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

March 2008

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The results and conclusions in this report are based on a series of experiments conducted over three years. 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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GROWER SUMMARY

Headline

The foliar fertiliser potassium phosphite, and to a lesser extent some other natural products, provided partial control of rose downy mildew and improved plant marketability; the efficacy of potassium phosphite applied as a spray (eg Farm-Fos 44) was significantly improved by addition of a silicone-based wetter (Silwet-L77).

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, although intensive spraying may be required. On garden centres, other areas with public access, and in the home garden, the range of permissible fungicides with activity against downy mildew is limited.

An increasing number of biostimulants and natural products are currently being marketed that claim to enhance a plant's resistance to disease. These have potential for use in the amenity sector to help manage downy mildew and other diseases of rose. However, there is very little robust scientific evidence on product efficacy. The overall objective of this project was to evaluate some biostimulants and natural products for prevention and control of downy mildew (*Peronospora sparsa*) and to assess their effect on shelf-life. Novel fungicides are being evaluated in a concurrent project (HNS 150).

Summary of the project and main conclusions

Biology and control of rose downy mildew - an overview

Peronospora sparsa, the cause of rose downy mildew, affects only members of the Rosaceae family, including blackberry and cherry laurel. Some varieties of rose (e.g. Gentle Touch, Silver Jubilee) are more susceptible than others. Symptoms on rose occur most commonly on young leaves (where it can be mistaken for black spot) and less commonly on other plant parts. As well as disfigurement, this serious disease causes premature rapid defoliation, stunted growth and shoot death (Figure 1). The disease is highly sporadic and can become epidemic under moist conditions. Outbreaks in spring are most common. The casual fungus is spread in the air as an asexual spore and persists in fallen leaves as resting spores, and in woody tissue as fungal strands. Management of downy mildew by early detection and treatment of infection sources is currently being investigated (HNS 150). Leaf wetness is critical for disease development with prolonged wetness (e.g. 84 h over 10 days) being particularly favourable; temperature in the range of 5-20°C had little effect on disease development. Control on commercial nurseries is usually achieved by a preventative programme of suitable fungicide sprays.

Figure 1. Symptoms of downy mildew

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

Pale green angular blotches indicative of downy mildew.

Severe leaf yellowing associated with downy mildew (untreated plants)

Sudden severe leaf fall caused by downy mildew

Pesticide legislation affecting use of natural products

The legal status regarding use of natural products to aid disease control is complex and changing. Products are likely to be judged by the Pesticides Safety Directorate (PSD) as currently outside the scope of UK pesticide legislation if they are nutritional products that only make general claims to increase resistance to disease by ensuring

adequate nutrition, giving resistance to a disorder related to a nutrient deficiency or increasing the population of beneficial soil micro-organisms, thereby outcompeting soil-borne diseases. PSD consider that the following are effectively plant protection products and therefore within the scope of UK pesticide legislation:

- products claiming to enhance a plant's resistance to a specific disease
- products based on recognised pesticide active substances (e.g. neem oil)
- products working by exerting a direct control on pests or disease (e.g. potassium bicarbonate on powdery mildew)
- products making a claim to provide direct disease control
- products influencing the life processes of plants (e.g. growth regulators)

