ADAS

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Project No: FV155 (ADAS Project C001296)

Project Title: **EVALUATION OF FUNGICIDES FOR THE CONTROL OF BRASSICA DOWNY MILDEW IN PROPAGATION**

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CONTENTS

Action for Growers

- Aliette foliar sprays applied at 0.5g/m^2 gave the best control of downy mildew.
- Filex drench reduced disease up to the third expanded leaf growth stage and increased plant vigour.
- The best chemical control programme was from the Filex drench (10.0 ml/m^2) supplemented with foliar sprays of Treatment X.
- Weekly applied Aliette foliar sprays performed better than fortnightly applications.
- An application for the emergency Off-Label Approval for Aliette as a foliar spray has been submitted and it is anticipated to come into effect from autumn 1996.
- Up to 10 sprays of Aliette as a foliar spray at 0.5 g/m^2 will be allowable (a total maximum of 5.0 g/m^2) to cover the over-wintering season October to March (20 weeks). Aliette should be applied fortnightly but there may be an opportunity during high risk periods to reduce the interval to 10 days.

Summary

In all three years of this experiment fungicides were evaluated on the early summer cauliflower cv. Marba propagated overwinter in a polythene tunnel.

In the first year, the effect of Aliette (fosetyl-aluminium), Curzate M (cymoxanil + mancozeb), fluazinam and Foli-R-Fos (phosphorous acid) were compared. They were applied with or without the adjuvant Solucuivre (copper tallate), and as protectant or eradicant spray programmes. Control of downy mildew on the cotyledons was given by Curzate M or fluazinam applied as protectants. Adjuvant improved control from Curzate M but not with fluazinam. Control of downy mildew on the leaves was given by Aliette applied without adjuvant, and no sporulation and less necrosis was detected following this treatment. At the planting-out stage, plants treated with Curzate M, Aliette or fluazinam were the most vigorous and the most marketable. The most marketable plants were those treated with the protectant programme without adjuvant.

In the second year, three experiments were made.

1. The effect of selected rates of Aliette (fosetyl-aluminium) and a single rate of Filex (propamocarb hydrochloride) applied as drenches at sowing was evaluated. Filex gave a larger reduction in sporulation and necrosis, and gave increased plant vigour. Aliette at 5 g/m^2 was effective, but only in late propagation.

2. The effect of fortnightly spray programmes of Aliette, applied at selected rates, from the first true leaf growth stage, was evaluated. Only Aliette at 0.5 g/m^2 gave a consistent reduction in sporulation and necrosis, especially in late propagation. There were no differences in marketability, with few trays being marketable.

3. Eleven selected fungicide foliar spray programmes, applied fortnightly from the expanded cotyledon stage, were evaluated. Good disease control in early propagation was achieved with fluazinam, Filex and especially Invader. Fungicides which gave some reduction in sporulation and increased plant vigour were Invader, Tatoo, fluazinam, Fubol and Treatment X. Invader and fluazinam treatments were assessed as being readily marketable.

In the third year two experiments were made.

1. The effect of Filex drench was compared with an initial Aliette spray, both with supplementary weekly or fortnightly sprays of Aliette. The Filex drench significantly reduced disease incidence compared with the Aliette foliar sprays, but the effect of Filex diminished by the third leaf expanding growth stage. At the leaf four expanding growth stage, in the absence of the Filex drench, chlorosis was significantly reduced by weekly Aliette sprays compared with fortnightly ones. Equally good control of chlorosis was obtained (at leaf four expanding growth stage) from the Filex drench treatment supplemented with fortnightly Aliette sprays to that given by weekly Aliette sprays. The most vigorous treatments were those which received the Filex drench but no differences in marketability were observed. The untreated was assessed as being unmarketable, reflecting severe disease.

2. The effect of Filex drench compared with initial sprays of Aliette on its own, Treatment X, Invader, Tatoo and fluazinam was evaluated with supplementary fortnightly sprays of the same foliar sprays. The Filex drench reduced disease up to the third expanded leaf growth stage. Aliette treatment, and Treatment X, reduced the number of plants with downy mildew up to the third expanded leaf growth stage, but Treatment X consistently significantly reduced leaf chlorosis. The most vigorous plants were those which had received the Filex drench, reflecting good early disease control. The most marketable plants were those treated with Filex drenches with supplementary sprays of Aliette, Treatment X, Invader and Tattoo and also the latter two treatments as sprays only. The untreated was assessed as being unmarketable.

INTRODUCTION

Downy mildew caused by the fungus *Peronospora parasitica* is an important disease of cauliflowers. It can be a major problem in propagation affecting appearance and vigour and, in severe cases, young plants may be stunted or killed.

With early summer cauliflowers raised in Hassey 308 trays, no control was obtained with Aliette incorporated in the compost; however in summer cauliflowers this treatment was more effective than as a compost drench or as foliar sprays (Davies & Wafford 1988).

Currently, Aliette can be used as a post-seeding drench under the Off-Label Approval and supplemented, as necessary, by foliar sprays of Elvaron. This treatment can be successful in spring propagation but not for the overwintered crop. Foliar sprays of Aliette have given good control of downy mildew in cv. Danish Perfection sown in mid October and raised in Hassey 308 trays when under low to moderate disease conditions (Davies 1993). At present, there is no approval for this use.

The overwintered, early summer cauliflower crop is particularly susceptible to downy mildew and with the introduction of GPG 345 modular trays and increased plant density, the mildew risk will be greater making fungicide application even more important. The aim of this work is to evaluate the efficiency of a range of fungicides applied as drench treatments and as protectant foliar sprays (before mildew appearance) and as eradicants (after mildew has developed in the crop) and with or without an adjuvant.

MATERIALS AND METHODS

Experiment in 1993/4

Treatments

1	Untreated control	
2	Curzate M (cymoxanil + mancozeb)	0.2 g/m^2
3	Foli-R-Fos (phosphorous acid)	0.25 ml/m^2
4	Aliette (fosetyl-aluminium)	0.5 g/m^2
5	Fluazinam	0.1 ml/m^2

Programme

(a) Foliar fungicide sprays applied routinely as protectants before appearance of downy mildew symptoms and every 2 weeks thereafter. See Appendix IV for details of fungicides.

(b) Foliar fungicide sprays applied as eradicants every 2 weeks from the appearance of extensive downy mildew symptoms i.e. most plants affected. See Appendix IV for details of fungicides.

Adjuvant

(a) Present as Solucuivre (copper tallate) 100 ml /100 l. See Appendix IV for details of adjuvants.

(b) Absent.

Application dates of fungicides are given in Appendix I.

Experiments in 1994/5

Experiment 1

Treatments

1	Untreated	
2	Aliette Drench	5.0 g/m^2
3	Aliette Drench	2.5 g/m^2
4	Aliette Drench	0.1 g/m^2
5	Filex Drench	10.0 ml/m^2

Drench treatments were applied pre-emergence and subsequent application dates of fungicides are given in Appendix I.

Experiment 2

All seed in this experiment was treated with metalaxyl to protect against downy mildew in early propagation. Curzate (0.2 g/m²) was applied to all trays on 1 December 1994.

Treatments

1	Untreated	
2	Aliette Spray	0.5 g/m²
3	Aliette Spray	0.4 g/m²
4	Aliette Spray	0.3 g/m²
5	Aliette Spray	0.2 g/m²
6	Aliette Spray	0.1 g/m²

Fungicide sprays commenced at the cotyledon growth stage. Seven fortnightly sprays were applied. Application dates are given in Appendix II.

Experiment 3

Treatments

1	Untreated	
2	Aliette	0.5 g/m²
3	Foli-R-Fos	0.5 ml/m²
4	Curzate	0.2 g/m²
5	Fluazinam	0.2 ml/m²
6	Tatoo	0.4 ml/m²
7	Invader	0.2 g/m²
8	Filex	0.2 ml/m²
9	Fubol 75 WP	0.2 g/m²
10	Elvaron	0.17 g/m²
11	Treatment X	
12	Treatment Y	

See Appendix IV for details of fungicides & adjuvants.

Fungicide sprays commenced at the expanded cotyledon growth stage and application dates are given in Appendix II.

Experiments in 1995/6

Experiment 1

Treatments

	Initial	Supplementary
1	Untreated	
2	Filex drench (10.0 ml/m²)	Aliette spray (0.5 g/m²) every 2 weeks*
3	Filex drench (10.0 ml/m²)	Aliette spray (0.5 g/m²) every week*
4	Aliette spray (0.5 g/m²)**	Aliette spray (0.5 g/m²) every 2 weeks*
5	Aliette spray (0.5 g/m²)**	Aliette spray (0.5 g/m²) every week*

*Aliette sprays applied at full cotyledons growth stage.

**Aliette spray applied at 50% cotyledons growth stage.

Ten weekly and eight fortnightly sprays were applied, see Appendix III for dates.

