Ripost	Aliette	Ripost	7
8.	Ripost	Aliette	Ripost	Aliette	-	Ripost	-	Aliette	Ripost	Aliette	8
9.	-	-	-	Aliette	Aliette	Aliette	Aliette	Aliette	Aliette	Aliette	7
10.	-	-	-	Ripost	Ripost	Ripost	Ripost	Ripost	Ripost	Ripost	7
11.	-	-	-	Fluaz.	Fluaz.	Fluaz.	Fluaz.	Fluaz.	Fluaz.	Fluaz.	7
12.	-	-	-	Favour	Favour	Favour	Favour	Favour	Favour	Favour	7
Downy mildew found	No	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes	

Occurence of blight periods (at RAF Wattisham) - 1994

Full periods	Half periods
24-25 June	13 July
2 - 3 July	10 August
28-29 July	31 August
4-5 August	
10-11 August	
24-25 August	

RESULTS

Experiment 1. Evaluation of fungicide treatments on protected rose, cv Hampshire - 1993.

No downy mildew occurred naturally on plants and none developed following the introduction of Silver Jubilee infector plants which were badly affected by the disease. Black spotting of leaves was present at a low level throughout the trial (Table 1) but no fungal pathogens were found associated with this symptom.

There were no significant differences in leaf cover and leaf yellowing after five sprays of each treatment. None of the treatments caused evident crop damage. In a supplementary laboratory experiment using detached rose leaves, downy mildew on leaves of Silver Jubilee inoculated on to leaves of Hampshire caused no leaf spotting.

Experiment 2. Evaluation of fungicide treatments on outdoor rose, cvs Silver Jubilee and Troika - 1993.

Downy mildew was first confirmed in the trial on 17 June when a low incidence of red-brown leaf spotting was observed in both varieties. The disease incidence and severity increased quickly on water treated plants of Silver Jubilee, causing severe leaf spotting (9.8% leaf area affected) and leaf loss (21.1%) within a week (Tables 2 and 3). The disease continued to increase on this variety but remained at a relatively low level on cv. Troika. By 10 August, 8 weeks after the disease was first observed, untreated plants of Silver Jubilee had 19.8% leaf area affected by downy mildew and had lost 32.5% of their leaf cover.

At the first disease assessment on 23 June, all of the fungicide treatments except Dithane sprays and Aliette drenches had significantly reduced both leaf spotting and leaf drop on cv. Silver Jubilee. The most effective treatments were Filex, Fubol 75, Ripost and experimental product, with less than 3% leaf spotting compared to 9.8% on the control (water treatment) (Table 2). Five out of the 10 initial fungicide treatments provided significant reductions in leaf spotting and/or leaf loss throughout the season (Tables 2 and 3) with Ripost (applied early) and the experimental fungicide considerably better than other treatments at later assessments.

The severity of downy mildew on cv. Troika remained very low and was significantly less than that on Silver Jubilee (Tables 2 and 3). No fungicide treatments had a significant effect on this low level of disease.

The effect of downy mildew on plant vigour first became evident in August, with noticeably better extension growth and more new leaves on plants where fungicides were providing good control of downy mildew. At the final assessment on 29 September plant vigour was significantly improved by four treatments, (Ripost, Aliette, Experimental and the programme). Fungicide treatments which gave good control of downy mildew also resulted in increased plant height (Table 4). The greatest effects were observed following treatment with Ripost, Aliette (sprays), Experimental and the programme, plants being 10cm or more taller than untreated plants by the end of September. Application of four Ripost sprays to plants already severely affected by downy mildew resulted in no significant reduction in downy mildew compared with untreated plants.

Cost of fungicide treatment

An estimate of the cost of different fungicide treatments at the rates used in this work is shown in Table 5. Cost of application and any discount for purchase of large packs is excluded. Application as a high-volume spray is considerably cheaper, and quicker to apply, than application as a drench at 300ml/plant.

Experiment 3. Evaluation of plant spacing on development of downy mildew on outdoor rose, cv. Hampshire - 1993.

No downy mildew occurred naturally on plants and none developed following the introduction of Silver Jubilee infector plants which were badly affected by the disease. Black spotting of leaves was present at a low incidence throughout the trial but no fungi were found associated with this symptom. There was slight leaf loss but this was not significantly affected by any of the spacing treatments (Table 6).

Plants in one of the blocks in Experiment 2 were spaced in July to allow ready access by growers at an Open Day. Subsequent development of mildew in this block appeared to be slower than in adjacent unspaced blocks.

Experiment 4. Evaluation of fungicide programmes and products on outdoor rose, cv. Silver Jubilee - 1994.

Downy mildew occurred naturally in the experiment being first confirmed on 10 June when a low incidence of leaf spotting was observed on untreated plants. The disease remained at a low level for two weeks but then was not found on 30 June or 9 July (Fig.1). On 22 July it was present in most treatments and affected 1% leaf area of untreated plants. Leaf spotting and leaf fall then increased rapidly in treatments 1 (untreated) and 6 ('blight risk'). By 5 August, untreated plants had 16% leaf area affected by downy mildew and had lost 11% of leaf cover (Tables 7 & 8; Figs. 1 & 2).

All fungicide programmes reduced the severity of downy mildew apart from treatment 6 in which the first spray was not applied until 22 July, two weeks after the occurrence of first symptoms. (Tables 7 & 8). By 16 August, untreated plants had lost 38% of their leaf cover compared to just 8% in treatment 11 (fluazinam sprays) and 9% in treatment 5 (Ripost/Aliette/fluazinam programme). Programmes with the first fungicide treatment applied as soon as downy mildew was observed in the experiment (10 June) were as effective as programmes where the first spray was applied six weeks earlier. Extending the spray interval to 28 days in hot dry weather during July and August (treatment 8) did not reduce the level of disease control.

By mid-September, plants treated with fungicide were 8-14cm taller than untreated plants (Table 9; Fig 4).

Fungicides applied as repeat sprays of the same product from 10 June (treatments 9-12) all gave good control of downy mildew (Tables 7 & 8).

Invader, Favour, Folio and Tattoo all appeared to give control of downy mildew, with Folio appearing slightly less effective than other treatments (Tables 7 & 8).

No symptoms of leaf scorch or other adverse effect on crop growth were observed in any of the treatments. Red-brown lesions occurred on petioles and flower stalks of a few plants and *P. sparsa* was found associated with these symptoms.

Experiment 5. Evaluation of plant spacing on development of downy mildew on outdoor rose, cv. Silver Jubilee - 1994

Downy mildew was first confirmed in the trial on 10 June when a low incidence of leaf spotting (less than 1% leaf area affected) occurred in plants at the tightest spacing. The disease was not found in other treatments, at wider spacings, at this time. By 22 July it was present at a low level in all treatments. The incidence of leaf spotting and leaf loss declined as plant spacing increased from 18 to 32 cm (Tables 9 & 10). Placing plants pot-tight in north-south rows with a space between rows also appeared to reduce the development of downy mildew. Placing plants pot tight in east-west rows and in a staggered arrangement appeared to have little or no effect on disease development. Differences between treatments in these unsprayed plants declined as the disease severity increased (Fig. 3). Spacing had no effect on final plant height (Table 10).

Table 1. Effect of fungicide treatments on leaf spotting on protected ground cover roses, cv. Hampshire (Experiment 1) - 1993.

	Treatment	Leaf spot (% area affected) 30 April	Leaf loss (%) 14 July
1	Untreated	1.4 (6.7)	16.4 (22.8)
2	Dithane DF	1.3 (6.4)	13.5 (21.2)
3	Curzate M	1.1 (5.9)	12.2 (20.2)
4	Filex	1.2 (6.2)	11.0 (18.8)
5	Fubol 75	1.1 (6.0)	11.0 (18.5)
6	Ripost	1.2 (6.2)	12.0 (19.8)
7	Aliette	1.5 (7.0)	8.5 (16.1)
8	Fongarid (drench)	1.3 (6.5)	7.5 (15.2)
9	Aliette (drench)	1.2 (6.4)	8.2 (15.3)
10	Experimental	1.2 (6.3)	14.0 (21.7)
11	Programme	1.5 (7.0)	10.0 (17.7)
	Significance	NS	NS
	SED between treatments	0.38	4.51
	vs. control (34 d.f.)	0.33	3.91

Downy mildew was not confirmed in the trial.
NS - not significant.
( ) - Angular transformed values, used for statistical analyses.

