Contract report for the Horticultural Development Council

Container grown rose: evaluation of natural products for prevention and control of downy mildew (*Peronospora sparsa*) and improved shelf life

HNS 135

February 2007

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Project title:	Container grown rose: evaluation of natural products for prevention and control of downy mildew (*Peronospora sparsa*) and improved shelf-life
Project number:	HNS 135
Report:	Annual
Previous reports:	February 2006
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Date project commenced:	1 April 2005
Date completion due:	31 March 2008
Key words:	Rose, *Peronospora sparsa*, downy mildew, natural products, shelf-life, fungicides

The results and conclusions in this report are based on a series of experiments conducted over one year. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

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AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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TABLE OF CONTENTS

GROWER SUMMARY

Headline

A range of foliar fertilisers and other natural products all provided some control of downy mildew under moderate disease pressure, whereas under severe pressure phosphite was the only natural product to give any level of control; a traditional fungicide programme gave moderately good control under severe disease pressure.

Background and expected deliverables

Roses are an important component of the container-grown shrubs market with frequent introductions of new varieties and a high profile in the UK. Downy mildew affects many varieties causing an obvious leaf spot or blotch, sudden premature leaf fall and stunted growth. A range of fungicides are available for control of the disease on production nurseries, and damaging attacks can be largely prevented through use of a suitable preventative spray programme. On garden centres and in other areas with public access, the range of permissible fungicides with activity against downy mildew is very limited. An increasing number of biostimulants and natural products are currently being marketed that claim to enhance a plant's resistance to disease. There is very little robust scientific evidence to support these claims.

The overall objective of the project is to evaluate some biostimulants and natural products for prevention and control of downy mildew (*Peronospora sparsa*) and improved shelf-life. If products are demonstrated to provide effective control, there will be an environmental benefit to be gained with reduced pesticide usage on nurseries; and a shelf-life improvement to be gained on garden centres from an improved level of downy mildew control.

Summary of the project and main conclusions

Experiment 1: E valuation of some natural products applied singly

In spring 2006, the following ten treatments using natural products were compared with a weekly fungicide spray (Aliette 80WG) for control of downy mildew on rose cvs Gentle Touch and Peek-A-Boo:

- Farm-Fos 44 spray at 14 day intervals
- Farm-Fos 44 spray at 7 day intervals
- Farm-Fos 44 drench at 28 day intervals
- Farm-Fos 44 drench at 14 day intervals
- Orophyte spray at 7 day intervals
- Milsana spray at 7 day intervals
- Biosept All Clear spray at 7 day intervals
- Seagold growing medium incorporation and top dressing at 28 day intervals
- EndoRoots mycorrhiza drench at 28 day intervals
- Turf Vigour Special drench at 7 day intervals.

Containers were set down on Mypex matting in an unheated polythene tunnel with overhead irrigation. A low level of downy mildew was visible on some plants at the start of the experiment. Treatments were applied from 5 May (shortly before infector plants were introduced into the tunnel) until 30 June. On cv. Gentle Touch, the disease progressed to affect most plants by 15 June, irrespective of treatment.

- Disease severity (which reached 13% leaf area affected of untreated plants by 15 June), was significantly reduced by all treatments (Figure 1).

- Four treatments (Biosept All Clear spray, Farm Fos 44 drench, Seagold incorporation and Turf Vigour Special drench) reduced leaf area affected to less than 5%.

- Application of Milsana at 3 ml/L at weekly intervals was phytotoxic, resulting in death of the growing point after 8 weeks and subsequently more general leaf death.

- Disease levels on cv. Peek-a-Boo were low and there were no significant differences between treatments.

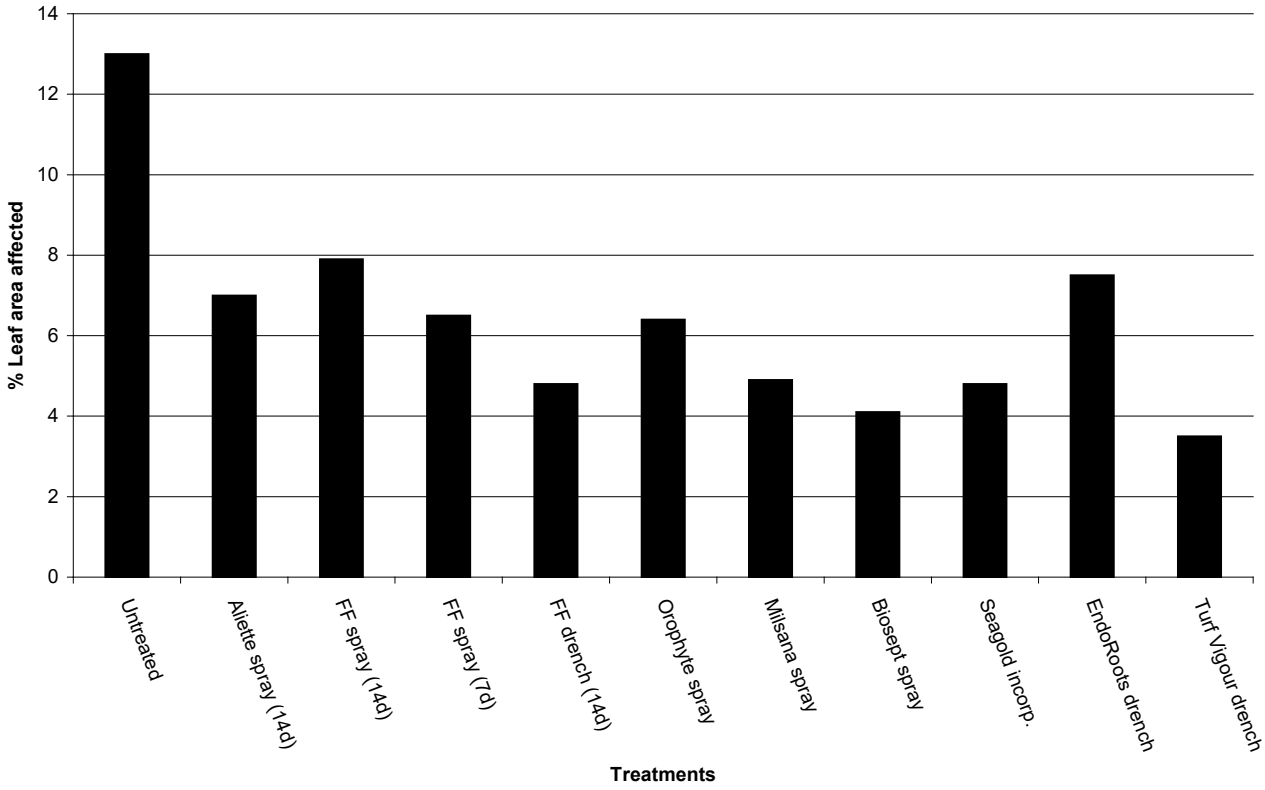

Figure 1. Effect of natural products and fungicides on downy mildew severity on rose plants (cv. Gentle Touch) - 2006.

Experiment 2: Evaluation of some natural products applied in programmes

In autumn 2006, five programmes of two or more natural products were compared with a fungicide programme for control of downy mildew on rose cvs Gentle Touch and Silver Jubilee. Additional treatments included a comparison of Farm-Fos 44 applied as a drench at 14 and 28 day intervals, the effect of adding Epsom salts to Farm-Fos 44 applied as a spray, and the effect of spraying a garlic product (Garshield Biostimulant) at 7 day intervals. Plants were grown as previously except that they were sprayed with water and immediately covered with polythene for 48 hours on four occasions to encourage disease development.

- Epidemic downy mildew developed and most plants suffered severe leaf loss due to downy mildew.

- Leaf fall was significantly reduced by a fungicide programme (Fubol Gold, Aliette 80WG and Amistar applied alternately every 7 days) and by Farm-Fos 44 spray and drench treatments (Figure 2).

- Farm-Fos 44 applied as a drench every 14 days gave no greater control than treatment every 28 days;

- Epsom salts did not improve the efficacy of Farm-Fos 44 applied as a spray every 7 days.