Experiment 2

Treatments

	Initial	Supplementary
1	Untreated	
2	Filex drench (10.0 ml/m²)	Aliette (0.5 g/m²) every 2 weeks*
3	Filex drench (10.0 ml/m²)	Treatment X every 2 weeks*
4	Filex drench (10.0 ml/m²)	Invader (0.2 ml/m²) every 2 weeks*
5	Filex drench (10.0 ml/m²)	Tattoo (0.4 ml/m²) every 2 weeks*
6	Filex drench (10.0 ml/m²)	Fluazinam (0.2 ml/m²) every 2 weeks*
7	Aliette spray (0.5 g/m²)**	Aliette (0.5 g/m²) every 2 weeks*
8	Treatment X	Treatment X every 2 weeks*
9	Invader spray (0.2 g/m²)**	Invader (0.2 ml/m²) every 2 weeks*
10	Tattoo spray (0.4 g/m²)**	Tattoo (0.4 ml/m²) every 2 weeks*
11	Fluazinam spray (0.2 g/m²)**	Fluazinam (0.2 ml/m²) every 2 weeks*

*Sprays applied at full cotyledons growth stage.

**Sprays applied at 50% cotyledons growth stage.

Eight fortnightly sprays were applied see Appendix III for dates.

Fungicide application

Fungicide drenches were applied using an MDM Oxford Precision sprayer at 100 kPa pressure with an 8008E jet. All fungicide drenches were applied in 250 ml of water per tray. Fungicide foliar sprays were applied with an MDM Oxford Precision sprayer at 110 kPa pressure with an 8002E jet. All foliar fungicides were applied in 25 ml of water per tray.

Propagation

Plants were propagated in a polythene tunnel under frost free conditions, in GPG 345 modular trays (each tray 0.25m^2) using specialist proprietary free-flowing modular compost with controlled levels of nitrogen. Plants were fed as necessary with Sangral SHL 1•1•1.

Downy mildew infector plants were introduced around the experiments in pots and trays after plant emergence . The temperature and humidity were raised to encourage high disease on the cotyledons.

Experiment design and statistical analysis

1993/4

This experiment was a three-way factorial design, randomised in three blocks.

1994/5

Experiment 1 - Randomised block design with five treatments and five replicates.
Experiment 2 - Randomised block design with six treatments and five replicates.
Experiment 3 - Randomised block with twelve treatments and four replicates.

1995/6

Experiment 1 - 2 x 2 factorial plus untreated control and four replicates.
Experiment 2 - 2 x 5 factorial plus untreated control and four replicates.

In all years continuous data sets (e.g. percentage plants infected) were subjected to analysis of variance. Standard errors of differences between means (SED) are quoted when probability P is <0.05. NS = not significant, $P>0.05$. In the second and third year discrete data sets (e.g.

sporulation, vigour scores) were subjected to Friedman's test and treatment mean differences were according to Dunnet's test. Fungicide treatment means were compared with the untreated control.

Assessment methods

Downy mildew was assessed on 100 plants from the centre of each tray in year 1 and this was then reduced to 50 plants in subsequent years. Prior to each spray date downy mildew was assessed as (a) % plants affected, (when % plant infection reached 100%, this assessment was omitted) (b) sporulation index and (c) necrosis index. The assessment of % plants infected included plants showing sporulation, chlorosis or necrosis.

Sporulation index	Necrosis index
0 = nil	0 = no symptoms
1 = sparse	1 = discrete necrotic flecking
2 = moderate	2 = small necrotic patches
3 = good	3 = necrotic patches beginning to coalesce
4 = heavy	4 = widespread necrosis

Crop performance

Crop growth stage (number of cotyledons and true leaves) was recorded at each disease assessment date.

Phytotoxicity was recorded when differences between treatments were apparent, using a vigour score, where 0 represented no effect and 5 the greatest effect. Marketability was recorded using a similar index in the first year but in subsequent years trays were assessed as being marketable or unmarketable.

Results

1993/4

Downy mildew was first recorded on the stems on 6 December, four days after the first protectant sprays were applied. The disease developed with up to 38% plants affected with downy mildew on the stems in the untreated on 26 January.

Downy mildew was first recorded on the cotyledons on 16 December in the untreated trays with 18% plants affected. Downy mildew on the stem was reduced by treatment with Curzate M, Aliette or fluazinam, the last having the greatest effect. Only the protectant spray programme had an effect with fewer dead plants being seen (Appendix I).

Up to 100% of plants in the untreated controls were affected with downy mildew on the cotyledons from mid-January onwards. There was less downy mildew, sporulation and necrosis of the cotyledons and plants were more vigorous following the protectant programme (Appendix I). Differences between fungicides and between fungicide/adjuvant combinations were detected in plant vigour (Appendix I).

At the end of January fewer plants ($P < 0.001$) were affected with downy mildew (83%) on the cotyledons following the protectant programme compared with the untreated or following the eradication programme (99% and 100%) respectively. No control was achieved with Foli-R-Fos or Aliette. There was less downy mildew on the cotyledons following treatment with Curzate M and fluazinam (Appendix I). Only Curzate M and fluazinam applied as protectants reduced the number of plants with downy mildew on the cotyledons (table 1).

Table 1 Effects of fungicide and spray programme on downy mildew on the cotyledons (26 January).

	% Plants with downy mildew on the cotyledons				
Spray Programme	Untreated	Curzate M	Foli-R-Fos	Aliette	Fluazinam
None	99				
Protectant		60	100	100	72
Eradicant		100	100	100	100
SED (df 39)					8.3
P					0.002
CV%					15.5

On 26 January, downy mildew was recorded on the first true leaves with up to 10% of plants affected. Plant necrosis was also reduced by fungicides, and spray programmes (Appendix 1).

By mid February, downy mildew incidence had increased on the leaves. More downy mildew on the leaves ($P = 0.006$) was present with adjuvant with 99% plants affected compared with 86% without adjuvant. The number of plants affected with downy mildew on the leaves was reduced only by the Aliette treatment (table 2).

Table 2 Effect of fungicides on downy mildew on the leaves. Second /third true leaf unfolding (10 February).

	Untreated	Curzate M	Foli-R-Fos	Aliette	Fluazinam
% Plants downy mildew	91	100	99	72	100
SED (df 39)					7.2
P					< 0.001
CV%					17.7

Aliette treatment without adjuvant resulted in the least downy mildew on the leaves. There was no effect of any of the other fungicide spray programme or adjuvant combinations (table 3).

Table 3 Effect of fungicide and adjuvant on downy mildew on the leaves. Second/third true leaf unfolding (10 February).

	% Plants with downy mildew				
Adjuvant	Untreated	Curzate M	Foli-R-Fos	Aliette	Fluazinam
Absent	91				
Absent		99	100	44	100
Present		100	99	99	99
SED (df 39)					8.6
P					<0.001
CV%					17.7

No sporulation was detected following Aliette treatment. There was no effect of any of the other fungicides on sporulation (table 4).

Table 4 Effect of fungicides on sporulation. Second/third true leaf unfolding (10 February).

	Untreated	Curzate M	Foli-R-Fos	Aliette	Fluazinam
Sporulation (index)*	1.8	1.7	1.9	0.0	1.7
SED (df 39)					0.53
P					>0.001
CV%					86.4

*0 = nil 4 = the most

At the third true leaf growth stage (24 February) only the Aliette treatment reduced downy mildew on the leaves (Appendix I).

There was also an effect of adjuvants and fungicides on sporulation necrosis on the leaves and on plant vigour (Appendix I).

At the planting out stage (10 March), there were fewer dead plants following the protectant spray programme (4%) compared with the eradicant programme (10%) or the untreated control (11%).

Neither fungicides or adjuvants had an effect on plant death.

Plants treated with the protectant programme were more vigorous with an index of 2.9 compared with 2.1 following the eradication programme.

Plants treated with Curzate M, Aliette or fluazinam were the most vigorous and were the most marketable. In addition, the most marketable plants were those treated with the protectant programme without adjuvant (Appendix I).

1994/5

Experiment 1

At the first true leaf expanded growth stage, only the Filex drench significantly reduced sporulation and necrosis and also increased plant vigour (table 5).

Table 5 Effect of fungicide drench on downy mildew sporulation, plant necrosis and vigour. First true leaf expanding (7 December).

Treatment		Sporulation index (median)	Necrosis index (median)	Vigour index (median)
Untreated		4.0	2.0	2.0
Aliette Drench	5.0 g/m²	3.0	1.0	3.0
Aliette Drench	2.5 g/m²	3.0	1.2	2.8
Aliette Drench	0.1 g/m²	4.0	2.8	2.0
Filex Drench	10.0 ml/m²	1.0	0.0	4.2
P (df 4)		0.001	0.001	0.004

When assessed at the third true leaf growth stage Aliette drench at 5.0 g/m² reduced sporulation and necrosis compared with the untreated and this treatment and the Filex drench increased plant vigour (table 6).

Table 6 Effect of fungicide drench on downy mildew sporulation index, plant necrosis and vigour. Third true leaf emerging (18 January).

Treatment		Sporulation index (median)	Necrosis index (median)	Vigour index (median)
Untreated		2.0	3.0	1.0
Aliette Drench	5.0 g/m²	0.8	1.0	4.0
Aliette Drench	2.5 g/m²	2.0	2.0	3.0
Aliette Drench	0.1 g/m²	2.0	2.0	2.0
Filex Drench	10.0 ml/m²	3.2	3.0	5.0
P (df 4)		0.012	0.011	0.001

1994/5

Experiment 2

The Aliette spray at 0.5 g/m² reduced sporulation and necrosis compared with the untreated. There were no differences in vigour between treatments.