Table 2. Effect of variety and fungicide treatment on downy mildew of outdoor rose, cv. Silver Jubilee (Experiment 2) - 1993.

	% leaf area affected by downy mildew							
Treatment	23 June		14 July		10 Aug		29 Sept	
1. Untreated	9.8	(17.9)	6.8	(14.8)	19.8	(26.4)	11.0	(19.3)
2. Dithane	8.6	(17.0)	5.9	(14.0)	15.7	(28.3)	9.7	(18.0)
3. Curzate M	6.9	(15.2)	5.5	(13.3)	19.8	(26.4)	11.0	(19.2)
4. Filex	2.4	(8.1)	2.9	(9.5)	14.5	(22.2)	8.0	(16.2)
5. Fubol 75	2.5	(8.6)	1.2	(6.1)	7.6	(15.1)	7.7	(16.2)
6. Ripost	0.8	(4.1)	1.1	(5.8)	1.4	(6.8)	1.0	(5.7)
7. Aliette	3.9	(10.3)	1.6	(6.8)	11.4	(19.2)	5.3	(12.8)
8. Fongarid (drench)	5.7	(13.7)	5.6	(13.3)	12.6	(19.7)	8.3	(16.1)
9. Aliette (drench)	11.9	(19.7)	7.2	(15.4)	16.5	(23.8)	9.4	(17.8)
10. Experimental	0.6	(4.4)	0.7	(4.3)	3.0	(8.7)	1.4	(6.5)
11. Programme	5.0	(12.7)	3.3	(10.3)	6.6	(14.6)	4.9	(12.3)
12. Ripost (late)	-	-	-	-	19.6	(26.3)	10.0	(18.1)
Significance	***		***		***		***	
SED between treatments	2.16		1.74		2.34		1.96	
vs. control (69 d.f.)	1.87		1.51		-	-	-	

*** - significant at $P < 0.001$.

( ) - Angular transformed values, used for statistical analyses.

Table 3. Effect of variety and fungicide treatment on loss of foliage of outdoor rose, cv. Silver Jubilee (Experiment 2) - 1993.

Treatment	% leaf loss			
	23 June	14 July	10 Aug	29 Sept
1. Untreated	21.1	30.8	32.5	28.0
2. Dithane	11.7	18.0	25.0	26.2
3. Curzate M	10.1	28.3	35.7	29.5
4. Filex	7.0	8.4	24.0	21.5
5. Fubol 75	3.9	2.0	11.0	19.7
6. Ripost	1.7	2.0	2.2	3.5
7. Aliette	8.5	7.7	16.1	11.2
8. Fongarid (drench)	7.2	13.6	23.4	21.7
9. Aliette (drench)	29.8	31.9	31.6	24.2
10. Experimental	1.1	2.0	3.5	4.0
11. Programme	8.5	7.2	10.8	12.4
12. Ripost (late)	-	-	35.4	26.0
Significance	**	**	**	**
SED between treatments	4.09	4.75	3.27	5.06
vs. control (69 d.f.)	3.55	4.12	-	-

** - significant at $P < 0.01$.

Table 4. Effect of variety and fungicide treatment on plant quality of outdoor rose, cvs Silver Jubilee and Troika (Experiment 2) - 1993.

Treatment	Final plant quality (29 Sept)			
	Plant vigour (0-5)		Plant height (cm)	
	Silver Jubilee	Troika	Silver Jubilee	Troika
1. Untreated	2	5	37	68
2. Dithane	3	5	49	66
3. Curzate M	3	5	46	67
4. Filex	3	5	44	71
5. Fubol 75	3	5	51	70
6. Ripost	5	5	53	70
7. Aliette	5	5	58	68
8. Fongarid (drench)	3	5	38	67
9. Aliette (drench)	2	5	37	67
10. Experimental	5	5	57	67
11. Programme	4	5	60	70
12. Ripost (late)	3	5	41	70
Significance	***	NS	***	***
SED (69 d.f.)	0.2	0.2	1.8	1.8

*** - significant at $P < 0.001$
NS - not significant

Table 5. Cost (£) of fungicide treatment (1993)

Treatment Treatment	Cost/unit (kg or l)	Cost/100 l (at treatment rate)	Cost/100m² (1 spray or drench)	Cost/pot (1 drench)
1. Untreated	-	-	-	-
2. Dithane DF	3.48	0.70	0.07	-
3. Curzate M	10.00	2.00	0.20	-
4. Filex	38.40	5.73	0.57	-
5. Fubol 75	12.53	2.51	0.25	-
6. Ripost	10.00	2.50	0.25	-
7. Aliette	22.47	11.23	1.12	-
8. Fongarid (drench)	69.83	27.93	83.79	0.08
9. Aliette (drench)	22.47	4.49	13.47	0.13

Cost of application is not included.

Table 6. Effect of plant spacing on leaf loss in outdoor container-grown roses (cv. Hampshire) (Experiment 3) - 1993.

Treatments		% leaf loss (14 July)
1.	Standard spacing (22 cm centres)	2.0
2.	27 cm centres	1.8
3.	32 cm centres	1.9
4.	37 cm centres	1.8
5.	42 cm centres	2.0
6.	Pot tight in rows; spaced 22 cm between rows	1.5
	Significance	NS
	SED (15 d.f.)	0.21

No fungicides applied for control of downy mildew.
No downy mildew was confirmed in the trial.

Key to figures

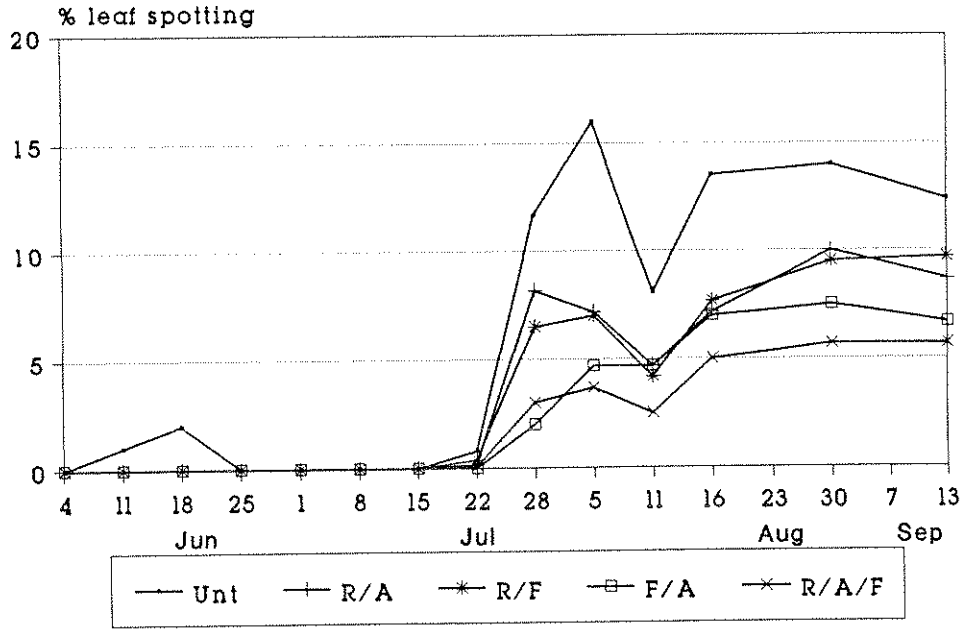
Figures 1, 2 and 4

Unt	Untreated
R/A	Ripost alternating with Aliette (from 29 April)
R/F	Ripost alternating with fluazinam (from 29 April)
F/A	Fluazinam alternating with Aliette (from 29 Spril)
R/A/F	Ripost alternating with Aliette and fluazinam (from 29 April)
R/A - B	Ripost alternating with Aliette (from 23 June)
R/A - F	Ripost alternating with Aliette (from 10 June)
R/A - W	Ripost alternating with Aliette (no sprays in dry weather)
AL	Aliette (from 10 June)
Ri	Ripost (from 10 June)
FL	Fluazinam (from 10 June)
Fa	Favour (from 10 June)