- None of the other treatments significantly reduced the disease.

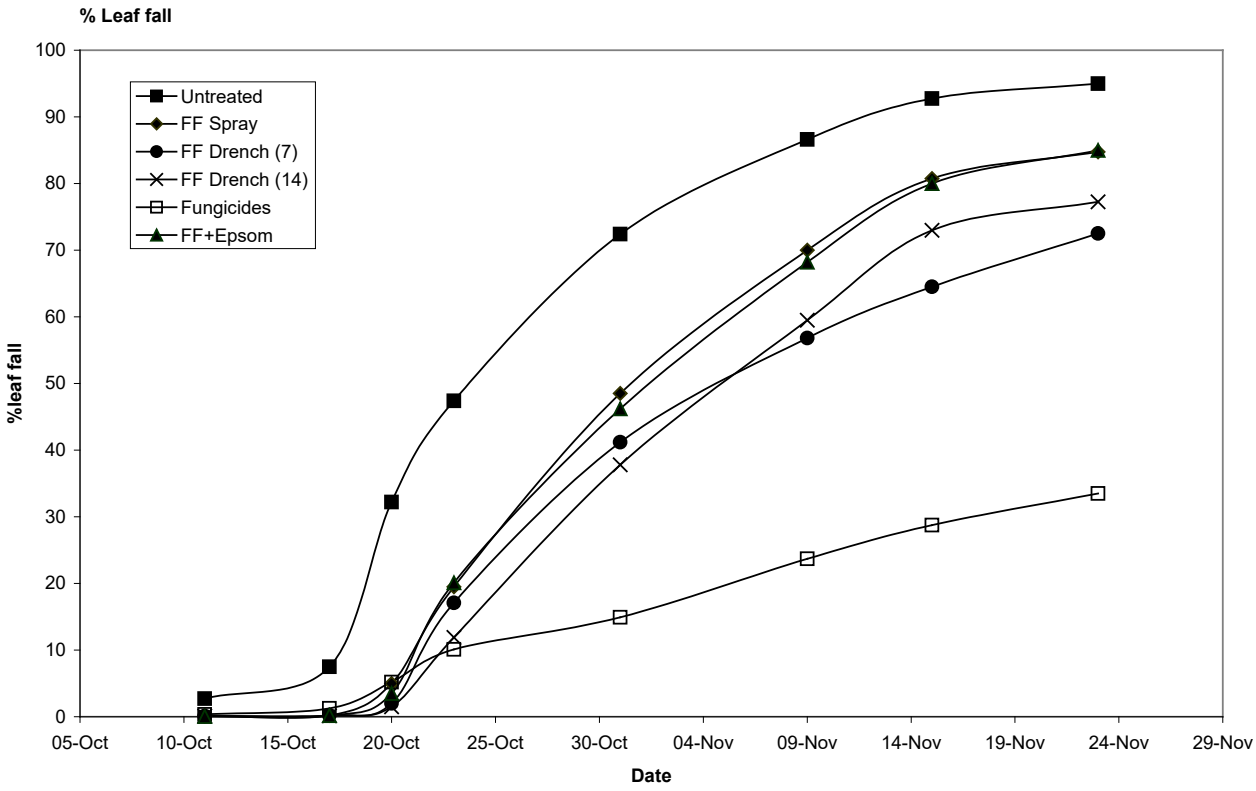

Figure 2. Effect of programmes of Farm-Fos 44 and fungicide on severity of rose downy mildew - 2006 (for clarity, treatments that did not differ significantly from the untreated control are omitted)

Dark coloured leaf spots and leaf yellowing caused by downy mildew.

Severe leaf yellowing associated with downy mildew in an untreated plot.

Pale green angular blotches indicative of downy mildew.

Sudden, severe leaf fall caused by downy mildew.

Figure 3. Symptoms of rose downy mildew.

Financial benefits

Rose downy mildew causes direct losses by rendering plants unsaleable. Additional labour is then required to trim-back plants in an attempt to save them for sale at a later date. Further, because of the adverse effect on the appearance

of plants, especially in garden centres, the disease is believed to have contributed to the decline in popularity of rose over the last 20 years. Estimates of the financial value of such losses are not available. Grower and garden centre manager experience indicates sporadic substantial losses.

Action points for growers (years 1 and 2)

- Prolonged wetness duration markedly increases the risk of downy mildew outbreaks; consider what practical actions can be taken on your nursery to reduce leaf wetness:
    - do not locate container plants in hollows or close to windbreaks
    - consider increased plant spacing
    - time application of irrigation so that leaves dry quickly, if possible.

- Maintain a strict disease management programme in the spring and early summer – newly emerged leaves are particularly susceptible to downy mildew. See HDC Factsheet 12/04 for guidance on suitable fungicides for use on production nurseries.

- Check leaf spots carefully as downy mildew can be mistaken for black spot. The latter usually has a feathery edge, whereas downy mildew leaf spots are often angular, bounded by the leaf veins (see HDC Factsheet 12/04, and Figure 3, above).

- If rose plants show sudden severe leaf yellowing and premature leaf fall, check for downy mildew as a possible cause (Figure 3).

- Remove fallen leaves and any trimmings before re-stocking an area. There is limited experimental evidence that fallen leaves may act as a source of pathogen carry-over between seasons.

- Where rose plants are to be treated with a natural product aimed at a general improvement in crop health, consider using a phosphite product (such as Farm-Fos 44 or TKO Phosphite), Biosept All Clear, EndoRoots Soluble, Orophyte, Seagold or Turf Vigour Special. Regular treatment with these substances was associated with reduced levels of downy mildew.

- Under severe disease pressure, treatment with Farm-Fos 44 or an equivalent phosphite product may give a small though significant reduction in downy mildew and an associated increase in plant vigour.

- On young, micropropagated rose plants, drench treatment with Farm-Fos 44 at 28-day intervals was as effective as foliar sprays at 7-day intervals in

reducing downy mildew. Such treatment is likely to be less effective than a programme of foliar sprays using fungicides with known activity against downy mildew (eg Aliette 80WG, Amistar, Fubol Gold). The efficacy of Farm-Fos 44 against downy mildew on young rose plants was not improved by addition of Epsom salts.

SCIENCE SECTION

1. Evaluation of some natural products applied singly

Introduction

Downy mildew is probably underestimated as a threat to quality rose production compared with the more obvious powdery mildew and black spot diseases. The symptoms are varied and include leaf yellowing, premature leaf fall and poor growth, symptoms that could easily be mistaken for a nutritional or growing problem. More useful as a diagnostic feature is the purplish-brown usually angular spotting visible on the upper leaf surface, though even here care needs to be taken not to confuse downy mildew with black spot. Sometimes a sparse, off-white fungal growth is visible on the lower surface beneath spots. Downy mildew is most common in the spring and autumn, affects a wide range of varieties (some are much more susceptible than others) and can spread very rapidly in wet weather. It can cause serious disfigurement to densely packed container-grown roses on garden centres and field-grown plants in display areas, especially in areas with restricted air-movement and overhead irrigation.

The range of fungicides registered with the Pesticide Safety Directorate for use on roses or other ornamentals in home garden situations is small and none claim activity against downy mildew (see: www.pesticides.gov.uk `garden pesticides search`). The aim of the current project is to seek natural products, such as foliar fertilisers and growth stimulants, that are not subject to pesticide regulation but enhance the plant`s resistance to downy mildew. These materials could potentially be used in areas open to public access. The overall aim is to reduce the risk of severe downy mildew and maintain plant quality.

A literature review in first year of this project identified a range of fertilisers, plant extracts and growth stimulants that are both marketed for use on plants and are reported in research to provide some control of various crop diseases.

In this second year of the project, experiments were conducted to determine the efficacy of natural products. Products were applied as a series of sprays, drenches or as a compost incorporation followed by top-dressing and were compared with a currently approved fungicide, Aliette 80WG, for their efficacy against downy mildew on micro-propagated rose plants.