Table 7 Effect of Aliette spray on downy mildew sporulation, plant necrosis and vigour. Leaf seven emerging (16 March).

Treatment		Sporulation index (median)	Necrosis index (median)	Vigour index (median)
Untreated		1.6	3.2	2.5
Aliette Spray	0.5 g/m²	0.1	1.0	2.3
Aliette Spray	0.4 g/m²	0.3	2.0	2.3
Aliette Spray	0.3 g/m²	0.6	2.2	3.7
Aliette Spray	0.2 g/m²	1.1	2.7	2.7
Aliette Spray	0.1 g/m²	1.9	3.0	2.5
P (df 5)		0.006	0.002	0.516

1994/5

Experiment 3

Fluazinam, Invader and Filex significantly reduced the percentage of plants affected with downy mildew compared with the untreated control (table 8).

Table 8 Effect of fungicides on downy mildew. Second true leaf emerging growth stage (20 December).

Treatment	% Plants with downy mildew
Untreated	100.0
Aliette	100.0
Foli-R-Fos	100.0
Curzate	83.5
Fluazinam	55.3
Tatoo	92.8
Invader	18.9
Filex	64.0
Fubol	84.6
Elvaron	100.0
Treatment X	94.2
Treatment Y	97.6
SED (df 33)	13.25
P	0.05
CV%	16.0

At the planting out stage, there was no effect of treatment on sporulation but Treatment Y reduced necrosis compared with the untreated control. Fluazinam, Tatoo, Invader, Fubol and Treatment X increased vigour compared with the untreated control (table 9).

Table 9 Effect of fungicide sprays on downy mildew sporulation, plant necrosis and vigour. Leaf seven emerging (16 March).

Treatment	Sporulation index (median)	Necrosis index (median)	Vigour index (median)
Untreated	0.04	2.5	1.0
Aliette	0.00	1.1	3.3
Foli-R-Fos	0.00	2.4	2.5
Curzate	0.33	2.0	3.3
Fluazinam	0.04	2.0	3.5
Tatoo	0.00	2.9	3.7
Invader	0.00	2.0	4.2
Filex	0.08	2.0	2.7
Fubol	0.46	3.0	3.5
Elvaron	0.04	1.9	2.7
Treatment X	0.00	1.2	3.5
Treatment Y	0.00	0.5	3.3
P (df 11)	NS	0.001	0.016

Marketability was assessed on 17 March and the untreated, Foli-R-Fos and the Elvaron treatments were considered unmarketable. Invader and fluazinam treatments were readily marketable and all others were intermediate.

1995/6

Experiment 1

Downy mildew was first seen on the untreated plots on 24 December. Downy mildew incidence increased on the untreated to 46.2%, 84.8% and 100% plants affected when assessed on 8,15 and 22 January respectively. Downy mildew was first recorded in treated plots on 22 January with least disease after the Filex drench (table 10).

Table 10 Effect of Filex drench v Aliette spray on % plants with two true leaves infected with downy mildew.

Treatment	% Plants with downy mildew	
	15 Jan	22 Jan
Untreated	8.4	100.0
Filex drench	0	7.2
Aliette spray	0	39.9
SED (20 df)	NS	12.46
P		0.005
CV%	133.9	58.6

On 29 January (three true leaves) all plants in all treatments were infected with downy mildew.

On 19 February (leaf four expanding) the least disease was seen in the weekly Aliette spray treatments with no effect of the initial Filex drench. However, Filex drench applications followed by Aliette foliar sprays every two weeks had lower disease than Aliette foliar sprays on their own (table 11).

Table 11 Effect of fungicide programme on % plants with chlorosis. Leaf four expanding (19 February).

Treatment	Untreated	Aliette weekly	Aliette every two weeks
Untreated	100		
Filex drench		42.2	54.4
Aliette spray		42.4	89.6
SED (20 df)			9.97
P			0.022
CV%			24.0

No significant differences were seen between the Filex drench and the Aliette spray and the untreated on the mean leaf number on 12 March 1996.

The most vigorous treatments were those which received the Filex drench (Appendix III).

The untreated was assessed as being unmarketable with no differences in marketability between the fungicide treatments.

Experiment 2

On treated plots, downy mildew was first recorded on 2 January at the first true leaf growth stage at trace levels. The disease developed to 20.3% (on 8 January, leaf 3 in bud) with the disease being mainly on the cotyledons. On 15 January (leaf 3 emerging) 62% of plants were affected in the untreated mainly on the cotyledons with trace levels on plants treated with fungicide.
High levels of downy mildew developed on the leaves with the least disease on plants treated with Aliette or Treatment X (table 12).

Table 12 Effect of fungicide treatment on % plants with true leaves infected with downy mildew. Third leaf expanding (22 January).

Treatment	% Plants with downy mildew
Untreated	100.0
Aliette	51.9
Treatment X	49.4
Invader	86.9
Tattoo	88.6
Fluazinam	92.4
SED (33 df)	16.69
P	0.003
CV%	35.8

Plants treated with the drench had the least disease (table 13).

Table 13 Effect of drench v no drench on % of plants with downy mildew. Third leaf expanding (22 January).

Treatment	% Plants with downy mildew
Untreated	100
No Drench	90.0
Drench	57.6
SED (33 df)	14.93
P	<0.001
CV%	35.8

The least number of chlorotic plants were seen consistently in Treatment X (table 14).

Table 14 Effect of fungicide treatment on % plants with leaf chlorosis (from third leaf to fourth leaf expanding).

	% Plants with leaf chlorosis			
Treatment	29 Jan	5 Feb	12 Feb	19 Feb
Untreated	100.0	100.0	100.0	100.0
Aliette	55.0	65.6	74.6	84.2
Treatment X	11.0	11.4	24.0	37.8
Invader	81.2	72.2	90.2	93.7
Tattoo	80.6	78.5	85.7	92.6
Fluazinam	100.0	90.0	100.0	100.0
SED (df 33)	16.10	11.69	13.09	9.44
P	<0.001	<0.001	<0.001	<0.001
CV%	38.3	28.5	27.7	18.5

There was no effect of the drench treatment on leaf chlorosis.

The most vigorous plants were those which had received the Filex drench (Appendix III)

The untreated were assessed as unmarketable. The most marketable were plants treated with Filex drenches with supplementary sprays of Aliette, Treatment X, Invader and Tattoo, and also the latter two treatments as sprays only (Appendix III).

Discussion

In each of the three years of this project very high levels of downy mildew developed in the early summer cauliflower cv. Marba propagated overwinter in a polythene tunnel. The environmental conditions created were very conducive for downy mildew development.

In the first year only, downy mildew was recorded on the stems in early December and had developed by late January on 38% of untreated plants. Downy mildew on the stem was reduced by treatments with Curzate M, Aliette and fluazinam, the last having the greatest effect. Only the protectant spray programme had an effect with fewer dead plants being seen. Aliette gave no control of downy mildew on the cotyledons but this was the only fungicide to give control of downy mildew on the leaves with no sporulation detected. The use the adjuvant Solucuivre did not reduce downy mildew which was disappointing as encouraging results had previously been obtained in the control of downy mildew on grape vines (Soyez 1992).

In the second year of this work, the first experiment showed that only the Filex drench reduced the incidence and sporulation of downy mildew on the cotyledons. The Filex and the Aliette drench at 5 g/m^2 reduced sporulation and necrosis on the expanded leaves and increased vigour. From the second true leaf growth stage onwards, Aliette drench at 5 g/m^2 gave the best reduction in leaf necrosis, and later, downy mildew sporulation.

In the second experiment in the second year, the metalaxyl seed treatment and the Curzate spray delayed the onset of disease by one week (compared with experiment 1). Only the Aliette spray at 0.5 g/m^2 gave a reduction in sporulation and necrosis at most assessment dates. There was no effect of Aliette treatment on plant vigour. There were no differences in marketability and few trays were marketable.

In the third experiment in the second year, significant reductions in the number of plants affected were achieved up to 20 December by fluazinam and Filex with the best reduction being given by Invader. Several fungicides reduced sporulation and necrosis especially Aliette. Plants treated with Invader, Tatoo, fluazinam, Aliette, Fubol and Treatment X were consistently more vigorous and this was reflected in greater dry weights at the planting out stage. The untreated, Foli-R-Fos and Elvaron treated plants were assessed as being unmarketable. Plants from all other treatments were marketable with Invader and fluazinam treatments giving the best quality.

In first experiment in the third year, during early propagation, the Filex drench significantly reduced disease incidence compared with the Aliette foliar sprays but the effect of Filex diminished by 22 January, third leaf expanding growth stage. At the leaf four expanding growth stage, in the

absence of the Filex drench, chlorosis was significantly reduced by weekly Aliette sprays compared with fortnightly ones. However, under the conditions of the intended Off Label Approval which would allow a maximum of 10 sprays at the optimum rate of 0.5 g/m², weekly applications of Aliette could not be made to extend over the full growing season of approximately 18 weeks. The data suggest equally good control of chlorosis at leaf four expanding growth stage with the Filex drench treatment supplemented with fortnightly Aliette sprays as that given by weekly Aliette sprays. This would allow the use of further sprays timed at 10 day intervals during critical high risk disease periods and conversely extend the interval between sprays during periods of low risk. The most vigorous treatments were those which received the Filex drench, reflecting good early disease control. No differences in marketability were seen between the fungicide treatments but the untreated was assessed as being unmarketable, reflecting severe disease.