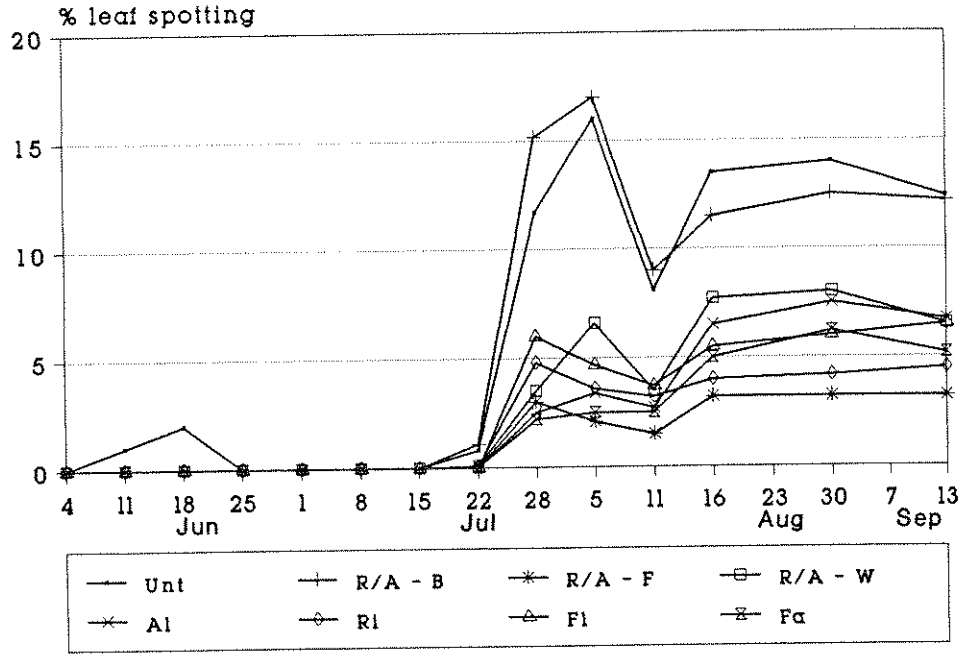
Figure 3

18 cm	Pots at 18 cm spacing
25 cm	Pots at 25 cm spacing
32 cm	Pots at 32 cm spacing
NS rows	Pot tight in North-South oriented rows
EW rows	Pot titght in East-West oriented rows
Stag	Staggered placement at 18 cm spacing