Information on several of the products used in this experiment (Biosept All Clear, Orophyte, Milsana and Seagold) is given in the first year report. Biosept and Seagold gave significant reductions of downy mildew in experiments in this project in 2005. Products tested for the first time in this project in 2006 were Farm-Fos 44, EndoRoots Soluble and Turf Vigour Special. Information on these products is given below.

Farm-Fos 44 is a liquid foliar fertiliser consisting of an aqueous solution of potassium phosphite. Its nutrient content is 0:32:29 N:P:K by volume. It is available from Farm-Fos Ltd, Builth Farm, Eau Withington, Hereford, HR1 3HQ.

EndoRoots Soluble is a mycorrhizal rooting stimulant containing spores and propagules of nine endomycorrhiza (arbuscular mycorrhizal fungi) species (*Glomus* species and *Gigaspora margarita*), together with humic acids, kelp extracts, ascorbic acid, amino acids, myo-inositol, a surfactant and vitamins B1 and E. The label claims it increases nutrient and water absorption and improves plant disease resistance and stress tolerance. It is available from Novozymes Biologicals (hugf@novozymes.com).

Turf Vigour Special is a liquid formulation of nutrients (8% urea), biostimulants and the bacterium *Bacillus licheniformis.* In the UK it is sold as a rooting stimulant for use in turf grass cultivation, applied as a foliar spray or a soil drench. In the USA it is sold as EcoGuard. Experimental work in the USA has demonstrated activity against *Phytophthora* sp. and *Rhizoctonia* sp. on ornamental seedlings. It is available in the UK from Novozymes Biologicals.

Methods

Treatments are shown in Table 1.1. Each treatment was replicated four times in a randomised block split-plot design; the untreated control was replicated eight times. Each plot contained two varieties of rose. Results were examined by analysis of variance (ANOVA) in Genstat.

Table 1.1. Treatment list for single product efficacy experiment – spring 2006

Treatment		Active ingredient	Rate	Interval (days)
1	Control (water spray)		-	-
2	Aliette 80 WG	80% fosetyl-aluminium	2.5 g/L	14
3	Farm-Fos 44 spray	100% phosphite	2.5 ml/L	14
4	Farm-Fos 44 spray	100% phosphite	2.5 ml/L	7
5	Farm-Fos 44 drench	100% phosphite	5.0 ml/L	28
6	Farm-Fos 44 drench	100% phosphite	5.0 ml/L	14
7	Orophyte spray	Foliar feed	3.0 ml/L	7
8	Milsana spray (+ wetter)	Plant extract	3.0 ml/L	7
9	Biosept All Clear spray	Grapefruit oil & plant extracts	4 ml/L	7
10	Seagold	Calcified seaweed	2.2 g/L	28
11	EndoRoots Soluble drench	Mychorrhizae	1.13 g/L	28
12	Turf Vigour Special drench*	*Bacillus licheniformis*	4.0 ml/L	7

* Sold as Ecoguard in USA

Plants were potted in Levington M2 compost in 1L pots on 21 April. Each bag of compost was mixed with 150 g of 6-12 month slow release fertiliser granules. Each plot was made up of nine young micropropagated rose plants (var. Gentle Touch) and four one-year old plants (var. Peek-a-Boo) laid out pot thick.

Plants were grown in a polythene tunnel on Mypex matting and irrigated with overhead sprinklers. Blocks were arranged in the same direction as the sprinklers and equi-distant either side of the sprinkler line. Plots were spaced at least 0.5 m apart to avoid spray drift between treatments. Sides of the polytunnel were closed to reduce air movement, except on hot, sunny days.

Spray treatments were applied using an Oxford precision sprayer with a single 03F110 nozzle, to the point of run-off (approx. 100 mL/m^2 (1000 L/ha)). Drenches were applied at 100 mL/pot over the leaves. Spray treatments were applied over a period of 9 weeks from 5 May to 30 June. Repeat applications of Seagold (T10) as a top dressing (1 g/pot) were incorporated into the growing medium surface, every 28 days.

Plants were assessed every 14 days commencing from the first spray until 2 weeks after the final spray. They were assessed for percent infected leaves, an estimate of the number of fallen leaves, plant vigour and any phytotoxic effects. At the final assessment, the height of the main stem was measured and stem thickness and leaf colour were also assessed.

Plant vigour was assessed on a 0-5 scale:

0 – Plant dead/dying
1 – Severe downy mildew, 1-5 healthy green leaves
2 – Moderate downy mildew, 10 healthy green leaves remaining
3 – Low level downy mildew (6-10 leaves) but many green leaves
4 – Trace of downy mildew (1-5 leaves), many green leaves
5 – No downy mildew or other defects.

Results and discussion

Full results of all assessments are shown in Appendices 1 and 2. Key results are tabulated below. The first two applications of the Turf Vigour Special drench treatment were applied erroneously at 0.4 mL/L; all subsequent applications were applied at the intended rate of 4.0 mL/L.

Control of downy mildew

Both incidence and severity of disease were considered. On cv. Gentle Touch, the incidence of downy mildew was visible as an occasional spot on 9-28% of plants at the start of the experiment (Table 1.2). By 1 June, 42% of untreated

plants and by 15 July all untreated plants, were affected. Only one product at one assessment had an effect on the incidence of affected plants, and this was slight (Table 1.2).
When assessed on 15 June, disease severity on untreated plants was 13.0% leaf area affected (Table 1.3). This was significantly reduced by all treatments, with Biosept All Clear, Milsana, SeaGold, Farm-Fos drench and Turf Vigour Special reducing it to less that 5% (note: the Milsana treatment was phytotoxic, see below). On 29 June, leaf fall was significantly reduced by Biosept All Clear, one of the Farm-Fos 44 spray treatments and Turf Vigour Special (Table 1.3).

The Aliette spray and Farm-Fos 44 spray applied at 14 day intervals gave similar levels of control. Surprisingly, application of Farm-Fos 44 every 7 days did not improve control over the 14-day spray interval. Disease severity was reduced from 13% on untreated plants to 3.5-7.9% by the various treatments (Table 1.3) Possibly a greater reduction could be achieved on plants that are completely free of downy mildew at the start of treatment as it is unlikely that any of the treatments have significant eradicant activity. On cv. Peek-a-Boo, disease severity was considerably lower (Appendix 2) and none of the treatments significantly reduced % leaf area affected or leaf fall compared with untreated plants.

Table 1.2. Effect of fungicides and natural products on rose downy mildew – disease incidence

Treatment		Treatment interval (days)	Mean number plants affected (of 9), cv. Gentle Touch		
			4 May	1 June	15 June
1.	Untreated	-	2.0	3.8	9.0
2.	Aliette spray	14	2.5	3.8	8.8
3.	Farm-Fos 44 spray	14	1.5	4.3	9.0
4.	Farm-Fos 44 spray	7	0.8	3.0	9.0
5.	Farm-Fos 44 drench	28[a]	2.5	3.8	9.0
6.	Farm-Fos 44 drench	14	1.5	4.3	9.0
7.	Orophyte spray	7	0.8	3.0	9.0
8.	Milsana spray	7	2.3	5.0	8.3
9	Biosept All Clear	7	1.5	4.3	8.3
10.	Seagold incorporation	28	0.8	3.0	8.3
11.	Endo Roots MR drench	28	2.3	5.0	8.8
12.	Turf Vigour Special	7	0.8	3.0	7.8
Significance			0.338	0.925	0.002

SED	0.087-0.150	0.130–0.187	0.000–0.050

[a] Applied in error at 14 day intervals, so treatments 5 and 6 are identical

Plant quality

At the plant vigour assessment on 29 June, there were significant differences between treatments (Table 1.4). Plants that had been treated weekly with Turf Vigour Special were noticeably greener than other plants, probably a reflection of the 5% urea content in this product. On 18 July, two weeks after the final treatment, stem thickness was significantly increased by Biosept All Clear and Turf Vigour Special, but there was no significant effect of treatments on stem height (Table 1.4).