In the second experiment in the third year, the Filex drench treatment reduced disease up to the third expanded leaf growth stage with no significant effect after this time on leaf chlorosis. Aliette treatment or Treatment X reduced the number of plants with downy mildew up to the third expanded leaf growth stage but Treatment X consistently significantly reduced leaf chlorosis although there was some reduction from Aliette. The most vigorous plants were those which had received the Filex drench, reflecting good early disease control. The most marketable plants were from Filex drenches with supplementary sprays of Aliette, Treatment X, Invader and Tattoo and also the latter two treatments as sprays only. The untreated was assessed as being unmarketable.

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Appendix I EXPERIMENT IN 1993/4

1.1 *Spray programme application dates*

Protectant	Eradicant
02.12.93	
17.12.93	
31.12.93	31.12.93
13.01.94	13.01.94
27.01.94	27.01.94
11.02.94	11.02.94

On 17 December Foli-R-Fos plus adjuvant was inadvertently applied to plants already treated with Curzate M plus adjuvant. Thereafter, follow up treatments were applied as intended.

1.2 *Cultivar and sowing date*

Cv. Marba sown 26 October 1993.

1.3 Effect of the spray programme on downy mildew on the cotyledons and vigour (13 January).

	Programme				
	Control	Protectant	Eradicant	*P*	CV%
% Plants downy mildew	100.0	51.0	100.0	<0.001	26.5
Sporulation (index)*	4.0	1.3	3.5	<0.001	22.1
Necrosis (index)*	2.7	1.6	2.9	<0.001	24.8
Plant vigour (index)**	1.6	4.2	2.0	<0.001	20.0

(df 39)
Sporulation and necrosis index Plant vigour index
*index 0 = nil 4 = the most **index 0 = low 5 = the most

There was less downy mildew, sporulation and necrosis of the cotyledons and plants were more vigorous following the protectant programme.

1.4 Effect of fungicides on downy mildew on the stems. (26 January).

	Untreated	Curzate M	Foli-R-Fos	Aliette	Fluazinam
% Plants with downy mildew	35	23	27	18	8
SED (df 39)					5.1
P					0.002
CV%					53.7

All fungicides except for Foli-R-Fos reduced downy mildew on the stems compared with the untreated. Fluazinam treatment resulted in the lowest disease scores.

1.5 Effect of fungicides on downy mildew on the cotyledons (26 January).

	Untreated	Curzate M	Foli-R-Fos	Aliette	Fluazinam
% Plants with downy mildew	99	80	100	100	86
SED (df 39)					6.3
P					0.002
CV%					15.5

Curzate M and fluazinam reduced downy mildew on the cotyledons.

1.6 Effect of fungicide/adjuvant on downy mildew on the cotyledons (26 January).

	% Plants with downy mildew				
Adjuvant	Untreated	Curzate M	Foli-R-Fos	Aliette	Fluazinam
Absent	99				
Absent		94	100	100	78
Present		66	100	100	94
SED (df 39)					7.6
P					0.005
CV%					15.5

Curzate M with adjuvant and fluazinam without adjuvant had less downy mildew on the cotyledons than any other treatment.

1.7 Effect of the spray programme on downy mildew on the cotyledons, sporulation, necrosis, stem distortion and plant vigour (30 December).

	Programme				
	Untreated	Protectant	Eradicant	*P*	CV%
% Plants with downy mildew	54	21	49	<0.001	36.6
Sporulation on cotyledons (index)*	3.4	0.8	3.0	<0.001	40.0
Necrosis of cotyledons (index)*	1.1	0.1	1.0	<0.001	89.8
Stem distortion (index)*	2.8	1.2	1.8	<0.012	80.3
Plant vigour (index)**	2.7	4.2	3.4	<0.001	13.7

*index 0 = nil 4 = the most **index 0 = low 5 = the most

Fewer plants affected with downy mildew, less sporulation, necrosis and stem distortion with increased plant vigour following protectant sprays.

Sporulation following use of the adjuvant was 1.7 compared with 3.4 in the untreated (P=0.041).

1.8 Effect of fungicides on plant vigour (13 January).

	Untreated	Curzate M	Foli-R-Fos	Aliette	Fluazinam
Vigour (index)*	1.6	3.2	2.7	3.2	3.4
SED (df 39)					0.25
P					0.018
CV%					20.0

*index 0 = low 4 = the most

The most vigorous plants were those treated with Aliette, Curzate M and fluazinam. All fungicide treated plants were more vigorous than untreated plants.

1.9 Effect of fungicide and adjuvant on plant vigour (13 January).

		Vigour (index)*			
Adjuvant	Untreated	Curzate M	Foli-R-Fos	Aliette	Fluazinam
Absent	1.6				
Absent		2.8	3.0	3.5	3.3
Present		3.5	2.3	3.0	3.5
SED (df 39)					0.30
P					0.027
CV%					20.0

*index 0 = low 5 = the most

All fungicide/adjuvant treatments were more vigorous than the untreated. Without adjuvant, Aliette treated plants were the most vigorous. With adjuvant, fluazinam and Curzate M treated plants were the most vigorous. The addition of adjuvant to Aliette and fluazinam had no effect on plant vigour and had a beneficial effect with Curzate M but with Foli-R-Fos vigour was reduced.

On 26 January, downy mildew was recorded on the first true leaves with up to 10% of plants affected. Plant necrosis was also reduced by fungicides, and spray programmes.

1.10 Effect of fungicides on necrosis (26 January).

	Untreated	Curzate M	Foli-R-Fos	Aliette	Fluazinam
Necrosis (index)*	4.0	2.7	3.5	3.3	2.7
SED (df 39)					0.26
P					0.002
CV%					18.4

index 0 = nil 4 = the most

All fungicide treatments except for Foli-R-Fos reduced necrosis and the lowest necrosis scores followed treatment with Curzate M and fluazinam.

1.11 Effect of fungicides and spray programmes on necrosis (26 January).

	Necrosis (index)*				
Spray Programme	Untreated	Curzate M	Foli-R-Fos	Aliette	Fluazinam
None	4.0				
Protectant		1.3	3.0	2.7	1.5
Eradicant		4.0	4.0	4.0	4.0
SED (df 39)					0.31
P					0.002
CV%					18.4

*index 0 = nil 4 = the most

All fungicides applied as protectants reduced necrosis but had no effect applied as eradicants. The least necrosis followed protectant treatments of Curzate M or fluazinam. Spray programmes or the addition of adjuvant had no effect on necrosis.

Plants treated with the protectant programme were more vigorous ($P< 0.001$), with an index of 4.5 compared with 2.4 following the eradicant programme. However the latter was more vigorous than the untreated control which had an index of 1.6.

1.12 Effect of adjuvant and fungicides on necrosis (10 February).

Adjuvant	Untreated	Necrosis (index)* Curzate M	Foli-R-Fos	Aliette	Fluazinam
Absent	2.2				
Absent		1.7	2.7	0.9	2.2
Present		1.5	1.5	2.1	1.7
SED (df 39)					0.39
P					0.003
CV%					40.7

*0 = nil 4 = the most

The least necrosis was in plants treated with Aliette without adjuvant and was the only treatment which had less necrosis than the untreated.

1.13 Effect of fungicide on downy mildew on the leaves. (24 February)

	Untreated	Curzate M	Foli-R-Fos	Aliette	Fluazinam
% Plants downy mildew	100	100	99	76	100
SED (df 39)					7.2
P					0.001
CV%					17.3

Only the Aliette treatment reduces downy mildew on the leaves.

1.14 Effect of adjuvant on sporulation (24 February).

	Sporulation (index)* Adjuvant		
	Untreated	Absent	Present
Untreated	0.7		
Treated		1.0	0.5
SED (df 39)			0.29
P			0.023
CV%			103.8

*index 0 = nil 4 = the most

Less sporulation was recorded following fungicide treatments with adjuvant.

1.15 Effect of fungicides on sporulation (24 February).

	Untreated	Curzate M	Foli-R-Fos	Aliette	Fluazinam
Sporulation (index)*	0.7	0.9	0.7	0.0	1.2
SED (df 39)					0.32
P					0.003
CV%					103.8

*index 0 = nil 4 = the most

Least sporulation was recorded following the Aliette treatment.

Necrosis following the eradication programme was 1.7 compared with 2.2 following the protectant programme and 2.0 in the untreated. Fungicides, adjuvant and spray programme, adjuvants and fungicides all had an effect on necrosis. (Tables 1.16 to 1.19).

1.16 Effect of fungicides on necrosis (26 February).

	Untreated	Curzate M	Foli-R-Fos	Aliette	Fluazinam
Necrosis (index)*	2.0	1.6	2.7	1.7	1.8
SED (df 39)					0.32
P					0.002
CV%					36.6

*index 0 = nil 4 = the most

None of the fungicides reduced necrosis compared with the untreated apart from Foli-R-Fos which had more necrosis than the untreated and the other fungicide treatments.