Fig 1. Effect of fungicides on rose downy mildew - 1994

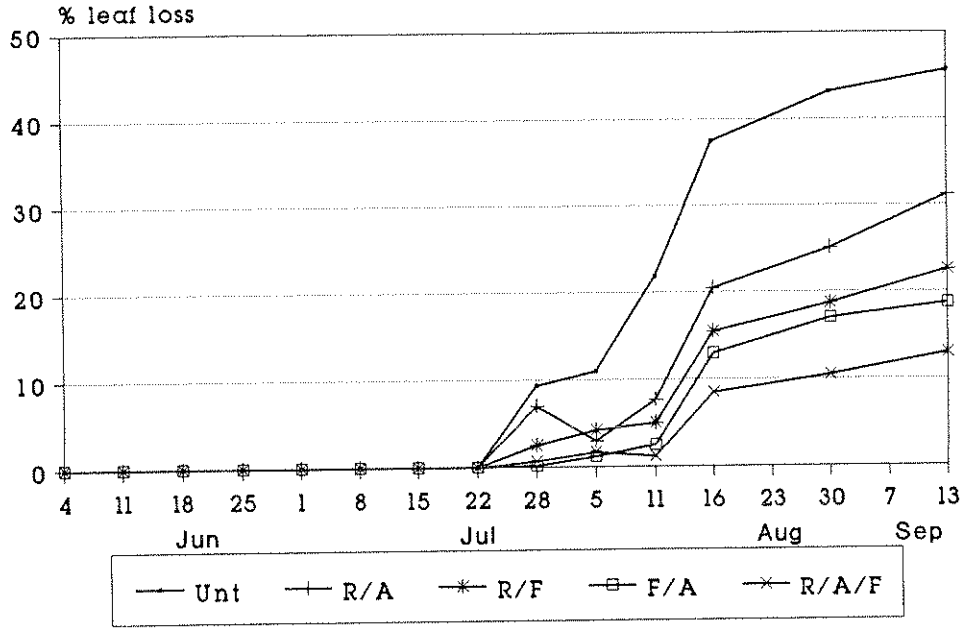


Rose941

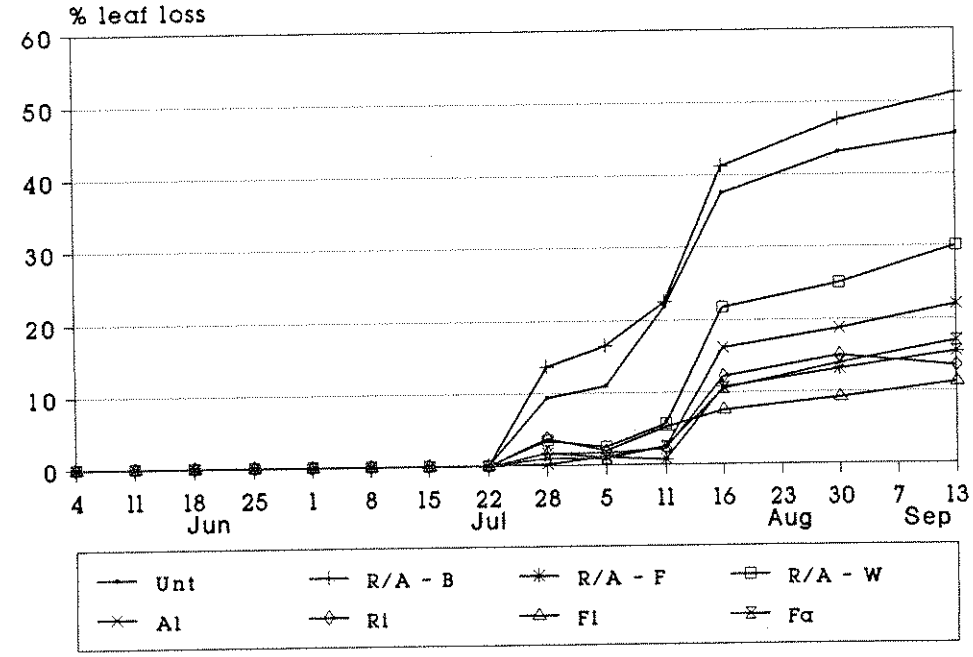


Rose942

Fig 2. Effect of fungicides on rose downy mildew - 1994

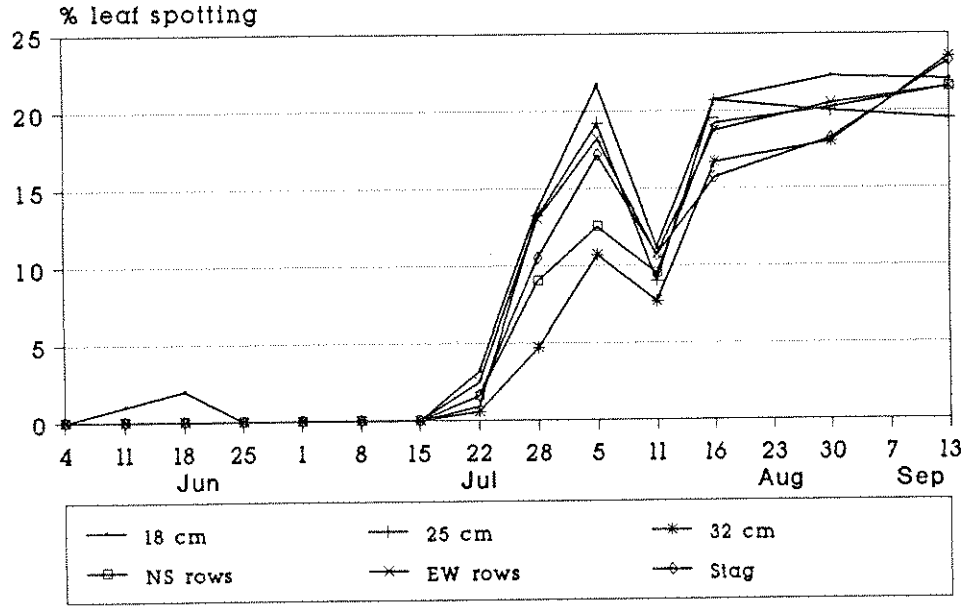


Rose945

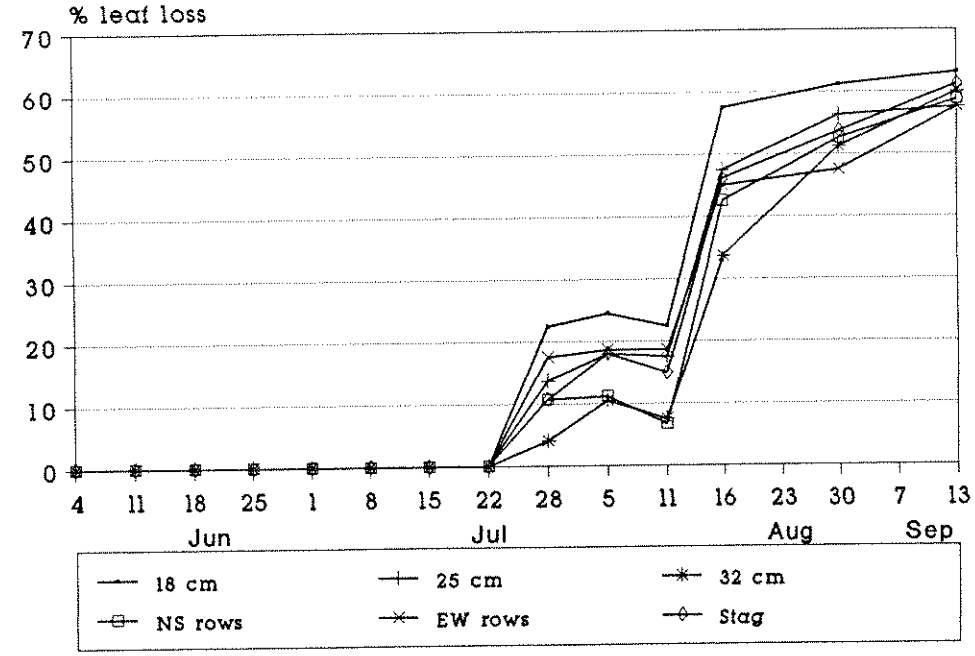


Rose946

Fig 3. Effect of plant spacing on rose downy mildew - 1994

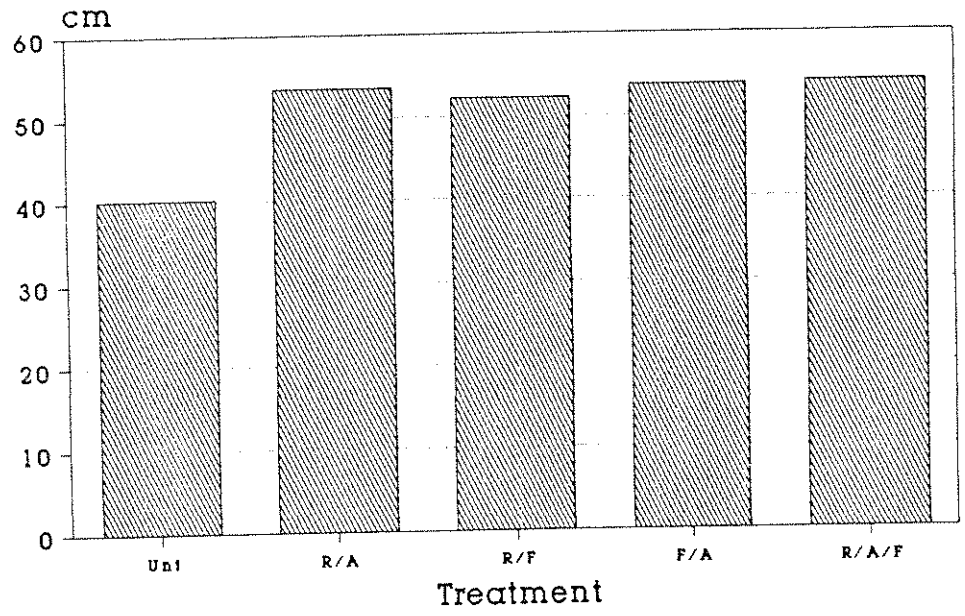


Rose943

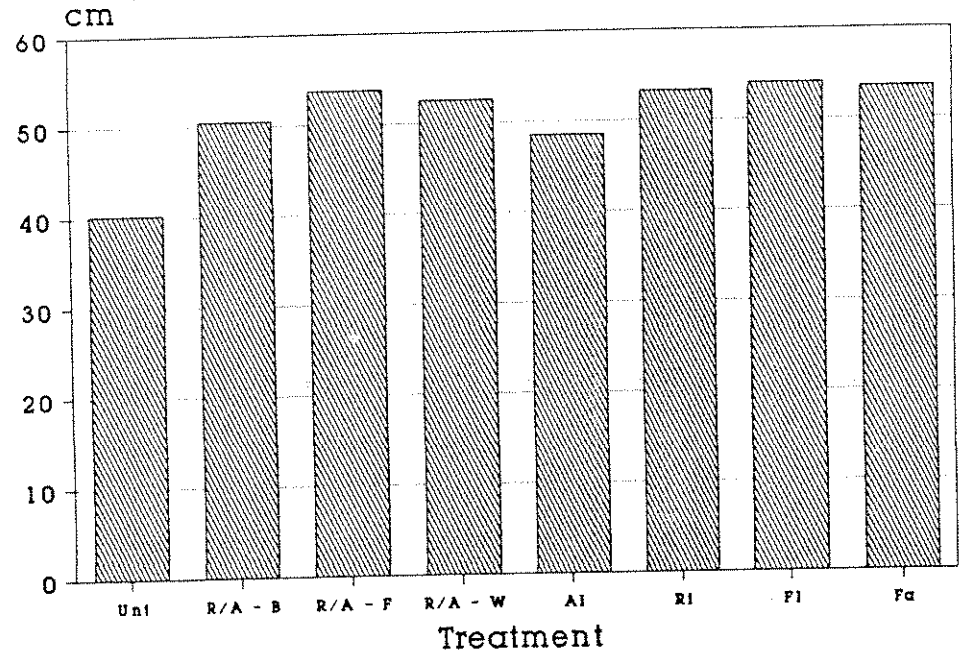


Rose944

Fig 4. Effect of fungicides on plant height - 1994



Ros14



Ros15

Table 7. Effect of fungicides on leaf spotting on outdoor roses, cv. Silver Jubilee - 1994.