Table 1.3. Effect of fungicides and natural products on rose downy mildew – disease severity on cv. Gentle Touch

Treatment		Treatment interval (days)	Total no. applications (5 May-30 Jun)	Mean % leaf area affected[a]	Leaf fall (0-5)
				15 June	29 June
1.	Untreated	-	-	13.0	6.3
2.	Aliette spray	14	5	7.0	4.8
3.	Farm-Fos 44 spray	14	5	7.9	4.1
4.	Farm-Fos 44 spray	7	9	6.5	5.9
5.	Farm-Fos 44 drench	28[b]	5	6.5	5.8
6.	Farm-Fos 44 drench	14	5	4.8	5.9
7.	Orophyte spray	7	9	6.4	5.4
8.	Milsana spray	7	9	4.9	7.6
9	Biosept All Clear	7	9	4.1	3.5
10.	Seagold incorporation	28	3	4.8	5.1
11.	Endo Roots MR	28	3	7.5	5.0
12.	Turf Vigour Special	7	8	3.5	3.3
Significance				0.006	0.009
SED vs untreated				2.23	0.91

[a] Purple lesions and associated yellowing
[b]Applied in error at 14 day intervals so treatments 5 and 6 are identical

Confirmation of *P. sparsa* in leaves and stems

Samples of leaves collected on 12 and 23 June were tested at NIAB by a molecular method (polymerase chain reaction, or PCR) designed to detect the DNA of the causal fungus *P. sparsa*. Most of the samples with symptoms considered to be due to downy mildew tested positive for *P. sparsa.* Interestingly, some visibly healthy green leaves gave a strong positive result (Table 1.5). This probably reflects colonisation of the leaf by mycelium of *P. sparsa* prior to sporulation. In previous work, abundant sporulation of *P. sparsa* has been noted on the lower surface of green leaves of some rose varieties (T Pettitt, pers com.). Further leaf and stem samples were collected from each treatment on 26 July and many of these tested positive for *P. sparsa* (Table 1.6).

Phytotoxicity

The Milsana treatment at the rate and frequency used proved to be phytotoxic, initially causing blindness of the growing point (noted after 8 sprays) and subsequently leaf death. No problem was observed with the other treatments.

Table 1.4. Effect of fungicides and natural products on rose downy mildew – plant quality, cv. Gentle Touch

Treatment		Treatment interval (days)	Vigour score (0-5)	Greenness score (1-5)	Stem height (cm)	Stem thickness (1-3)
			29 June	30 June	18 July	18 July
1.	Untreated	-	3.5	2.8	33.2	1.3
2.	Aliette spray	14	3.8	2.5	36.5	1.3
3.	Farm-Fos 44 spray	14	3.7	2.8	32.3	1.5
4.	Farm-Fos 44 spray	7	3.6	3.8	37.7	2.0
5.	Farm-Fos 44 drench	28[a]	3.6	3.5	36.2	1.3
6.	Farm-Fos 44 drench	14	3.4	4.3	38.1	2.0
7.	Orophyte spray	7	3.7	3.3	37.3	2.0
8.	Milsana spray	7	2.2	4.0	29.5	2.0
9	Biosept All Clear	7	3.7	3.8	35.3	2.5
10.	Seagold incorporation	28	3.6	3.3	36.8	1.5
11.	Endo Roots MR drench	28	3.7	4.3	37.4	2.0
12.	Turf Vigour Special	7	3.8	5.0	41.6	2.8
Significance			<0.001	0.098	0.189	0.005
SED vs untreated			0.13	0.71	3.26	0.36

[a]Applied in error at 14 day intervals so treatments 5 and 6 are identical

Table 1.5. Detection of *Peronospora sparsa* by PCR test in leaves of cv. Gentle Touch from plants affected by downy mildew

Tissue and symptom	Appearance	PCR positive?
Collected 15 June		
Leaves	Patchy yellow/brown (1 sporangium seen)	Yes
	Mottled green/light green	Very low amount
	Pink patches and pink underside of leaf	No
	Green	Yes
	Yellow leaf with pink spots	No
	Concave yellow leaf	Very low amount
	Green	Yes
	Yellow/brown leaves	Yes
	Green	A PCR product with a different melting point

Table 1.6. Detection of *Peronospora sparsa* by PCR test in leaves of cv. Gentle Touch from plants affected by downy mildew – all treatments

Tissue type and origin	Appearance	PCR positive?
Collected 26 July		
Leaves		
T1 sample 1	Green	Yes
T1 sample 2	Yellow/brown	No
T2 sample 1	Green with yellow/pink central vein	No
T2 sample 2	Brown	No
T3 sample 1	Green, mottled yellow	No
T3 sample 2	Green, mottled yellow with pink patches ~ 2mm	No
T4 sample 1	Brown	Yes
T4 sample 2	Green	No
T5 sample 1	Green	No
T5 sample 2	Green/yellow with pink spots	No
T6 sample 1	Green	No
T6 sample 2	Green with brown patches	Yes
T7 sample 1	Green	No
T7 sample 2	Green, mottled yellow / pink	No
T8 sample 1	Green	No
T8 sample 2	Green with large brown patches	Yes
T9 sample 1	Green	No
T9 sample 2	Green with yellow central vein	Yes
T10 sample 1	Green, mottled yellow	No
T10 sample 2	Green	Yes
T11 sample 1	Green	No
T11 sample 2	Green, mottled yellow / pink	No
T12 sample 1	Green	Yes
T12 sample 2	Green with brown patches	Yes
T13 sample 1	Green, mottled yellow / pink	Yes
Collected July		
Stems		
T stem 1	Yellow	No
T stem 2	Green	No
T stem 3	Base of stem – brown v. woody	Weak signal

T1 and T13 were untreated.

2. Evaluation of some natural products applied in programmes

Introduction

The single product experiment (see above) demonstrated that a range of natural products applied as repeat applications of the same product significantly reduced the severity of rose downy mildew. Biosept All Clear, Farm-Fos 44 and Turf Vigour Special were the most effective and reduced leaf area affected to less than 5%. The objective of this experiment was to devise and test treatment programmes using two or more natural products with the aim of improving the level of control over that obtained using a single product. Treatments were compared with an untreated control and a grower standard fungicide programme. Additional treatments were included to compare the efficacy of Farm-Fos 44 drench treatments applied at 14 and 28 day intervals (this treatment was applied incorrectly in the first experiment), and to investigate the effect of adding Epsom salt (magnesium sulphate) to Farm-Fos 44 applied as a spray. The efficacy of Farm-Fos 44 applied as a spray to hops for control of downy mildew has been reported to improve when combined with the use of a synthetic wetter or Epsom salts (P Glendinning, pers. comm.). Epsom salts rather than a synthetic wetter was used in order that, if proved effective, treatment could be applied to plants in an amenity situation.

Methods

Details of products used are shown in Table 2.1 and treatment programmes are shown in Table 2.2. Treatments were replicated four times in a randomised block split-plot design; the untreated control was replicated eight times. Each plot contained plants of two varieties of rose. Results were examined by analysis of variance (ANOVA) in Genstat.

Table 2.1. Treatment list for product programme efficacy experiment – autumn 2006

Treatment	Active ingredient	Rate
Aliette 80WG	80% fosetyl aluminium	2.5 g/L
Amistar	25% azoxystrobin	2.5 g/L
Biosept All Clear	Grapefruit oil + plant extracts	4 ml/L
EndoRoots Soluble	Mycorrhiza	1.13 g/L
Farm-Fos 44	100% phosphite	2.5 ml/L
Fubol Gold	Metalaxyl + mancozeb	1.9 g/L
Garshield	Garlic extract	10 ml/L
Orophyte	Foliar feed	3 ml/L
Seagold	Calcified seaweed	2.2 g/L
Turf Vigour Special	*Bacillus licheniformis*	4.0 ml/L

Plants were potted in 1 L pots on 1 September and grown in a polythene tunnel on Mypex matting, with overhead irrigation. Each plot consisted of 12 young micropropagated plants, 10 of variety Gentle Touch and two of Silver Jubilee. Arrangement of plots, plant nutrition and application of spray and drench treatments were all as described previously.