1.17 Effect of spray programme and adjuvant on necrosis (26 February).

	Necrosis (index)* Spray Programme		
Adjuvant	Untreated	Protectant	Eradicant
Absent	2.0		
Absent		1.9	1.9
Present		2.4	1.5
SED (df 39)			0.32
P			0.032
CV%			36.6

*index 0 = nil 4 = the most

Less necrosis was recorded with adjuvant following the eradication programme.

1.18 Effect of adjuvants and fungicides on necrosis (26 February).

	Necrosis (index)*				
Adjuvant	Untreated	Curzate M	Foli-R-Fos	Aliette	Fluazinam
Untreated	2.0				
Absent		1.7	3.2	1.0	1.8
Present		1.5	2.2	2.3	1.8
SED (df 39)					0.38
P					0.003
CV%					36.6

*index 0 = nil 4 = the most

Aliette without adjuvant had the lowest necrosis scores and was the only treatment to differ from the untreated.

Plants treated with the protectant programme were more vigorous ($P < 0.001$) with a vigour score of 3.1 compared with 2.3 following the protectant programme and 1.3 for the untreated.

1.19 Effect of fungicides on vigour (26 February).

	Untreated	Curzate M	Foli-R-Fos	Aliette	Fluazinam
Vigour (index)*	1.3	3.0	2.0	2.8	2.9
SED (df 39)					0.32
P					0.006
CV%					29.8

*index 0 = low 5 = the most

All the fungicide treatments increased vigour.

1.20 Effect of adjuvant and spray programme on necrosis (10 March).

		Necrosis (index)* Spray programme	
Adjuvant	Untreated	Protectant	Eradicant
Absent	1.0		
Absent		1.3	1.3
Present		1.0	1.1
SED (df 39)			0.16
P			0.019
CV%			35.8

*index 0 = nil 4 = the most

There was less necrosis in the protectant spray programme with adjuvant (table 1.21).

1.21 Effect of fungicide and adjuvant on necrosis (10 March).

	Necrosis (index)*				
Adjuvant	Untreated	Curzate M	Foli-R-Fos	Aliette	Fluazinam
Absent	1.0				
Absent		1.3	1.3	1.0	1.7
Present		0.8	1.0	1.3	1.0
SED (df 39)					0.22
P					0.028
CV%					35.8

*index 0 = nil 4 = the most

More necrosis was recorded following fluazinam and Curzate M without adjuvant. The addition of adjuvant to Foli-R-Fos or Aliette had no effect.

1.22 Effect of fungicides on vigour (10 March).

	Untreated	Curzate M	Foli-R-Fos	Aliette	Fluazinam
Vigour (index)*	1.2	2.9	1.6	2.6	2.9
SED (df 39)					0.35
P					0.001
CV%					34.8

* index 0 = low 4 = the most

Plants were more marketable following the protectant spray programme which had an index of 2.5, compared with eradicant programme 2.0, both of which were more marketable than the untreated with an index 1.0.

1.23 Effect of fungicides on marketability (10 March).

	Untreated	Curzate M	Foli-R-Fos	Aliette	Fluazinam
Marketability (index)*	1.0	2.4	1.5	2.2	2.7
SED (df 39)					0.31
P					0.001
CV%					35.0

*index 0 = low 4 = the most

Plants treated with Curzate M, Aliette and fluazinam were the most marketable.

1.24 Effect of spray programme and adjuvant on marketability (10 March).

	Marketability (index)* Spray programme		
Adjuvant	Untreated	Protectant	Eradicant
Absent	1.0		
Absent		2.8	1.7
Present		2.2	2.2
SED (df 39)			0.31
P			0.012
CV%			35.0

*index 0 = low 4 = the most

The most marketable plants were those treated with the protectant programme without adjuvant.

1.25 Effect of fungicide and adjuvant on marketability (10 March).

	Marketability (index)*				
Adjuvant	Untreated	Curzate M	Foli-R-Fos	Aliette	Fluazinam
Absent	1.0				
Absent		2.0	1.8	2.7	2.7
Present		2.8	1.2	1.8	2.8
SED (df 39)					0.38
P					0.023
CV%					35.0

*index 0 = low 5 = the most

All combinations of fungicides and adjuvants increased marketability compared with the untreated apart from Foli-R-Fos with adjuvant. Plants treated with Aliette without adjuvant were more marketable than Aliette with adjuvant but the converse was so for Curzate M. Adjuvant had no effect on the marketability of plants treated with fluazinam or Foli-R-Fos.

APPENDIX II EXPERIMENTS IN 1994/5

2.1 *Experiment 1*

Fungicide application

Fungicide drenches were applied on 2 November 1994.

2.2 *Experiment 2*

Spray programme application dates - Aliette spray programmes were applied fortnightly on:-

7 December 1994
20 December 1994
5 January 1995
18 January 1995
31 January 1995
15 February 1995
27 February 1995

2.3 *Experiment 3*

Fungicide spray programme application dates

1 December 1994
7 December 1994
20 December 1994
5 January 1995
18 January 1995
31 January 1995
15 February 1995
27 February 1995

2.4 *Cultivar and sowing date*

In all three experiments cv. Marba sown 31 October 1994. Basilex (2 g/m^2 in 250 ml/tray) was applied to all trays on 2 November.

1994/5

Experiment 1

2.5 Effect of fungicide drench on plants affected with downy mildew on the cotyledons (1 December).

Treatment		Mean % downy mildew	
		transformed (n + 1)	back-transformed
Untreated		2.0	6.4
Aliette Drench	5.0 g/m²	1.1	2.0
Aliette Drench	2.5 g/m²	1.4	2.9
Aliette Drench	0.1 g/m²	2.6	11.8
Filex Drench	10.0 ml/m²	0.0	0.0
SED (df 16)		0.66	
P		0.005	
CV%		47.30	

Only the Filex drench significantly controlled downy mildew.

2.6 Effect of fungicide drench on downy mildew sporulation. Fully expanded cotyledons. (1 December).

Treatment		Sporulation index (median)
Untreated		2.2
Aliette Drench	5.0 g/m²	0.6
Aliette Drench	2.5 g/m²	2.2
Aliette Drench	0.1 g/m²	2.0
Filex Drench	10.0 ml/m²	0.0
P (df 4)		0.007

Only the Filex drench significantly reduced downy mildew sporulation.

2.7 Effect of fungicide drench on plants affected with downy mildew. First true leaf expanded. (7 December).

Treatment		Mean % downy mildew transformed (n + 1)
Untreated		98.2
Aliette Drench	5.0 g/m²	88.4
Aliette Drench	2.5 g/m²	97.3
Aliette Drench	0.1 g/m²	97.1
Filex Drench	10.0 ml/m²	71.3
SED (df 16)		9.21
P		0.005
CV%		0.20

Only the Filex drench significantly controlled downy mildew.

2.8 Effect of fungicide drench on downy mildew sporulation, plant necrosis and vigour. Second true leaf emerging (14 December).

Treatment		Sporulation index (median)	Necrosis index (median)	Vigour index (median)
		3.0	3.0	2.0
Aliette Drench	5.0 g/m²	1.2	2.2	3.0
Aliette Drench	2.5 g/m²	2.8	3.0	2.8
Aliette Drench	0.1 g/m²	3.0	4.0	2.8
Filex Drench	10.0 ml/m²	0.0	1.8	4.2
P (df 4)		0.004	0.022	0.002

Sporulation was significantly reduced following both the Aliette drench at 5.0 g/m² and the Filex drench. None of the treatments affected necrosis. Plant vigour was only increased by the Filex drench compared with the untreated control.

2.9 Effect of fungicide drench on downy mildew sporulation, plant necrosis and vigour. Second true leaf expanding. (21 December).

Treatment		Sporulation index (median)	Necrosis index (median)	Vigour (median)
Untreated		3.0	3.0	2.8
Aliette Drench	5.0 g/m²	1.0	2.6	3.8
Aliette Drench	2.5 g/m²	2.2	3.2	3.8
Aliette Drench	0.1 g/m²	2.8	3.2	2.6
Filex Drench	10.0 ml/m²	0.0	2.0	5.0
P (df 4)		0.005	NS	0.002

Only the Filex drench reduced sporulation and increased vigour compared with the untreated. There were no treatment differences in plant necrosis.

2.10 Effect of fungicide drench on downy mildew sporulation, plant necrosis and vigour. Second true leaf expanding (29 December).

Treatment		Sporulation index (median)	Necrosis index (median)	Vigour index (median)
Untreated		4.0	4.0	1.2
Aliette Drench	5.0 g/m²	1.8	3.0	3.8
Aliette Drench	2.5 g/m²	2.6	3.2	3.0
Aliette Drench	0.1 g/m²	3.6	4.0	2.2
Filex Drench	10.0 ml/m²	1.0	2.8	4.8
P (df 4)		0.004	0.004	0.003

Both the Aliette drench at 5.0 g/m² and the Filex drench reduced sporulation compared with the untreated but only the Filex drench reduced necrosis and increased plant vigour.