	Treatments	% leaf affected by downy mildew							
		22 July		28 July		5 Aug		11Aug	
1.	Untreated (water spray)	0.8	(3.1)	11.7	(19.1)	16.0	(22.2)	8.1	(16.3)
2.	Ripost/Aliette	0.2	(1.4)	8.2	(15.4)	7.2	(15.0)	4.7	(12.3)
3.	Ripost/fluazinam	0.4	(2.2)	6.5	(13.8)	7.0	(14.4)	4.2	(11.3)
4.	Fluazinam/Aliette	0	(0.5)	2.0	(7.5)	4.7	(11.6)	4.7	(12.5)
5.	Ripost/Aliette/fluazinam	0.1	(1.5)	3.0	(9.8)	3.7	(10.8)	2.5	(9.0)
6.	R/A - blight risk	1.1	(5.1)	15.2	(21.4)	17.0	(23.1)	9.0	(16.9)
7.	R/A - first symptoms	0	(0.6)	3.0	(8.7)	2.1	(7.9)	1.5	(6.9)
8.	R/A - weather dictated	0.1	(1.2)	3.5	(9.9)	6.6	(13.3)	3.5	(10.1)
9.	Aliette - first symptoms	0	(0.5)	2.5	(8.2)	3.4	(9.8)	2.7	(8.9)
10.	Ripost - first symptoms	0.1	(1.5)	4.8	(10.1)	3.6	(10.1)	3.2	(9.6)
11.	Fluazinam - first symptoms	0	(0.5)	6.0	(13.9)	4.7	(12.3)	3.7	(11.1)
12.	Favour - first symptoms	0	(0.9)	2.2	(8.4)	2.5	(8.6)	2.5	(8.7)
	Significance	-	NS	-	*	-	*	-	*
	SED between treatments		(1.84)		(4.19)		(4.51)		(2.43)
	vs control (37 df)		(1.60)		(3.63)		(3.91)		(2.11)
	Observational plots								
1.	Invader	0		3		3		3	
2.	Favour	0		2		6		4	
3.	Folio	0		5		8		8	
4.	Tattoo	0		2		4		3	

R/A - Ripost alternating with Aliette
( ) - Angular transformed values, used for statistical analyses

NS - not significant
* - significant at $P < 0.05$

Table 7 continued:

		% leaf area affected by downy mildew					
	Treatment	16 Aug		30Aug		13 Sep	
1.	Untreated (water spray)	13.5	(21.3)	14.0	(21.6)	12.4	(20.3)
2.	Ripost/Aliette	7.2	(15.4)	10.0	(18.1)	8.7	(17.0)
3.	Ripost/fluazinam	7.7	(15.5)	9.5	(17.4)	9.7	(17.4)
4.	Fluazinam/Aliette	7.0	(15.1)	7.5	(15.7)	6.7	(14.8)
5.	Ripost/Aliette/fluazinam	5.0	(12.9)	5.7	(13.8)	5.7	(13.8)
6.	R/A - blight risk	11.5	(19.5)	12.5	(20.5)	12.2	(20.4)
7.	R/A - first symptoms	3.2	(10.3)	3.2	(9.9)	3.2	(9.9)
8.	R/A - weather dictated	7.7	(15.5)	8.0	(15.7)	6.5	(13.9)
9.	Aliette - first symptoms	6.5	(14.6)	7.5	(15.7)	6.7	(14.8)
10.	Ripost - first symptoms	4.0	(10.8)	4.2	(11.0)	4.5	(11.0)
11.	Fluazinam - first symptoms	5.5	(12.9)	6.0	(13.4)	6.5	(13.9)
12.	Favour - first symptoms	5.0	(12.6)	6.2	(13.8)	5.2	(12.7)
	Significance	-	NS	-	NS	-	NS
	SED between treatments		(2.78)		(3.27)		(3.27)
	vs control (37 d.f.)		(2.40)		(2.83)		(2.83)

Observational plots

1.	Invader	5	6	5
2.	Favour	10	8	6
3.	Folio	12	12	10
4.	Tattoo	5	8	7

R/A Ripost/Aliette alternating
( ) Angular transformed values, used for statistical analyses

NS - not significant

Table 8. Effect of fungicides on loss of foliage of outdoor roses, cv. Silver Jubilee - 1994

		% leaf loss					
		28 July		5 Aug		11Aug	
1.	Untreated	9.4	(16.0)	11.0	(17.8)	21.9	(26.9)
2.	Ripost/Aliette	7.0	(12.7)	3.0	(9.7)	7.7	(15.0)
3.	Ripost/fluazinam	2.5	(7.8)	4.2	(10.2)	5.0	(10.7)
4.	Fluazinam/Aliette	0.2	(1.4)	1.2	(5.4)	2.5	(6.5)
5.	Ripost/Aliette/fluazinam	0.7	(4.3)	1.7	(7.5)	1.2	(3.2)
6.	R/A - blight risk	13.7	(19.0)	16.5	(22.2)	22.5	(27.3)
7.	R/A - first symptoms	1.7	(6.1)	1.1	(5.9)	0.7	(2.5)
8.	R/A - weather dictated	3.5	(8.5)	2.5	(7.5)	5.7	(11.7)
9.	Aliette - first symtpms	0.2	(1.4)	1.2	(5.5)	2.5	(4.6)
10.	Ripost - first symptoms	1.2	(5.4)	1.7	(6.1)	2.2	(6.1)
11.	Fluazinam - first symptoms	3.7	(10.7)	2.0	(8.0)	5.2	(12.8)
12.	Favour - first symptoms	1.0	(3.9)	0.9	(4.5)	2.5	(6.5)
	Significance	-	*	-	**	-	**
	SED between treatments		(5.02)		(4.24)		(5.66)
	vs control (37 d.f.)		(4.34)		(3.67)		(4.91)
Observational plots							
1.	Invader	0		1		0	
2.	Favour	1		2		5	
3.	Folio	5		3		10	
4.	Tattoo	2		2		0	

R/A - Ripost alternating with Aliette
( ) - Angular transformed values, used for statistical analyses

* Significant at $P < 0.05$
** Significant at $P < 0.01$

Table 8. continued

	Treatment	% leaf loss 16 Aug		30 Aug		13 Sept	
1.	Untreated	37.5	(37.4)	43.1	(40.8)	45.6	(42.3)
2.	Ripost/Aliette	20.5	(26.5)	25.0	(29.6)	31.2	(33.7)
3.	Ripost/fluazinam	15.5	(22.6)	18.7	(24.9)	22.5	(27.3)
4.	Fluazinam/Aliette	13.0	(21.1)	17.0	(24.3)	18.7	(25.6)
5.	Ripost/Aliette/fluazinam	8.5	(16.9)	10.5	(18.9)	13.0	(21.1)
6.	R/A - blight risk	41.2	(39.7)	47.5	(43.5)	51.2	(45.7)
7.	R/A - first symptoms	10.7	(18.6)	13.2	(20.7)	15.5	(22.5)
8.	R/A - weather dictated	21.7	(26.5)	25.0	(28.7)	30.0	(31.8)
9.	Aliette - first symptoms	16.2	(23.5)	18.7	(25.3)	22.0	(27.7)
10.	Ripost - first symptoms	12.2	(20.2)	15.0	(22.5)	13.5	(20.7)
11.	Fluazinam - first symptoms	7.5	(15.4)	9.2	(17.2)	11.2	(19.0)
12.	Favour - first symptoms	10.5	(17.9)	14.0	(21.3)	17.0	(23.5)
	Significance	-	*	-	**	-	**
	SED between treatments		(5.03)		(5.49)		(5.82)
	vs control (37 d.f.)		(4.35)		(4.75)		(5.04)

Observational plots

1.	Invader	15	8	20
2.	Favour	18	18	20
3.	Folio	25	25	25
4.	Tattoo	15	15	18

R/A - Ripost/Aliette alternating
( ) - Angular transformed values, used for statistical analyses.