On 6 September, all plants were treated with Subdue (metalaxyl-M) at 0.25 L/ha in 2,000 L/ha of water. The purpose of this spray was to eliminate any background downy mildew before the experiment started.

Treatments were applied over a period of 8 weeks from 18 September to 7 November 2006. Two infector plants were introduced between each set of adjacent plots a few days after the first spray. As no disease had developed on plants by 26 September, it was decided to provide conditions more favourable to development of downy mildew. On 27 September, one day after spray treatments had been applied, plants were lightly irrigated using the overhead sprinklers to wet leaves and then all plots in each block were covered with a sheet of polythene for 48 h. This was repeated weekly until 20 October, when disease had begun to cause severe leaf drop.

Plants were assessed for percentage leaf drop every 7-14 days. Additionally, at the final assessment on 23 November, 2 weeks after the final spray, the leaf area affected was estimated and each plant was assessed for plant vigour (0-5 scale, as described previously).

Table 2.2. Effect of treatment on mean number of plants (incidence) affected by downy mildew – autumn 2006

Treatment (interval)		Mean number plants affected (of 12)				
		11 Oct	17 Oct	23 Oct	31 Oct	9 Nov
1.	Untreated (control)	2.0	5.3	11.1	11.6	12.0
2.	Farm Fos spray (7d)	0	0.5	9.5	11.8	12.0
3.	Farm Fos drench (14d)	0.8	1.8	7.8	11.8	12.0
4.	Farm Fos drench (28d)	0	0.3	8.5	11.8	12.0
5.	FF/Biosept (7d)	0.3	1.0	10.0	12.0	12.0
6.	FF/Orophyte (7d)	0.3	4.5	10.5	12.0	12.0
7.	FF/TVS (7d)	0.5	3.3	9.5	11.5	12.0
8.	SG/FF/FF/FF/FF/SG/FF/FF/FF (7d)	0.5	1.8	10.3	12.0	12.0
9.	ER/TVS/TVS/TVS/TVS/TVS/ER/TVS/TVS (7d)	0	1.0	9.8	11.8	12.0
10.	Fub/Ali/Fub/Ali/Fub/Ami/Ali/Ami	1.3	2.8	5.8	9.0	10.5
11.	Garshield Biostimulant (7d)	0	3.8	10.3	12.0	12.0
12.	Farm Fos spray + Epsom Salts (7d)	0	1.5	8.8	12.0	12.0
	Significance level (37df)	0.588	0.076	0.084	0.010	0.010
	Control vs rest	0.012	0.003	0.030	0.930	0.502
	LSD (5%) between trt	2.36	3.83	3.27	1.44	0.75
	vs control	2.05	3.24	2.84	1.25	0.69

Ali – Aliette 80WG spray; Ami – Amstar spray; ER – EndoRoots mycorrhiza drench; FF – Farm-Fos 44 spray; Fub – Fubol Gold spray; SG – SeaGold incorporation as top dressing; TVS – Turf Vigour Special; / - products applied in alternation.

Table 2.3: Effect of treatment on the disease progress of downy mildew and number of days to 50% leaf-drop – autumn 2006

Treatment (interval)		Total number treatments	Area under disease progress curve [a]	Number of days to 50% leaf drop [b]
1.	Untreated (control)	-	2,693	14
2.	Farm-Fos 44 spray (7d)	8	1,965	22
3.	Farm-Fos 44 drench (14d)	4	1,619	26
4.	Farm-Fos 44 drench (28d)	2	1,658	26
5.	FF/Biosept (7d)	8	2,310	18
6.	FF/Orophyte (7d)	8	2,377	18
7.	FF/TVS (7d)	8	2,397	18
8.	SG/FF/FF/FF/FF/SG/FF/FF/FF (7d)	9	2,407	17
9.	ER/TVS/TVS/TVS/TVS/TVS/ER/TVS/ TVS (7d)	9	2,233	19
10.	Fub/Ali/Fub/Ali/Fub/Ami/Ali/Ami	8	718	- [c]
11.	Garshield Biostimulant (7d)	8	2,525	16
12.	Farm Fos spray + Epsom Salts (7d)	8	1,926	23
	Significance level (37df)		<0.001	
	Control vs rest		<0.001	
	LSD (5%) between treatments		695	
	Vs control		602	

[a] 11 Oct- 23 November
[b] From 11 October
[c] Did not reach 50% leaf drop

Table 2.4. Effect of treatment and variety on severity of rose downy mildew – 23 November 2006

Treatment (interval)		% leaf area affected		
		Gentle Touch	Silver Jubilee	Mean
1.	Untreated (control)	52.8	72.8	56.2
2.	Farm-Fos 44 spray (7d)	50.1	54.1	50.7
3.	Farm-Fos 44 drench (14d)	43.6	46.3	44.0
4.	Farm-Fos 44 drench (28d)	41.4	49.0	42.7
5.	FF/Biosept (7d)	42.8	55.3	44.9
6.	FF/Orophyte (7d)	46.3	69.6	50.2
7.	FF/TVS (7d)	51.6	55.6	52.3
8.	SG/FF/FF/FF/FF/SG/FF/FF/FF (7d)	53.9	58.8	54.7
9.	ER/TVS/TVS/TVS/TVS/TVS/ER/ TVS/TVS (7d)	54.4	64.8	56.1
10.	Fub/Ali/Fub/Ali/Fub/Ami/Ali/Ami	24.2	18.3	23.2
11.	Garshield Biostimulant (7d)	48.7	69.5	52.1
12.	Farm Fos spray + Epsom Salts (7d)	48.4	60.4	50.4
	Significance level (33df)			<0.001
	LSD between treatments			11.28
	vs control			9.97

The mean level of infection was significantly greater (P<0.001) on Silver Jubilee (57.5%) than Gentle Touch (47.0%).

Table 2.5. Effect of treatment on vigour of rose plants – November 2006

Treatment (interval)		Plant vigour (0-5)		
		Gentle Touch	Silver Jubilee	Mean
1.	Untreated (control)	0.9	0.8	0.9
2.	Farm-Fos 44 spray (7d)	1.3	1.8	1.4
3.	Farm-Fos 44 drench (14d)	1.5	1.9	1.5
4.	Farm-Fos 44 drench (28d)	1.4	1.4	1.4
5.	FF/Biosept (7d)	1.3	1.3	1.3
6.	FF/Orophyte (7d)	1.2	0.8	1.1
7.	FF/TVS (7d)	1.1	1.3	1.1
8.	SG/FF/FF/FF/FF/SG/FF/FF/FF (7d)	1.0	1.3	1.0
9.	ER/TVS/TVS/TVS/TVSTVS/ER/TVS/TVS (7d)	1.0	1.0	1.0
10.	Fub/Ali/Fub/Ali/Fub/Ami/Ali/Ami	3.0	3.3	3.1
11.	Garshield Biostimulant (7d)	1.1	0.9	1.1
12.	Farm Fos spray + Epsom Salts (7d)	1.2	1.0	1.1
	Significance level (33df)			<0.001
	LSD between treatments			0.42
	vs control			0.36

The mean plant vigour of Gentle Touch (1.3) was not significantly different from that of Silver Jubilee (1.3) (P=0.758).

Results and discussions

Control of downy mildew

When the plants were potted on 1 September, symptoms suggestive of downy mildew were visible on occasional plants. Plants were treated with Subdue to control this uneven infection originating with the plants; infector rose and blackberry plants, showing symptoms of downy mildew, were then introduced between all plots. The disease progressed slowly and after 6 weeks (11 October) affected on average two out of 12 untreated plants, appearing as purple leaf spots, and occasionally on treated plants (Table 2.2). Sporulation of *P. sparsa* was confirmed on 11 October. After two periods of 48 h leaf wetness, achieved by covering the plants with polythene, the disease was visible on most plants. The incidence of infected plants on 31 October and 9 November was significantly reduced by the alternating fungicide programme (Table 2.2) and not by other treatments.