2.11 Effect of fungicide drench on plant necrosis and vigour. Second true leaf expanding. (5 January).

Treatment		Necrosis index (median)	Vigour index (median)
Untreated		2.0	1.0
Aliette Drench	5.0 g/m²	0.4	2.0
Aliette Drench	2.5 g/m²	1.2	1.0
Aliette Drench	0.1 g/m²	1.8	1.0
Filex Drench	10.0 ml/m²	2.6	3.0
P (df 4)		0.015	0.002

None of the fungicide treatments significantly affected necrosis but the Filex drench significantly increased vigour compared with the untreated. Very low levels of downy mildew sporulation were recorded in all treatments.

2.12 Effect of fungicide drench on plant necrosis and vigour. Second true leaf fully expanded. (11 January).

Treatment		Necrosis index (median)	Vigour index (median)
Untreated		3.0	1.0
Aliette Drench	5.0 g/m²	1.0	4.0
Aliette Drench	2.5 g/m²	2.0	2.8
Aliette Drench	0.1 g/m²	2.0	2.2
Filex Drench	10.0 ml/m²	3.0	5.0
P (df 4)		0.008	0.001

Only the Aliette drench at 5.0 g/m² significantly reduced plant necrosis compared with the untreated. Plant vigour was significantly increased by both the Aliette drench at 5.0 g/m² and the Filex drench. Low levels of downy mildew sporulation were found in a few plots only.

1994/5

Experiment 2

2.13 Effect of Aliette spray on plants affected with downy mildew on the first true leaves (7 December).

Treatment		% Plants downy mildew
Untreated		48.8
Aliette Spray	0.5 g/m²	51.2
Aliette Spray	0.4 g/m²	51.3
Aliette Spray	0.3 g/m²	49.2
Aliette Spray	0.2 g/m²	47.2
Aliette Spray	0.1 g/m²	60.4
SED (df 14)		NS
CV%		36.9

The Aliette sprays had no effect on downy mildew.

2.14 Effect of Aliette spray on downy mildew sporulation. First true leaf expanded (7 December).

Treatment		Sporulation index (median)
Untreated		2.3
Aliette Spray	0.5 g/m²	1.7
Aliette Spray	0.4 g/m²	1.3
Aliette Spray	0.3 g/m²	1.5
Aliette Spray	0.2 g/m²	1.5
Aliette Spray	0.1 g/m²	1.7
P (df 5)		NS

The Aliette sprays had no effect on sporulation on the first true leaves.

2.15 Downy mildew sporulation and plant necrosis. Second true leaf expanding (20 December).

Treatment		Sporulation index (median)	Necrosis index (median)
Untreated		1.6	2.3
Aliette Spray	0.5 g/m²	0.8	2.2
Aliette Spray	0.4 g/m²	0.6	1.8
Aliette Spray	0.3 g/m²	0.2	2.2
Aliette Spray	0.2 g/m²	0.6	2.2
Aliette Spray	0.1 g/m²	0.8	2.3
P (df 5)		NS	NS

The Aliette sprays had no effect on sporulation and necrosis. There was no apparent visual difference in vigour between treatments and they were not individually assessed but had an overall vigour index of 3.0.

2.16 Effect of Aliette spray on downy mildew necrosis and plant vigour. Second true leaf expanding (5 January).

Treatment		Necrosis index (median)	Vigour index (median)
Untreated		2.0	3.0
Aliette Spray	0.5 g/m²	0.8	3.0
Aliette Spray	0.4 g/m²	1.0	3.0
Aliette Spray	0.3 g/m²	1.0	3.0
Aliette Spray	0.2 g/m²	1.2	3.0
Aliette Spray	0.1 g/m²	1.0	3.0
P (df 5)		0.016	NS

Necrosis was only reduced by the Aliette spray at 0.5 g/m² compared with the untreated control. There was no effect of treatment on plant vigour.

2.17 Effect of Aliette spray on downy mildew sporulation, plant necrosis and vigour. Second true leaves fully expanded (18 January).

Treatment		Sporulation index (median)	Necrosis index (median)	Vigour index (median)
Untreated		2.0	2.0	2.3
Aliette Spray	0.5 g/m²	1.0	1.0	3.1
Aliette Spray	0.4 g/m²	2.0	1.0	2.9
Aliette Spray	0.3 g/m²	2.0	1.0	2.6
Aliette Spray	0.2 g/m²	2.0	1.0	3.6
Aliette Spray	0.1 g/m²	2.0	1.0	3.1
P (df 5)		NS	NS	NS

There was no effect of the Aliette sprays on sporulation, plant necrosis or vigour.

2.18 Effect of Aliette spray on downy mildew sporulation, plant necrosis and vigour. Three true leaves fully expanded (31 January).

Treatment		Sporulation index (median)	Necrosis index (median)	Vigour index (median)
Untreated		4.0	3.0	2.1
Aliette Spray	0.5 g/m²	2.0	1.7	2.8
Aliette Spray	0.4 g/m²	2.2	2.2	2.9
Aliette Spray	0.3 g/m²	2.0	2.0	2.3
Aliette Spray	0.2 g/m²	3.0	2.0	2.4
Aliette Spray	0.1 g/m²	3.8	2.2	2.1
P (df 5)		0.002	0.057	NS

Aliette at 0.5, 0.4 and 0.3 g/m² reduced sporulation but only Aliette at 0.5 g/m² reduced necrosis.

2.19 Effect of Aliette spray on downy mildew sporulation, plant necrosis and vigour. Leaf four expanding (14 February).

Treatment		Sporulation index (median)	Necrosis index (median)	Vigour index (median)
Untreated		1.8	2.8	1.9
Aliette Spray	0.5 g/m²	0.8	1.2	2.1
Aliette Spray	0.4 g/m²	0.8	1.5	2.1
Aliette Spray	0.3 g/m²	1.0	2.2	2.1
Aliette Spray	0.2 g/m²	1.5	2.2	2.3
Aliette Spray	0.1 g/m²	1.0	2.2	2.1
P (df 5)		NS	0.013	NS

There was no treatment effect on sporulation or vigour but Aliette at 0.5 g/m² reduced necrosis.

2.20 Effect of Aliette spray on downy mildew sporulation, plant necrosis and vigour. Leaf five emerging (27 February).

Treatment		Sporulation index (median)	Necrosis index (median)	Vigour index (median)
Untreated		1.8	1.7	2.0
Aliette Spray	0.5 g/m²	0.8	1.3	3.3
Aliette Spray	0.4 g/m²	1.8	1.0	3.0
Aliette Spray	0.3 g/m²	1.7	1.3	2.8
Aliette Spray	0.2 g/m²	2.7	1.7	3.0
Aliette Spray	0.1 g/m²	2.2	2.0	2.8
P (df 5)		0.016	NS	NS

Aliette at 0.5 g/m² reduced sporulation, but there was no effect of sprays on necrosis or on vigour.

There were no differences in marketability with few trays being marketable.

1994/5

Experiment 3

2.21 Effect of fungicide sprays on plants affected with downy mildew. Fully expanded cotyledons (1 December).

Treatment	% Plants downy mildew
Untreated	4.38
Aliette	3.59
Foli-R-Fos	7.92
Curzate	2.73
Fluazinam	3.19
Tatoo	3.78
Invader	3.68
Filex	3.50
Fubol 75 WP	2.24
Elvaron	1.79
Treatment X	0.45
Treatment Y	0.48
SED (df 33)	NS

Fungicide treatment had no effect on downy mildew on the cotyledons.

2.22 Effect of fungicide sprays on plants affected with downy mildew. First true leaf expanded (7 December).

	% Plants downy mildew	
Treatment	log (n + 1) transformed	Back transformed
Untreated	4.57	95.93
Aliette	2.79	15.03
Foli-R-Fos	4.23	67.57
Curzate	3.67	38.11
Fluazinam	1.87	5.46
Tatoo	3.44	30.18
Invader	2.26	8.63
Filex	2.83	15.99
Fubol	2.53	11.59
Elvaron	4.08	58.66
Treatment X	3.17	22.91
Treatment Y	3.17	22.85
SED (df 33)	0.385	
P	0.05	
CV%	16.9	

Aliette, Fluazinam, Invader, Filex, Fubol, Treatment X and Treatment Y significantly reduced the percentage of plants affected with downy mildew compared with the untreated control.

2.23 Effect of fungicide sprays on downy mildew sporulation, plant necrosis and vigour. First true leaf expanded (7 December).

Treatment	Sporulation index (median)	Necrosis index (median)	Vigour index (median)
Untreated	3.6	1.1	2.2
Aliette	1.2	1.0	4.0
Foli-R-Fos	3.1	1.1	3.2
Curzate	1.6	1.0	4.6
Fluazinam	0.8	1.0	4.5
Tatoo	1.6	1.5	3.9
Invader	0.7	1.0	4.7
Filex	1.1	1.0	4.6
Fubol	0.6	1.0	4.6
Elvaron	2.2	1.0	3.3
Treatment X	1.3	1.0	4.8
Treatment Y	0.8	0.9	4.1
P (df 11)	0.003	NS	NS

Fluazinam, Invader, Fubol and Treatment Y reduced downy mildew sporulation compared with the untreated control. There was no effect of fungicide treatment on necrosis and vigour.

2.24 Effect of fungicide sprays on downy mildew sporulation, plant necrosis and vigour. Second true leaf emerging (20 December).