* Significant at $P < 0.05$
** Significant at $P < 0.01$

Table 9. Effect of fungicides on plant height of outdoor roses, cv. Silver Jubilee - 1994

	Treatment	Plant height (cm) 13 Sept
1.	Untreated	40.2
2.	Ripost/Aliette	53.5
3.	Ripost/fluazinam	52.2
4.	Fluazinam/Aliette	53.7
5.	Ripost/Aliette/fluazinam	54.0
6.	R/A - blight risk	50.5
7.	R/A - first symptoms	53.7
8.	R/A - weather dictated	52.5
9.	Aliette - first symptoms	48.5
10.	Ripost - first symptoms	53.2
11.	Fluazinam - first symptoms	54.0
12.	Favour - first symptoms	53.5
	Significance	**
	SED between treatments	1.38
	vs control (37 d.f.)	1.19
Observational plots		
1.	Invader	52
2.	Favour	55
3.	Folio	53
4.	Tattoo	50

R/A - Ripost/Aliette alternating

Table 10. Effect of plant spacing on leaf spotting and plant height of outdoor roses, cv. Silver Jubilee - 1994

		% leaf area affected by downy mildew									
		22 July		28 July		5 Aug		11Aug		16 Aug	
1.	18 cm centres	3.2	(9.6)	13.7	(21.7)	21.7	(27.6)	11.2	(19.2)	20.7	(27.1)
2.	25 cm centres	0.9	(5.3)	13.2	(21.1)	19.2	(26.0)	9.0	(17.4)	20.7	(27.1)
3.	32 cm centres	0.6	(4.5)	4.7	(12.3)	10.7	(19.0)	7.7	(15.8)	16.7	(23.8)
4.	Pot tight on NS^+ rows	1.6	(6.8)	9.0	(16.9)	12.5	(20.6)	9.5	(17.8)	19.2	(25.9)
5.	Pot tight in EW^+ rows	2.5	(8.2)	13.0	(20.1)	18.2	(25.0)	10.7	(19.0)	18.7	(25.6)
6.	Staggered spacing	1.6	(7.3)	10.5	(18.6)	17.2	(24.5)	10.7	(19.0)	15.7	(23.4)
	Significance	-	NS	-	NS	-	*	-	NS	-	NS
	SED (15 d.f.)		(2.45)		(3.33)		(2.44)		(2.03)		(1.66)

		% leaf area affected		Plant height (cm)
		30 Aug	13 Sept	13 Sept
1.	18 cm centres	22.2 (28.1)	22.0 (27.9)	49.5
2.	25 cm centres	20.0 (26.6)	19.5 (26.2)	49.7
3.	32 cm centres	18.0 (25.0)	23.5 (29.0)	49.2
4.	Pot tight on NS^+ rows	20.2 (26.7)	21.5 (27.6)	49.2
5.	Pot tight in EW^+ rows	20.5 (26.9)	21.5 (27.6)	49.0
6.	Staggered spacing	18.2 (25.2)	23.2 (28.8)	49.7
	Significance	- NS	- NS	NS
	SED (15 d.f.)	(1.58)	(1.05)	1.21

$^+$NS - North-South rows
$^+$EW - East-West rows

NS - no significant differences
* Significant at $P < 0.05$

Table 11. Effect of plant spacing on leaf loss on outdoor roses cv. Silver Jubilee - 1994

		% leaf loss									
	Treatment	22 July	28 July		5 Aug		11Aug		16 Aug	
1.	18 cm centres	-	22.5	(27.8)	24.5	(28.6)	22.5	(27.9)	57.5	(49.3)
2.	25 cm centres	-	13.7	(20.6)	18.0	(24.9)	17.5	(24.2)	47.5	(43.5)
3.	32 cm centres	-	4.0	(11.1)	10.5	(18.5)	7.5	(15.4)	33.7	(35.4)
4.	Pot tight on NS^{+} rows	-	10.7	(18.7)	11.2	(19.3)	6.7	(14.9)	42.5	(40.6)
5.	Pot tight in EW^{+} rows	-	17.5	(23.9)	18.7	(25.6)	18.7	(25.6)	45.0	(42.1)
6.	Staggered spacing	-	10.7	(18.4)	18.0	(25.0)	15.0	(22.5)	46.2	(42.8)
	Significance		-	*	-	NS	-	*	-	*
	SED (15 d.f.)			(4.53)		(4.44)		(3.69)		(3.18)

		% leaf loss		
		30 Aug		13 Sept
1.	18 cm centres	61.2	(51.5)	63.7 (53.0)
2.	25 cm centres	56.2	(48.6)	57.5 (49.3)
3.	Pot tight on NS^{+} rows	51.2	(45.7)	60.0 (50.8)
4.	Pot tight on NS^{+} rows	52.5	(46.4)	58.7 (50.1)
5.	Pot tight in EW rows	47.5	(43.5)	57.5 (49.3)
6.	Staggered spacing	53.7	(47.2)	61.2 (51.5)
	Significance	-	NS	- NS
	SED (15 d.f.)		(3.16)	(2.15)

$^{+}$NS - North-South rows
$^{+}$EW - East-West rows, used for statistical analyses

NS - no significant differences
* Significant at $P < 0.05$

( ) - Angular transformed values, used for statistical analyses.

DISCUSSION

The results of Experiments 2 and 4 indicate a range of fungicides are available which provide significant control of rose downy mildew. Previous studies (Baker, 1953; Bertus, 1977) reported that dithiocarbamate fungicides (e.g. Dithane DF) controlled the disease. This study indicates that several products provide control superior to that of dithiocarbamate fungicides.

Ripost gave highly effective control. This product is also reported to give good control of potato blight (*Phytophthora infestans*) when used as a preventative treatment; synergism between the three active ingredients has been suggested as an explanation for its good effect (Samoucha & Cohen, 1989). Although Ripost was very effective in controlling rose downy mildew when applied before the disease was found, it was ineffective in 1993 when sprays were started 6 weeks after the disease was found. In 1994, a Ripost/Aliette spray programme gave good disease control when started as soon as symptoms of downy mildew occurred but no control when started just two weeks later. These results indicate that early treatment is essential to achieve control of rose downy mildew. Jones *et al.* (1993) found that spray programmes which included Aliette gave control of hebe downy mildew (*Personospora grisea*) on plants already infected, but three phenylamide fungicides (benalaxyl, metalaxyl and oxadixyl) were ineffective.

Aliette gave good control of rose downy mildew when applied as a high volume spray but no control when applied monthly as a drench. Possibly this results from poor systemicity in woody rose stems.

Highly effective control resulted following treatment with the experimental protectant fungicide (fluazinam). This chemical has previously been found to control downy mildew on cucumber (Anema *et al.*, 1993).

Fongarid applied monthly as a drench gave some control of downy mildew. Possibly more frequent application would result in better control, although this would be costly.

Resistance of lettuce downy mildew (*B. lactucae*) to phenylamide fungicides (e.g. metalaxyl in Fubol) was reported by Crute (1987). There was no evidence from our work that rose downy mildew is resistant to phenylamide fungicides; Fongarid (furalaxyl) gave control.

Alternating spray programmes of Ripost/Aliette, Ripost/fluazinam, fluazinam/Aliette and Ripost/Aliette/fluazinam all gave good control of rose downy mildew. Aliette (an organo-phosphorus product), Ripost (a dithiocarbamate + thiocarbamate + phenylamide product) and fluazinam (a diarylamine product) have active ingredients in different fungicide groups and are well suited for use as alternating products in programmes aimed at minimising the risk of fungicide resistance developing. In experiment 4, a weather-dictated spray programme (treatment 8) and 'first symptom' programmes (treatments 9-12) gave good disease control with reduced fungicide use. The weather-dictated programme showed that the spray interval can be extended in dry weather. However, given the rapid speed at which rose downy mildew can develop, and the poor control by fungicides when disease is established, this is a very risky strategy to adopt at present; possibly, in-crop leaf wetness monitoring may allow use of such a strategy in the future. Fungicide treatments with Aliette, Ripost, fluazinam or Favour starting at first symptoms gave good control. This strategy of spraying at first symptoms would depend on frequent and careful crop monitoring.

As the roses in this experiment were irrigated by overhead sprinklers 'blight conditions' favourable to infection are likely to have occurred more frequently than at the recording station, where rain would be the main cause of high humidity. This probably explains why downy mildew occurred in the experiment before the first recorded 'blight period'.