At the final assessment of 23 November, two weeks after the final spray, leaf fall was greatest on untreated plants (95%) and least on plants treated with fungicides (40%) (Fig. 2.1). Treatments were compared statistically after expressing disease severity as the area under the disease progress curves (% leaf fall x no. of days) (Table 2.3). Downy mildew was significantly reduced by the Farm-Fos 44 spray, Farm-Fos 44 drench and the alternating fungicide programme. Drench application of Farm-Fos 44 at 14-day intervals gave no greater control than drench application at 28-day intervals; addition of Epsom salts to Farm-Fos 44 applied as a spray did not improve control. None of the other treatments were significantly different from the untreated control. Treatments were further compared by estimating the number of days that elapsed from the first assessment of downy mildew in the experiment (11 October), to 50% leaf fall. This period was increased from 14 days (untreated) to 22-23 days by Farm-Fos 44 applied as a spray and to 26 days by Farm-Fos 44 applied as a drench. The alternating programmes of natural products appeared to increase the period from 14 days to 16-19 days (Table 2.3). Plants treated with the alternating fungicide programme had less than 50% leaf fall at the end of the experiment.

Treatments that resulted in reduced leaf fall also reduced leaf spotting due to downy mildew (Table 2.4) and improved plant vigour (Table 2.5). The alternating treatment of Farm-Fos 44 with Biosept All Clear was as effective as the Farm-Fos 44 spray programme in these assessments.

At the final assessment, the mean level of leaf spotting on Silver Jubilee (57.5% leaf are affected) was significantly greater than that on Gentle Touch (47.0%). The two varieties did not differ in plant vigour at this time.

This experiment clearly demonstrated that under conditions highly conducive to downy mildew, as created by covering wet plants with polythene for 48 h, downy mildew is very difficult to control. Application of a fungicide spray every 7 days reduced percentage leaf fall from 95% to 33.5%, and leaf spotting from 56% to 23%. Although none of the programmes of natural products were as effective as the fungicide programme, Farm-Fos 44 did result in a small but significant reduction in downy mildew severity. Both spray and drench treatments were effective. In the initial experiment (spring 2006), where the disease pressure was lower, Farm-Fos 44 applied as a spray every 7 days reduced percentage leaf fall by 50%. The other natural products that significantly reduced downy mildew at the lower disease pressure were generally ineffective when tested at the high disease pressure and as alternating sprays with Farm-Fos 44; the exception was the Farm-Fos/Biosept All Clear programme, which significantly reduced leaf spotting, though not leaf fall.

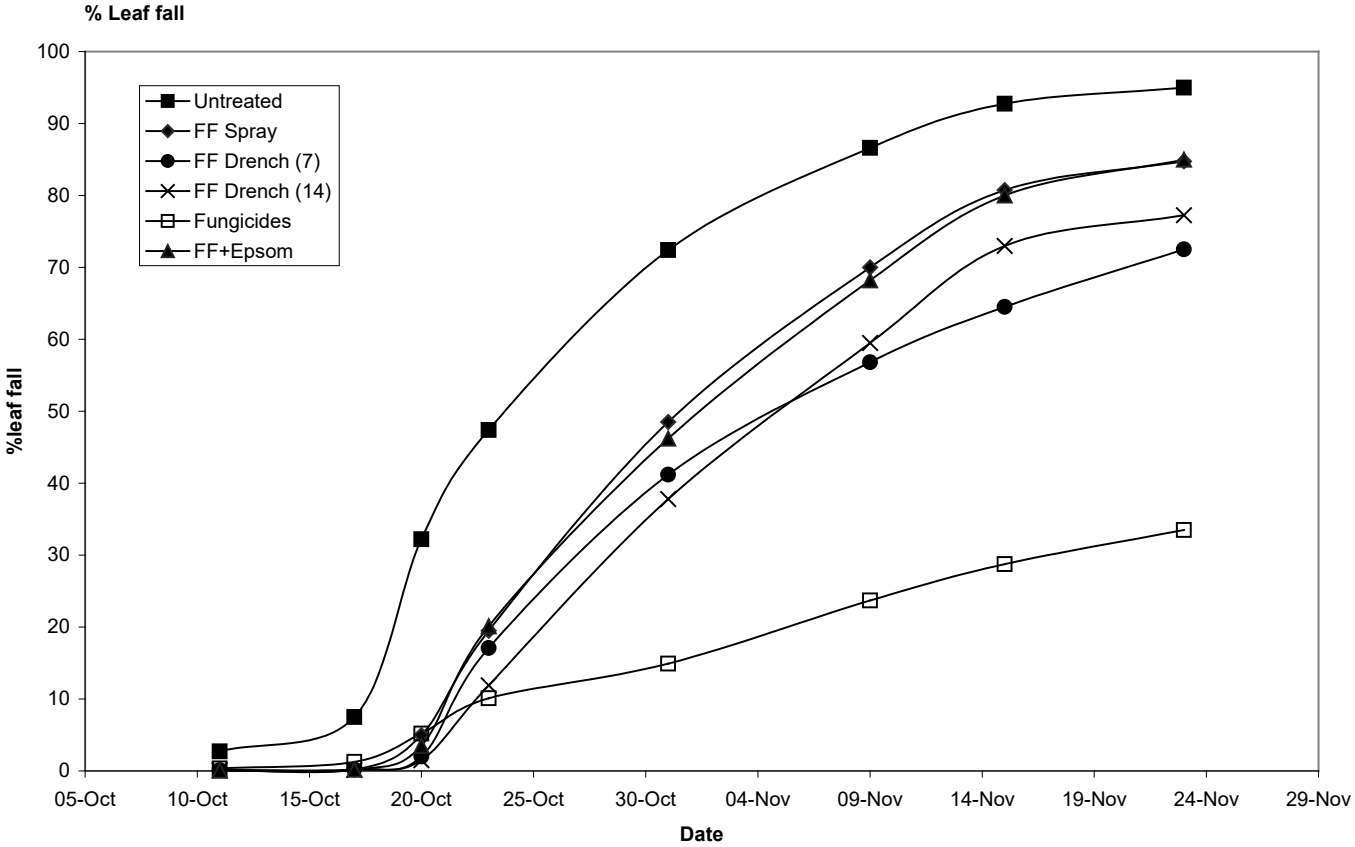

Figure 2.1. Progression of leaf fall caused by rose downy mildew (for clarity, treatments 5, 6, 7, 8 and 9 are omitted as these did not differ significantly from the untreated control)

Phytotoxicity

Very slight yellowing and distortion of new growth was seen after the application of Subdue but this was very minor (15 Sept) and the effect had almost disappeared by the time of the first application of the treatment (18 Sept).

None of the natural product treatments resulted in leaf scorch or other symptoms of phytotoxicity. Leaf margin scorch was visible on some plants after treatment with Fubol Gold, one of the products used in the fungicide programme; this effect was transient.

3. Conclusions

1. Development of rose downy mildew is strongly influenced by leaf wetness duration. Epidemic disease developed following four 48 h periods of leaf wetness at weekly intervals on the susceptible varieties Gentle Touch and Silver Jubilee.

2. Under low to moderate disease pressure, a range of natural products can provide some control of rose downy mildew. Product applications resulting in reduced severity of downy mildew were three foliar fertilisers (Farm-Fos 44, Orophyte, Biosept All Clear), two rooting stimulants (EndoRoots mycorrhiza and Turf Vigour Special) and a growing medium amendment (Seagold).

3. Under severe disease pressure, the foliar fertiliser potassium phosphite (Farm-Fos 44) can provide a small though significant reduction in rose downy mildew severity and an improvement in plant vigour.

4. Under severe disease pressure, Garshield alone and alternating programmes of Farm-Fos 44 with Orosorb, Seagold and Turf Vigour special did not reduce downy mildew.

5. Under severe disease pressure, the addition of Epsom salts to Farm-Fos 44 applied as a foliar spray did not improve control of downy mildew.

6. In these experiments the rose variety Peek-a-Boo was less susceptible to downy mildew than Gentle Touch, which was less susceptible than Silver Jubilee.