Treatment	Sporulation index (median)	Necrosis index (median)	Vigour index (median)
Untreated	3.8	4.0	1.0
Aliette	0.6	2.0	3.2
Foli-R-Fos	2.3	4.0	1.8
Curzate	0.8	2.1	3.4
Fluazinam	0.6	1.9	3.6
Tatoo	0.8	1.9	3.4
Invader	0.4	1.2	4.5
Filex	0.4	1.7	3.5
Fubol	0.9	1.6	3.8
Elvaron	2.4	2.7	2.6
Treatment X	0.1	1.9	4.0
Treatment Y	0.9	1.9	3.2
P(df 11)	0.006	0.017	0.001

Invader, Filex and Treatment X reduced sporulation compared with the untreated. Invader reduced necrosis compared with the untreated control. Invader, Fubol and Treatment X treatments increased vigour compared with the untreated control.

2.25 Effect of fungicide sprays on downy mildew sporulation, plant necrosis and vigour. Second true leaf emerging (5 January).

Treatment	Sporulation index (median)	Necrosis index (median)	Vigour index (median)
Untreated	0.01	2.2	0.9
Aliette	0.61	1.7	2.7
Foli-R-Fos	0.01	1.6	1.9
Curzate	0.95	1.4	3.1
Fluazinam	2.16	2.9	3.1
Tatoo	1.62	1.7	3.1
Invader	1.70	2.8	3.8
Filex	1.41	2.3	3.1
Fubol	1.37	1.7	3.2
Elvaron	0.91	2.5	1.1
Treatment X	0.32	1.4	3.0
Treatment Y	0.28	1.5	2.3
P (df 11)	NS	NS	0.001

There was no effect of fungicide treatment on sporulation or necrosis. Invader and Fubol treatments increased vigour compared with the untreated control.

2.26 Effect of fungicide sprays on downy mildew sporulation, plant necrosis and vigour. Second true leaves fully expanded (18 January).

Treatment	Sporulation index (median)	Necrosis index (median)	Vigour index (median)
Untreated	1.0	2.2	1.0
Aliette	0.9	1.1	3.2
Foli-R-Fos	1.1	1.4	2.5
Curzate	2.3	1.1	3.3
Fluazinam	2.5	1.4	3.4
Tatoo	1.1	1.6	3.7
Invader	1.9	1.8	3.6
Filex	1.0	1.6	3.2
Fubol	1.8	1.1	3.6
Elvaron	1.4	3.0	1.8
Treatment X	0.8	1.1	3.8
Treatment Y	0.9	0.9	4.2
P (df 11)	NS	NS	0.015

There was no effect of treatment on sporulation or necrosis. Tatoo, Treatment X and Treatment Y increased vigour compared with the untreated control.

2.27 Effect of fungicide sprays on downy mildew sporulation, plant necrosis and vigour. Third true leaf fully expanded (31 January).

Treatment	Sporulation index (median)	Necrosis index (median)	Vigour index (median)
Untreated	3.0	2.8	1.0
Aliette	1.4	2.3	3.6
Foli-R-Fos	2.1	2.4	2.8
Curzate	1.5	2.1	3.1
Fluazinam	2.9	2.0	3.0
Tatoo	1.7	2.6	3.6
Invader	2.3	2.2	4.2
Filex	2.3	2.5	3.0
Fubol	2.3	1.6	3.6
Elvaron	3.2	2.3	2.0
Treatment X	0.9	2.2	4.5
Treatment Y	1.5	1.7	3.3
P (df 11)	0.024	NS	0.001

Treatment X reduced sporulation. There was no effect of treatment on necrosis. Aliette, Tatoo, Invader and Treatment X increased vigour compared with the untreated.

2.28 Effect of fungicide sprays on downy mildew sporulation, plant necrosis and vigour. Leaf four emerging (14 February).

Treatment	Sporulation index (median)	Necrosis index (median)	Vigour index (median)
Untreated	1.5	2.6	1.1
Aliette	1.2	2.0	2.4
Foli-R-Fos	1.5	2.3	2.1
Curzate	1.3	2.4	3.0
Fluazinam	1.8	3.0	3.1
Tatoo	1.6	2.9	3.3
Invader	0.7	2.0	4.2
Filex	0.7	3.2	3.0
Fubol	1.3	2.8	3.0
Elvaron	1.5	2.8	1.4
Treatment X	0.6	2.2	3.4
Treatment Y	0.7	2.2	2.4
P (df 11)	0.022	NS	0.001

Invader, Filex, Treatment X and Treatment Y reduced sporulation. There was no effect of treatment on necrosis. Tatoo, Invader and Treatment X increased vigour compared with the untreated control.

2.29 Effect of fungicide sprays on downy mildew sporulation, plant necrosis and vigour. Leaf five emerging (27 February).

Treatment	Sporulation index (median)	Necrosis index (median)	Vigour index (median)
Untreated	0.9	1.5	1.1
Aliette	0.1	0.4	2.9
Foli-R-Fos	1.0	1.8	2.0
Curzate	0.5	1.0	3.0
Fluazinam	1.0	2.0	3.2
Tatoo	1.3	2.2	3.7
Invader	1.7	1.8	4.5
Filex	0.7	1.7	2.7
Fubol	0.9	2.0	3.4
Elvaron	1.0	2.0	1.9
Treatment X	0.7	3.2	3.9
Treatment Y	0.7	0.6	2.9
P (df 11)	NS	0.011	0.001

There were no effect of treatment on sporulation or necrosis compared with the untreated control. Tatoo, Invader Fubol and Treatment X increased vigour.

2.30 Effect of treatment on dry weight. Leaf seven emerged (21 March).

Treatment	Dry weight (g)
Untreated	10.5
Aliette	16.0
Foli-R-Fos	12.2
Curzate	16.0
Fluazinam	17.1
Tatoo	17.3
Invader	20.7
Filex	16.9
Fubol	17.1
Elvaron	14.0
Treatment X	17.6
Treatment Y	16.6
SED (df 33)	1.46
P	0.05
CV%	12.9

All fungicide treatments significantly increased plant dry weight compared with the untreated control apart from the Foli-R-Fos treatment.

APPENDIX III EXPERIMENTS IN 1995/6

3.1 Experiment 1 - Fungicide application dates

Treatment			
1	2	3	4
		20.11.95	20.11.95
27.11.95	27.11.95		27.11.95
	04.12.95	04.12.95	04.12.95
11.12.95	11.12 95		11.12.95
	18.12.95	18.12.95	18.12.95
24.12.95	24.12.95		24.12.95
	03.01.96	03.01.96	03.01.96
09.01.96	09.01.96		09.01.96
	15.01.96	15.01.96	15.01.96
23.01.96	23.01.96		23.01.96
	30.01.96	30.01.96	
05.02.96			
		12.02.96	
19.02.96			
		26.02.96	
04.03.96			

3.2 Experiment 2 - Fungicide application dates

Treatments	
1-5	6-10
	20.11.95
27.11.95	
	04.12.95
11.12.95	
	18.12.95
24.12.95	
	03.01.96
09.01.96	
	15.01.96
23.01.96	
	30.01.96
05.02.96	
	12.02.96
19.02.96	
	26.02.96
04.03.96	

3.3 *Cultivar and sowing date*

In both experiments cv. Marba was sown on 30 October 1995. Basilex (2 g/m² in 250 ml/tray) was applied to all trays on 31 October.

Experiment 1

3.4 Effect of Filex drench v Aliette spray on % plants with downy mildew on the cotyledons.

	% Plants downy mildew	
Treatment	8 Jan	15 Jan
Untreated	46.2	84.8
Filex drench	0	0
Aliette spray	0	0
SED (df 20)	NS	NS
CV%	19.6	72.8

No downy mildew on the cotyledons was recorded on 8 and 15 January on either fungicide treatment.

3.5 Effect of Filex drench v Aliette spray on % plants with downy mildew on the true leaves.

	% Plants downy mildew	
Treatment	15 Jan	22 Jan
Untreated	8.4	100.0
Filex drench	0	14.9
Aliette spray	0	39.9
SED (df 20)	NS	12.06
P		0.005
CV%	133.9	64.3

Downy mildew was reduced on 22 January by the Filex drench.

3.6 Effect of Filex drench v Aliette spray on % plants with chlorosis. Third leaf to fourth leaf expanding.

	% Plants chlorosis			
Treatment	29 Jan	5 Feb	12 Feb	19 Feb
Untreated	99.6	100.0	100.0	100.0
Filex drench	15.0	19.4	37.7	48.3
Aliette spray	20.4	19.1	46.6	66.0

3.3 *Cultivar and sowing date*

In both experiments cv. Marba was sown on 30 October 1995. Basilex (2 g/m² in 250 ml/tray) was applied to all trays on 31 October.

Experiment 1

3.4 Effect of Filex drench v Aliette spray on % plants with downy mildew on the cotyledons.

	% Plants downy mildew	
Treatment	8 Jan	15 Jan
Untreated	46.2	84.8
Filex drench	0	0
Aliette spray	0	0
SED (df 20)	NS	NS
CV%	19.6	72.8

No downy mildew on the cotyledons was recorded on 8 and 15 January on either fungicide treatment.