The results of experiments reported here show that varieties of rose obviously differ greatly in their susceptibility to *P. sparsa*. Silver Jubilee appears to be very susceptible, Troika slightly susceptible and Hampshire appears to be resistant. Differences in susceptibility have been noted by previous works (Baker, 1953; Gill, 1977). The basis of rose resistance to downy mildew appears to be unknown; if resistance is determined by single, major genes then varietal susceptibility may differ in different geographical areas, and resistance in a particular variety may be transient according to the occurrence of different pathotypes.

The symptoms of downy mildew observed in this work were reddish-brown spotting of leaves and premature, sudden leaf fall. Both symptoms have previously been associated with the disease (Francis, 1981). Dark spotting on rose leaves may also result from infection by *Diplocarpon rosae* or *Sphaerotheca pannosa*, the causes of black spot and powdery mildew respectively. Dark spotting and defoliation may also occur when no fungal pathogen is present (Tramier, 1962). In 1994, *P. sparsa* was also associated with red-brown lesions on flower stalks and occasionally on petioles.

Rose downy mildew is favoured by high humidity and leaf wetness (Gill, 1977). Experiment 5 demonstrated that increased plant spacing and arrangement in rows in direction of the prevailing wind (southerly) can delay first occurrence of the disease and slow epidemic development; possibly this resulted because of lower humidities between plants and more rapid leaf drying following rain or overhead watering. Experimental work is needed to determine the relative importance of leaf dryness, compared to use of a fungicide spray programme, for control of downy mildew. If leaf wetness is the predominant factor driving downy mildew development, it may be possible to control the disease by appropriate plant spacing and timing of irrigation; fungicide use could then be minimised. Investigation of irrigation, applied overhead early in the morning, or late in the evening, or without wetting leaves (e.g. sand bed or trickle irrigation) would be useful.

CONCLUSIONS

1. The variety Silver Jubilee was highly susceptible to downy mildew; Troika was slightly susceptible and Hampshire appears to be resistant.

2. Nine fungicides (Aliette, Curzate M, Dithane, Favour, Filex, fluazinam, Fongarid, Fubol 75 and Ripost) gave control of downy mildew. Ripost and fluazinam gave excellent control in 1993 Alternating programmes of Ripost, Aliette and fluazinam gave good control in 1994.

3. Aliette was effective when applied as a spray but ineffective when applied as a compost drench to woody-stemmed roses.

4. Although Ripost was high effective as a preventative treatment, application of four sprays to plants already severely affected by downy mildew gave no control.

5. A Ripost/Aliette programme starting at first symptoms of downy mildew gave good control but the same programme starting only two weeks later gave no control.

6. Extending the spray interval of a Ripost/Aliette programme from 14 days to 28 days in hot, dry weather did not reduce the level of disease control. However, this is a risky strategy and it is not recommended as a strategy to be used in commercial crops at present.

7. There was no evidence of resistance to phenylamide fungicides.

8. It was more expensive to apply fungicides as drenches than as high volume sprays.

9. Increased plant spacing delayed the first occurrence of downy mildew and slowed epidemic development.

10. Red-brown spotting on rose leaves caused by downy mildew may be confused with spotting caused by black spot (*Diplocarpon rosae)*, powdery mildew (*Sphaerotheca pannosa)* or a non-parasitic necrotic spotting. Downy mildew can cause red-brown lesions on flower stalks and petioles.

11. Severe downy mildew can lead to very poor growth resulting in smaller plants with thinner stems when compared to unaffected plants of the same variety.

ACKNOWLEDGEMENTS

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Mean effect of variety and fungicide treatment on downy mildew of outdoor rose, cvs. Silver Jubilee and Troika (Experiment 2) - 1993

Factor	% leaf area affected			
	23 June	14 July	10 Aug	29 Sept
Variety				
Silver Jubilee	5.7	4.1	12.4	7.3
Troika	0.5	0.3	0.9	1.2
Significance	**	**	**	**
SED (69 d.f.)	0.45	0.28	0.66	0.45
Treatment				
1. Untreated	5.4	3.6	10.6	6.6
2. Dithane	4.6	3.1	8.4	5.2
3. Curzate M	3.6	3.3	10.2	6.5
4. Filex	1.6	1.6	7.7	4.4
5. Fubol 75	1.6	0.7	4.1	4.4
6. Ripost	0.4	0.6	1.1	0.7
7. Aliette	2.1	1.0	6.1	2.9
8. Fongarid (drench)	3.0	3.0	6.9	5.2
9. Aliette (drench)	6.2	3.8	8.5	5.7
10. Experimental	0.4	0.5	1.9	0.9
11. Programme	2.6	1.7	3.7	2.8
12. Ripost (late)	--	--	10.6	5.7
Significance	**	**	**	**
SED between treatments	1.10	0.69	1.63	1.11
vs control (69 d.f.)	0.96	0.60	--	--

Downy mildew was first found in the trial on 17 June.
Fungicides were applied from 30 April to 6 September; treatment 12 was applied from 26 July

** - significant at $P < 0.01$

Effect of fungicide treatment on downy mildew of outdoor rose cv. Troika (Experiment 2) - 1993

Treatment	% leaf area affected by downy mildew			
	23 June	14 July	10 Aug	29 Sept
1. Untreated	1.0	0.4	1.4	2.3
2. Dithane	0.7	0.2	1.0	1.4
3. Curzate M	0.4	1.0	0.5	0.6
4. Filex	0.8	0.3	0.8	2.0
5. Fubol 75	0.6	0.1	0.7	0.7
6. Ripost	0.1	0.1	0.7	1.0
7. Aliette	0.4	0.3	0.8	0.4
8. Fongarid (drench)	0.3	0.3	1.2	0.5
9. Aliette (drench)	0.5	0.4	0.6	2.1
10. Experimental	0.2	0.7	0.8	2.1
11. Programme	0.2	3.3	0.8	0.4
12. Ripost (late)	-	-	1.6	0.8
Significance	NS	NS	NS	NS
SED between treatments	1.56	0.98	2.30	1.57
vs. control (69 d.f.)	1.35	0.85	-	-

NS - not significant

Mean effect of variety and fungicide treatment on loss of foliage of outdoor rose, cvs. Silver Jubilee and Troika (Experiment 2) -1993

Factor	% leaf drop			
	23 June	14 July	10 Aug	29 Sept
Variety				
Silver Jubilee	11.0	15.2	21.0	19.0
Troika	0.4	0.9	0.7	2.0
Significance	**	**	**	**
SED (69 d.f.)	1.18	1.37	2.31	1.46
Treatment				
1. Untreated	11.1	16.0	16.7	15.7
2. Dithane	6.2	9.5	12.9	13.8
3. Curzate M	5.1	14.7	18.0	15.9
4. Filex	3.5	4.7	12.4	11.5
5. Fubol 75	2.3	1.2	5.8	10.9
6. Ripost	0.8	1.2	1.3	2.2
7. Aliette	4.3	4.3	8.4	6.3
8. Fongarid (drench)	3.7	7.6	12.2	12.9
9. Aliette (drench)	15.0	16.3	16.0	13.2
10. Experimental	0.6	1.3	1.9	2.4
11. Programme	4.3	3.7	5.7	7.0
12. Ripost (late)	--	--	18.5	14.1
Significance	**	**	**	**
SED between treatments	2.89	3.36	3.27	3.57
vs control (69 d.f.)	2.51	2.91	--	--

Downy mildew was first found in the trial on 17 June.
Fungicides were applied from 30 April to 6 September (treatment 12 was applied from 28 July).