7. Using a PCR test, *Peronospora sparsa* was detected in apparently healthy green leaves as well as in brown, yellow, pink and mottled (light green/dark green) leaves from rose plants affected by downy mildew.

8. Milsana applied at 3 ml/L (+ wetter) every 7 days is cumulatively phytotoxic to young, micro-propagated rose cvs Gentle Touch and Peek-a-Boo, resulting in blindness of the growing point and leaf death.

4. Technology transfer

New crop protection options for roses. *HDC News* **123**, p19.

Rose downy mildew control – naturally. *HDC News* (in press).

Project meeting ADAS Arthur Rickwood, 26 June 2006 (Tim O`Neill, Neal Wright, Jane Thomas).

Project review meeting, London, 12 March 2007.

5. Acknowledgements

We are grateful to Dr Neal Wright, Micropropagation Services (E.M.) Ltd for supply of young rose plants, Chris Dyer, ADAS Statistician, for data analysis, and to Dr Jane Thomas, NIAB, for PCR testing of leaf and stem samples for *P. sparsa.*

APPENDICES

Appendix 1: Full results of assessments on cv Gentle Touch – spring 2006

Table A1. Effect of Aliette and some natural products on control of rose downy mildew – disease incidence (Friedman`s test)

Treatment	No. plants affected (of 9)				
	04.05.06	01.06.06	15.06.06	29.06.06	18.07.06
1. Untreated	2.5	4.0	9.0	9.0	9.0
2. Aliette spray	2.5	3.8	8.8	9.0	9.0
3. Farm-Fos spray 14 day	1.5	4.3	9.0	9.0	9.0
4. Farm-Fos spray 7 day	0.8	3.0	9.0	9.0	9.0
5. Farm-Fos drench 28 day[a]	2.5	3.8	9.0	9.0	9.0
6. Farm-Fos drench 14 day	1.5	4.3	9.0	9.0	9.0
7. Orophyte spray	0.8	3.0	9.0	9.0	9.0
8. Milsana spray	2.3	5.0	8.3	9.0	9.0
9. Biosept All Clear spray	1.5	4.3	8.3	9.0	9.0
10. Seagold incorporation	0.8	3.0	8.3	9.0	9.0
11. Endo Roots MR drench	2.3	5.0	8.8	9.0	9.0
12. Untreated	1.5	3.5	9.0	9.0	9.0
13. Turf Vigour Special drench	0.8	3.0	7.8	8.0	8.0
Significance	0.338	0.925	0.002	-	-
SED	0.087-0.150	0.130-0.187	<0.001-0.050	-	-

[a]Applied in error at 14 day intervals

Table A2. Effect of Aliette and some natural products on control of downy mildew – disease severity – mean % leaf area affected

Treatment	% leaf area affected				
	04.05.06	01.06.06	15.06.06	29.06.06	18.07.06
1. Untreated	1.7	0.9	13.0	4.7	10.4
2. Aliette spray	1.1	0.6	7.0	3.4	5.5
3. Farm-Fos spray 14 day	0.8	1.0	7.9	3.8	8.6
4. Farm-Fos spray 7 day	0.2	0.6	6.5	3.8	7.9
5. Farm-Fos drench 28 day[a]	1.0	1.0	6.6	4.3	8.2
6. Farm-Fos drench 14 day	0.4	0.6	4.8	5.3	6.7
7. Orophyte spray	1.0	1.1	6.4	3.4	6.9
8. Milsana spray	1.4	0.7	4.9	27.9	17.3
9. Biosept All Clear spray	0.6	0.6	4.1	4.2	8.8
10. Seagold incorporation	0.5	0.9	4.8	4.2	10.6
11. Endo Roots MR drench	0.7	0.7	7.5	3.5	8.1
12. Turf Vigour Special drench	0.8	0.6	3.5	4.0	8.3
Significance	0.354	0.93	0.006	<0.001	0.07
SED vs untreated	0.54	0.36	2.23	1.37	2.67
SED between treatments	0.63	0.42	2.57	1.58	3.08

[a]Applied in error at 14 day intervals

Table A3. Effect of Aliette and some natural products on control of downy mildew – disease severity – leaf fall

Treatment	% leaf fall				
	04.05.06	01.06.06	15.06.06	29.06.06	18.07.06
1. Untreated	0.3	0.5	2.6	6.3	18.3
2. Aliette spray	0.3	0.6	1.8	4.8	7.3
3. Farm-Fos spray 14 day	0.3	0.8	1.6	4.1	9.9
4. Farm-Fos spray 7 day	0.7	0.3	1.7	5.9	8.7
5. Farm-Fos drench 28 day[a]	0.0	0.3	1.3	5.8	12.4
6. Farm-Fos drench 14 day	0.6	0.0	1.4	5.9	11.2
7. Orophyte spray	0.0	0.8	1.7	5.4	7.1
8. Milsana spray	0.4	0.5	1.4	7.6	7.9
9. Biosept All Clear spray	0.3	0.3	1.3	3.5	9.7
10. Seagold incorporation	0.0	0.8	1.3	5.1	20.3
11. Endo Roots MR drench	0.1	0.4	1.7	5.0	12.6
12. Turf Vigour Special drench	0.3	0.6	0.6	3.3	12.6
Significance	0.847	0.524	0.113	0.009	0.259
SED vs untreated	0.37	0.32	0.52	0.91	4.95
SED between treatments	0.42	0.37	0.60	1.05	5.71

[a]Applied in error at 14 day intervals

Table A4. Effect of Aliette and some natural products on control of downy mildew – disease severity – vigour score

Treatment	vigour score (0-5)				
	04.05.06	01.06.06	15.06.06	29.06.06	18.07.06
1. Untreated	4.6	4.6	3.6	3.5	2.9
2. Aliette spray	4.7	4.5	3.9	3.8	3.4
3. Farm-Fos spray 14 day	4.8	4.4	3.8	3.7	3.1
4. Farm-Fos spray 7 day	4.9	4.6	3.9	3.6	3.1
5. Farm-Fos drench 28 day[a]	4.7	4.4	3.9	3.6	3.1
6. Farm-Fos drench 14 day	4.8	4.6	4.0	3.4	3.0
7. Orophyte spray	4.8	4.3	3.8	3.7	3.3
8. Milsana spray	4.6	4.5	4.1	2.2	2.8
9. Biosept All Clear spray	4.9	4.6	4.0	3.7	3.1
10. Seagold incorporation	4.8	4.4	4.0	3.6	2.9
11. Endo Roots MR drench	4.9	4.5	3.8	3.7	3.0
12. Turf Vigour Special drench	4.8	4.6	4.0	3.8	3.1
Significance	0.123	0.576	0.004	<0.001	0.311
SED vs untreated	0.10	0.14	0.12	0.13	0.19
SED between treatments	0.11	0.16	0.14	0.16	0.22

[a]Applied in error at 14 day intervals

Table A5. Effect of Aliette and some natural products on control of rose downy mildew – plant size and appearance – rose quality score (0-5)

Treatment	Quality score 07.07.06
1. Untreated	2.4
2. Aliette spray	2.8
3. Farm-Fos spray 14 day	3.0
4. Farm-Fos spray 7 day	3.5
5. Farm-Fos drench 28 day[a]	2.5
6. Farm-Fos drench 14 day	3.3
7. Orophyte spray	3.8
8. Milsana spray	1.0
9. Biosept All Clear spray	3.0
10. Seagold incorporation	3.0
11. Endo Roots MR drench	3.3
12. Turf Vigour Special drench	3.5
Significance	0.03
SED vs untreated	0.60
SED between treatments	0.69

[a]Applied in error at 14 day intervals

Appendix 2: Full results of assessments on cv Peek-a-Boo – spring 2006

Table A6. Effect of Aliette and some natural products on control of rose downy mildew – disease incidence (Friedman`s test)