3.5 Effect of Filex drench v Aliette spray on % plants with downy mildew on the true leaves.

	% Plants downy mildew	
Treatment	15 Jan	22 Jan
Untreated	8.4	100.0
Filex drench	0	14.9
Aliette spray	0	39.9
SED (df 20)	NS	12.06
P		0.005
CV%	133.9	64.3

Downy mildew was reduced on 22 January by the Filex drench.

3.6 Effect of Filex drench v Aliette spray on % plants with chlorosis. Third leaf to fourth leaf expanding.

	% Plants chlorosis			
Treatment	29 Jan	5 Feb	12 Feb	19 Feb
Untreated	99.6	100.0	100.0	100.0
Filex drench	15.0	19.4	37.7	48.3
Aliette spray	20.4	19.1	46.6	66.0
SED (df 20)	NS	NS	NS	7.05
P				0.021
CV%	46.6	16.5	35.0	24.0

There was no effect of treatment until 19 February with the least chlorosis following the Filex drench.

3.7 Effect of Aliette foliar sprays on leaf chlorosis.

	% Plants leaf chlorosis			
Treatment	29 Jan	5 Feb	12 Feb	19 Feb
Untreated	99.6	100.0	100.0	100.0
Aliette weekly	5.0	7.5	25.8	42.3
Aliette every two weeks	30.4	31.0	58.5	72.0
SED (df 20)	8.69	3.19	10.31	8.63
P	0.002	<0.001	<0.001	<0.001
CV%	46.6	16.5	35.0	24.0

Lower levels of leaf chlorosis were seen following the Aliette weekly fungicide programme at all dates.

3.8 Effect of fungicide programme on % plants with chlorosis on (5 February).

		% Plants with chlorosis	
		Aliette weekly	Aliette every two weeks
Treatment	Untreated		
Untreated	100		
Filex drench		10.8	28.0
Aliette spray		4.2	34.0
SED (df 20)			3.69
P			0.025
CV%			16.5

The least chlorosis was in plants treated with the Aliette weekly sprays.

3.9 Effect of fungicide programme on % plants with chlorosis on (12 February).

Treatment		% Plants with chlorosis	
	Untreated	Aliette weekly	Aliette every two weeks
Untreated	100		
Filex drench		33.4	42.0
Aliette spray		18.2	75.0
SED (df 20)			11.90
P			0.01
CV%			35.0

The least chlorosis was in plants treated with weekly Aliette sprays. There was less chlorosis in plants treated fortnightly with Aliette foliar sprays following the Aliette drench.

3.10 Effect of Filex drench v Aliette spray on mean leaf number per plant (12 March).

Treatment	Mean leaf number
Untreated	4.9
Filex drench	4.8
Aliette spray	5.0
SED (df 20)	0.08
P	0.051
CV%	3.5

There was a slight reduction in leaf number following the Filex drench.

3.11 Effect of Aliette foliar sprays on mean fresh weights per plant (12 March).

Treatment	Mean plant fresh weight (g)
Untreated	0.3
Aliette weekly	0.6
Aliette every two weeks	0.6
SED (df 20)	0.03
P	0.012
CV%	10.2

Higher plant weights were recorded following the Aliette treatments.

3.12 Effect of Filex drench v Aliette spray on mean fresh weights per plant (12 March).

Treatment	Mean plant fresh weight (g)
Untreated	0.3
Filex drench	0.7
Aliette spray	0.6
SED (df 20)	0.03
P	<0.001
CV%	10.2

The Filex drench treatment gave the greatest plant weight.

The untreated was assessed as being unmarketable with no differences in marketability between the fungicide treatments.

3.13 Effect of treatment on plant vigour.

Treatment		Vigour (median)							
Initial	Supplementary	8 Jan	15 Jan	22 Jan	29 Jan	5 Feb	12 Feb	19 Feb	12 Mar
Untreated		4.0	2.6	3.4	2.0	2.2	1.0	1.0	1.0
Filex drench	Aliette every 2 weeks	5.0	5.0	5.0	5.0	4.8	4.0	3.0	3.0
Filex drench	Aliette every week	5.0	4.2	4.8	5.0	5.0	3.8	4.0	4.0
Aliette spray	Aliette every 2 weeks	4.0	3.0	4.0	3.0	3.4	2.2	2.0	2.0
Aliette spray	Aliette every week	4.0	3.2	3.8	4.0	3.6	3.0	3.0	3.0
P (df 4)		0.004	0.003	0.004	0.001	0.002	0.001	0.001	0.001

The most vigorous treatments were those which received the Filex drench.
0

Experiment 2

3.14 Effect of fungicide treatment on mean plant fresh weight (12 March).

Treatment	Mean plant fresh weight (g)
Untreated	0.404
Aliette	0.654
Treatment X	0.734
Invader	0.714
Tattoo	0.764
Fluazinam	0.589
SED (df)	0.0053
P	0.004
CV%	13.6

Higher fresh and dry weights were seen following treatment with Treatment X, Invader and Tatoo compared with the Aliette treatment.

3.15 Effect of drench v no drench on mean fresh weight per plant (12 March).

Treatment	Mean plant fresh weight(g)
Untreated	0.404
No Drench	0.617
Drench	0.765
SED (df)	0.0494
P	<0.001
CV%	13.6

Higher plant weights were recorded following treatment with the highest following the Filex drench.

3.16 Effect of treatment on marketability.

Initial	Supplementary	Marketability index
Untreated		0.00
Filex drench	Aliette every 2 weeks	1.00
Filex drench	Treatment X every 2 weeks	1.00
Filex drench	Invader every 2 weeks	1.00
Filex drench	Tattoo every 2 weeks	1.00
Filex drench	Fluazinam every 2 weeks	0.86
Aliette spray	Aliette every 2 weeks	0.55
Treatment X	Treatment X every 2 weeks	0.55
Invader spray	Invader every 2 weeks	1.00
Tattoo spray	Tattoo every 2 weeks	1.00
Fluazinam spray	Fluazinam every 2 weeks	0.55
P (df 10)		0.018

The untreated were assessed as unmarketable. The most marketable were plants treated with Filex drenches with supplementary sprays of Aliette, Treatment X, Invader and Tattoo and also the latter two treatments as sprays only.

3.17 Effect of treatment on plant vigour.

Treatment		Vigour Index (median)							
Initial	Supplementary	8 Jan	15 Jan	22 Jan	29 Jan	5 Feb	12 Feb	19 Feb	12 Mar
Untreated		3.09	2.84	3.00	1.57	1.27	1.55	1.46	1.00
Filex drench	Aliette every 2 weeks	4.46	4.61	4.86	4.43	3.50	3.86	3.41	3.41
Filex drench	Treatment X every 2 weeks	5.00	4.43	5.00	4.43	4.82	4.46	4.55	3.86
Filex drench	Invader every 2 weeks	5.00	5.00	4.86	4.30	3.55	3.86	4.23	4.00
Filex drench	Tattoo every 2 weeks	5.00	4.61	5.00	3.98	3.73	4.00	4.55	3.82
Filex drench	Fluazinam every 2 weeks	4.82	4.84	4.59	2.84	2.77	3.31	3.50	3.00
Aliette spray	Aliette every 2 weeks	3.09	2.71	3.00	2.25	2.68	3.00	2.55	2.18
Treatment X	Treatment X	3.14	3.02	3.23	3.57	2.96	2.82	2.55	2.46
Invader spray	Invader every 2 weeks	3.96	3.39	3.86	2.39	2.18	2.96	3.05	3.14
Tattoo spray	Tattoo every 2 weeks	3.96	3.71	3.86	2.98	3.00	3.86	3.46	3.46
Fluazinam spray	Fluazinam every 2 weeks	4.00	3.43	3.23	2.02	1.55	2.32	1.73	2.18
P (df 10)		<0.001	<0.001	<0.001	0.001	0.002	0.001	0.001	0.018

The most vigorous plants were those which had received the Filex drench and particularly those which received supplementary sprays of Treatment X.

APPENDIX IV FUNGICIDES & ADJUVANTS

Fungicides

Product	Active Ingredient	Formulation	Marketing Company
Aliette	fosetyl-aluminium	80% WP	Rhone-Poulenc Agriculture Ltd
Basilex	tolclofos-methyl	50% w/w WP	Levington Horticulture
Curzate M	cymoxanil + mancozeb	4.5:68% w/w WP	DuPont
Elvaron WG	dichlofluanid	50% w/w WG	Bayer
Filex	propamocarb hydrochloride	722 g/l SL	Levington Horticulture Ltd
Foli-R-Fos 400	phosphorous acid		UIM Agrochemicals (Aust) Pty Ltd**
Fubol 75 WP	metalaxyl + mancozeb	67.5:7.5% w/w WP	Ciba Agric.
Invader	dimethomorph + mancozeb	7.5:66.7% w/w WG	Cyanamid
Tatoo	mancozeb + propamocarb hydrochloride	301.6.:248 g/l SC	AgrEvo
* see below	fluazinam	500 g/l	ISK Biosciences
Treatment X	----------In Confidence----------		
Treatment Y	----------In Confidence----------		

* now marketed as Legacy

** PO Box 72, Brisbane Market, Queensland, Australia 4106

Adjuvants

Product	Active Ingredient	Formulation	Marketing Company
Solucuivre	copper tallate	50g Cu metal /l	Proval S.A.R.L. 75012 Paris, France