Effect of fungicide treatment on loss of foliage of outdoor rose, cv. Troika (Experiment 2) - 1993

Treatment	% leaf drop			
	Troika			
	23 June	14 July	10 Aug	29 Sept
1. Untreated	1.1	1.2	0.9	3.5
2. Dithane	0.7	1.1	1.6	2.1
3. Curzate M	0.3	1.2	0.7	1.4
4. Filex	0.1	1.0	0.4	2.3
5. Fubol 75	0.7	0.4	0.7	1.5
6. Ripost	0	0.3	0.5	2.0
7. Aliette	0.2	0.8	0.3	0.9
8. Fongarid (drench)	0.2	1.5	0.6	1.3
9. Aliette (drench)	0.2	0.8	1.1	4.0
10. Experimental	0.1	0.7	0.3	2.3
11. Programme	0.1	0.3	0.3	0.8
12. Ripost (late)	-	-	0.5	1.6
Significance	NS	NS	NS	NS
SED between treatments	4.0	4.75	3.27	5.06
vs. control (69 d.f.)	3.5	4.12	-	-

NS - not significant

Mean effect of variety and fungicide treatment on plant quality of outdoor rose, cvs Silver Jubilee and Troika (Experiment 2) - 1993

Factor	Final plant quality (29 Sept)	
	Plant vigour (0-5)	Plant height (cm)
Silver Jubilee	4	48
Troika	5	69
Significance	**	**
SED (69 d.f.)	0.1	0.5
Treatment		
1. Untreated	4	52
2. Dithane	4	58
3. Curzate M	4	57
4. Filex	4	58
5. Fubol 75	4	61
6. Ripost	5	62
7. Aliette	5	63
8. Fongarid (drench)	4	52
9. Aliette (drench)	4	52
10. Experimental	5	64
11. Programme	5	65
12. Riposte (late)	4	56
Significance	**	**
SED (69 d.f.)	0.2	1.3

** - significant at $P < 0.01$

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

1. TITLE OF PROJECT **Contract No: HNS53 (Extension for a second year)**

CONTAINER GROWN ROSES: CONTROL OF DOWNY MILDEW BY MANIPULATION OF CULTURAL FACTORS AND TIMELY USE OF FUNGICIDES

2. BACKGROUND AND COMMERCIAL OBJECTIVE

As for HNS 53

In year 1 of the experiment (1993) three fungicides were identified which gave good control of the disease when applied as high-volume sprays at 14 day intervals from soon after potting. One of these was also evaluated as an eradicant treatment, but it gave no control when the first spray was delayed until plants were severely affected.

The commercial objective now is to develop effective programmes based on the first year's results, to include:

A. An evaluation of a range of alternating protectant programmes based on Aliette, Ripost and fluazinam.

B. An evaluation of programmes involving less frequent spraying.

C. An evaluation of four products for eradicant activity.

D. An evaluation of new fungicides for downy mildew control, should any become available.

E. An evaluation of plant spacings which may reduce the risk of downy mildew.

3. POTENTIAL FINANCIAL BENEFIT TO THE INDUSTRY

As for HNS53.

4. SCIENTIFIC/TECHNICAL TARGET OF THE WORK

As for HNS53.

5. CLOSELY RELATED WORK COMPLETED OR IN PROGRESS

As for HNS53.

6. DESCRIPTION OF THE WORK IN YEAR 2 (1994)

Trial 1. Comparison of fungicide programmes for control of downy mildew in container-grown roses

Site: Notcutts Nurseries, Woodbridge, Suffolk

Treatments:

1. Water spray
2.)
3.) Two-product protectant programmes
4.)
5. Three-product protectant programme
6.)
7.) Two-product reduced spraying programmes
8.)
9.)
10.) Comparison of products for eradicant activity
11.)
12.)

Details of treatments:

1. Water sprays every 14 days (double replication).
2. Ripost ~~Pepite~~ (250 g/ 100 l) alternating with Aliette (500 g/100 l) approximately every14 days * from first new leaf.
3. Ripost Pepite (250 g/100 l) alternating with fluazinam (200 ml/ 1001) approximately every 14 days * from first new leaf.
4. Fluazinam (200 ml/100 l) alternating with Aliette (500 g/100 l) approximately every 14 days * from first new leaf.
5. Ripost Pepite (250 g/100 l), alternating with Aliette (500 g/100 l) and fluazinam (100 ml/ 100 l) every 14 days from first new leaf.
6. Ripost Pepite (250 g/100 l) alternating with Aliette (500 g/100 l) every 14 days from first recorded blight risk period in the area.
7. Ripost Pepite (250 g/100 l) alternating with Aliette (500 g/100 l) every 14 days from first occurrence of leaf spotting in the experiment.
8. Ripost Pepite (250 g/100 l) alternating with Aliette (500 g/100 l), first spray at first new leaf; subsequent sprays at 14-28 day intervals according to weather.+
9. Aliette (500 g/100 l) every 14 days from first occurrence of leaf spotting.
10. Ripost Pepite (250 g100 l) every 14 days from first occurrence of leaf spotting.
11. Fluazinam (200 ml/100 l) every 14 days from first occurrence of leaf spotting.
12. Favour (400 ml/100 l) every 14 days from first occurrence of leaf spotting.

* Spray interval varied from 12-16 days dependent on weather; shorter intervals in wet weather.

\+ Long interval in dry weather; short interval in wet weather.

Four replicate blocks with 9 plants/pots arranged in a square. Randomised allocation of treatments within block.

Infector plants introduced into the trial area if disease does not occur naturally. Do not treat infector plants (remove them from the trial when further treatments are applied, and then replace them). Plants to be spaced at normal nursery spacing. Any new fungicides which become available in early 1994 would be evaluated in unreplicated plots.

Method — Sprays applied at HV to the point of run-off (900 l/ha). Plants potted in 3 l pots.

Assessments — After 4 sprays, and 2 weeks after the eighth and final spray. Assess:

1. % leaf area affected by purple-black spotting (sample to confirm downy mildew).
2. Number of stem lesions (count if few; index if large).
3. Estimate of leaf loss (downy mildew can cause premature leaf abscission).
4. Estimate of plant vigour (0-5).
5. Evidence of phytotoxicity (e.g. leaf scorch).

Varieties: Hybrid type, cv Silver Jubilee

Number plants:

52 plots x 9 plants =	468 plants.	
4 plots x 9 plants =	36 plants	(unreplicated plots for new fungicides).
Total	504 plants	

Approximate timings:

Establish trial in April. Apply sprays to end July (8 in total).

First assessment at end of May and second in mid-August.

Crop husbandry: Irrigate overhead.
No fungicides to be incorporated into compost.

Pest and weed control as required, to be done by Notcutts staff. Also overspray whole trial with Systhane to control powdery mildew, blackpoint and rust.

Trial 2. Effect of plant spacing on development of downy mildew in outdoor container-grown roses - 1994.

Site — Notcutts Nurseries, Woodbridge, Suffolk

Treatments:

1. Standard spacing (18 cm centres)
2. 25 centre to centre
3. 32 centre to centre
4. Pot tight in horizontal rows (18cm between rows)
5. Pot tight in vertical rows (18cm between rows)
6. Staggered placement at c.18cm centres.

Design — Randomised blocks with four-fold replication. 20 plants/plot.
Infector plants will be introduced into the experimental area, should the disease not occur naturally.

Assessments: Assess plants 6 weeks and 12 weeks after trial has been established.

Assess:

1. % leaf area affected by downy mildew spotting.
2. Number of stem lesions.
3. Estimate of green leaf cover.

Variety: cv. Silver Jubilee

Number plants required: 24 plots x 20 plants = 480 plants.

Approximate timing: Establish trial in April
Assess in May and July

Crop husbandry:
Irrigate overhead.
No fungicides to be incorporated into compost.
Overspray whole trial with Systhane to control powdery mildew, blackspot and rust.
Pest and weed control as required, to be done by Notcutts staff.

7. COMMENCEMENT DATE, DURATION AND REPORTING

Start date: 01.04.93; duration 2 years. A report for year 1 of the project will be produced by April 1994 and the results from year 1 and 2 will be combined into a final report which will be produced by March, 1995.

8. STAFF RESPONSIBILITIES

As for HNS53.

9. LOCATION

As for HNS53.

Contract No: HNS53 (Ext)
Date: 23.5.94

TERMS AND CONDITIONS

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

Signed for the Contractor(s)

Signature.....
Position.....
Date.....

Signed for the Contractor(s)

Signature.....
Position.....
Date.....

Signed for the Council

Signature.....
Position.....
Date.....