Treatment	No. plants affected (of 4)				
	04.05.06	01.06.06	15.06.06	29.06.06	18.07.06
1. Untreated	0.0	0.5	2.3	4.0	4.0
2. Aliette spray	0.0	0.3	1.3	4.0	4.0
3. Farm-Fos spray 14 day	0.0	0.3	2.0	4.0	4.0
4. Farm-Fos spray 7 day	0.0	0.8	2.0	4.0	4.0
5. Farm-Fos drench 28 day[a]	0.0	0.3	2.0	4.0	4.0
6. Farm-Fos drench 14 day	0.0	0.3	2.3	4.0	4.0
7. Orophyte spray	0.0	0.5	1.3	4.0	4.0
8. Milsana spray	0.0	0.0	2.3	4.0	4.0
9. Biosept All Clear spray	0.0	1.5	2.3	4.0	4.0
10. Seagold incorporation	0.0	0.0	0.8	4.0	4.0
11. Endo Roots MR drench	0.0	0.3	1.5	4.0	4.0
12. Untreated	0.0	0.3	2.0	4.0	4.0
13. Turf Vigour Special drench	*	*	*	*	*
Significance		<0.001	0.831		
SED		<0.001-0.088	0.178-0.253		

[a]Applied in error at 14 day intervals

Table A7. Effect of Aliette and some natural products on control of downy mildew – disease severity – mean % leaf area affected

Treatment	% leaf area affected				
	04.05.06	01.06.06	15.06.06	29.06.06	18.07.06
1. Untreated	0.0	0.1	0.4	4.8	3.5
2. Aliette spray	0.0	0.0	0.5	5.6	4.5
3. Farm-Fos spray 14 day	0.0	0.1	0.3	4.2	4.2
4. Farm-Fos spray 7 day	0.0	0.1	1.1	6.1	4.1
5. Farm-Fos drench 28 day[a]	0.0	0.0	0.8	3.8	4.6
6. Farm-Fos drench 14 day	0.0	0.0	1.0	5.0	5.1
7. Orophyte spray	0.0	0.1	0.6	5.3	3.7
8. Milsana spray	0.0	0.0	1.1	8.1	4.4
9. Biosept All Clear spray	0.0	0.3	0.5	5.6	5.8
10. Seagold incorporation	0.0	0.0	0.9	4.6	2.8
11. Endo Roots MR drench	0.0	0.0	0.4	4.2	5.4
12. Turf Vigour Special drench	*		*	*	*
Significance		0.011	0.849	0.209	0.384
SED vs untreated		0.06	0.52	1.23	1.06
SED between treatments		0.07	0.60	1.42	1.22

[a]Applied in error at 14 day intervals

Table A8. Effect of Aliette and some natural products on control of downy mildew – disease severity – leaf fall

Treatment	% leaf fall				
	04.05.06	01.06.06	15.06.06	29.06.06	18.07.06
1. Untreated	0.0	0.0	0.2	2.6	4.3
2. Aliette spray	0.0	0.0	0.2	3.2	5.9
3. Farm-Fos spray 14 day	0.0	0.0	0.4	2.6	5.5
4. Farm-Fos spray 7 day	0.0	0.0	0.6	3.8	5.0
5. Farm-Fos drench 28 day[a]	0.0	0.0	0.3	3.4	5.5
6. Farm-Fos drench 14 day	0.0	0.0	0.2	3.5	5.6
7. Orophyte spray	0.0	0.0	0.5	2.5	4.7
8. Milsana spray	0.0	0.0	1.1	4.6	7.2
9. Biosept All Clear spray	0.0	0.0	0.4	3.4	6.2
10. Seagold incorporation	0.0	0.0	0.3	1.8	8.8
11. Endo Roots MR drench	0.0	0.0	0.2	2.6	5.5
12. Turf Vigour Special drench	*	*	*	*	*
Significance			0.106	0.023	0.83
SED vs untreated			0.24	0.61	2.15
SED between treatments			0.28	0.71	2.49

[a]Applied in error at 14 day intervals

Table A9. Effect of Aliette and some natural products on control of downy mildew – disease severity – vigour score

Treatment	Vigour score (0-5)

	04.05.06	01.06.06	15.06.06	29.06.06	18.07.06
1. Untreated	5.0	4.9	4.5	3.7	3.8
2. Aliette spray	5.0	4.9	4.7	3.6	3.6
3. Farm-Fos spray 14 day	5.0	4.9	4.5	3.7	3.5
4. Farm-Fos spray 7 day	5.0	4.8	4.5	3.5	3.6
5. Farm-Fos drench 28 day[a]	5.0	4.9	4.5	3.7	3.5
6. Farm-Fos drench 14 day	5.0	4.9	4.4	3.6	3.4
7. Orophyte spray	5.0	4.9	4.7	3.8	3.8
8. Milsana spray	5.0	5.0	4.4	3.1	3.4
9. Biosept All Clear spray	5.0	4.6	4.4	3.4	3.4
10. Seagold incorporation	5.0	5.0	4.8	3.7	3.8
11. Endo Roots MR drench	5.0	4.9	4.6	3.8	3.3
12. Turf Vigour Special drench	*	*	*	*	*
Significance		0.032	0.714	0.012	0.179
SED vs untreated		0.08	0.19	0.14	0.19
SED between treatments		0.10	0.22	0.16	0.21

[a]Applied in error at 14 day intervals

Table A10. Effect of Aliette and some natural products on control of rose downy mildew – plant size and appearance – stem height (cm)

Treatment	Stem height 18.07.06

1. Untreated	29.7
2. Aliette spray	32.5
3. Farm-Fos spray 14 day	34.4
4. Farm-Fos spray 7 day	31.6
5. Farm-Fos drench 28 day[a]	35.0
6. Farm-Fos drench 14 day	35.2
7. Orophyte spray	30.4
8. Milsana spray	31.7
9. Biosept All Clear spray	30.8
10. Seagold incorporation	29.5
11. Endo Roots MR drench	31.2
12. Turf Vigour Special drench	*
Significance	0.667
SED vs untreated	3.04
SED between treatments	3.51

[a]Applied in error at 14 day intervals

Appendix 3: Full results of disease assessments - autumn 2006

Table A11. Effect of treatment on leaf drop – autumn 2006.

Treatment (interval)	Mean % leaf drop

		17 Oct	20 Oct	23 Oct	31 Oct	9 Nov	16 Nov	23 Nov
1.	Untreated (control)	7.5	32.2	47.4	72.4	86.6	92.8	95.0
2.	Farm Fos spray (7d)	0.2	5.0	19.5	48.5	70.0	80.8	84.8
3.	Farm Fos drench (14d)	0.2	2.0	17.1	41.2	56.8	64.5	72.5
4.	Farm Fos drench (28d)	0.1	1.5	11.9	37.8	59.5	73.0	77.2
5.	FF/Biosept (7d)	0.2	12.0	30.3	64.0	78.0	87.8	91.0
6.	FF/Orophyte (7d)	1.2	12.5	31.1	63.8	81.5	90.5	94.0
7.	FF/TVS (7d)	1.6	24.2	31.5	62.5	80.0	91.0	93.8
8.	SG/FF/FF/FF/ SG/FF/FF/FF (7d)	0.3	13.2	28.5	66.2	83.5	91.0	95.5
9.	ER/TVS/TVS/TVS/TVS /ER/TVS/TVS (7d)	0.5	4.0	25.0	60.2	79.5	86.8	91.2
10.	Fub/Ali/Fub/Ali/Fub/Ami/Ali/Ami	1.3	5.2	10.1	14.9	23.7	28.8	33.5
11.	Garshield Biostimulant (7d)	0.9	21.2	38.5	67.8	87.8	91.2	93.2
12.	Farm Fos spray + Epsom Salts (7d)	0.2	3.5	20.1	46.8	68.2	80.0	85.0
	Significant level (37df)	0.347	0.185	0.242	<0.001	<0.001	<0.001	<0.001
	control vs rest	0.001	0.004	0.008	0.004	0.002	0.002	0.004
	SED between trts	3.62	13.56	15.32	12.28	9.32	7.87	7.23
	vs control	3.13	11.75	13.26	10.63	8.08	6.82	6.26