Natural products for disease control

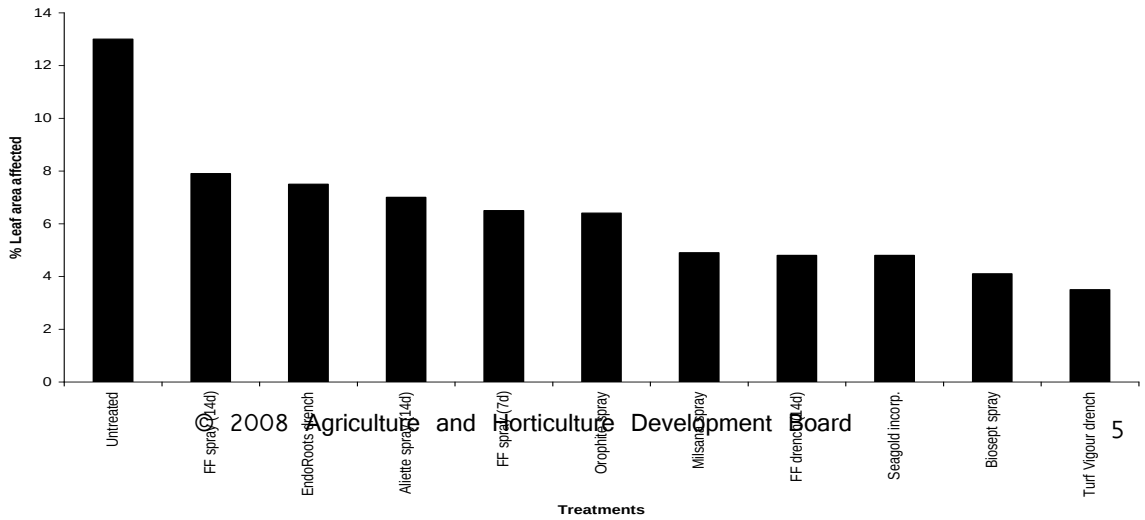
Information on the composition, mode of action (where known) and evidence for efficacy against downy mildew or related fungi was summarised for 18 substances (see Year 1 annual report). These comprise six chemical salts (Orophite, potassium bicarbonate, potassium chloride, potassium phosphite and sodium silicate), seven plant extracts (neem oil, Milsana, laminarin, herbal oils, Citrox P, Biosept All Clear and oilseed rape oil) and six other substances (crab shell powder, Seagold, salicylic acid, Companion, *Muscodor albus* and compost tea). The most promising products were chosen for testing on rose.

Comparison of some fungicides and natural products - 2005

Eight natural products (Biosept All Clear, crustacean shell powder, oilseed rape oil, potassium bicarbonate, salicylic acid, SeaGold, sodium silicate and TKO Phosphite) were compared with two fungicides, Aliette 80WG (fosetyl-aluminium) and Dithane 945 (mancozeb), for control of downy mildew on rose cvs Gentle Touch and Peek-

A-Boo and blackberry cv. Loch Ness in autumn 2005. Blackberry cv. Loch Ness was used alongside rose because it is very susceptible to the same downy mildew fungus and shows clear leaf symptoms. Plants were grown on mypex matting in an unheated polythene tunnel with overhead irrigation. Chitin and SeaGold were incorporated into the compost. The other substances were applied as foliar sprays every 7 days (10 sprays in total) except for Aliette 80 WG and TKO Phosphite, which were applied every 14 days (6 sprays in total). The experiment was conducted twice.

In experiment 1, the disease affected around 0.1% of rose leaf area at the start of the experiment, increased to a peak of 5% on untreated plants and then declined as affected leaves fell. The percentage leaf area affected one month after the final spray (Figure 2), was significantly reduced by Aliette 80WG, Biosept All Clear, Dithane 945 and salicylic acid. Dithane 945 left an obvious white spray deposit and salicylic acid significantly reduced plant vigour. No treatment increased plant vigour. On untreated blackberry plants, 20% leaf area was affected 1 week after the final spray (Figure 3). This was significantly reduced by Aliette 80WG, TKO Phosphite, and Dithane 945. Compared with untreated plants, Aliette 80WG and Dithane 945 increased the final plant vigour score.



In experiment 2, levels of downy mildew were very low. Two weeks after the final spray on rose, disease incidence was 19% in untreated plants and 6% or less in plants treated with Aliette 80WG, Dithane 945, sodium silicate and TKO Phosphite. Plants treated with sodium silicate were stunted. None of the treatments significantly reduced disease severity.

Figure 2. Effect of fungicides and natural products on rose downy mildew (Experiment 1) – 16th November 2005.

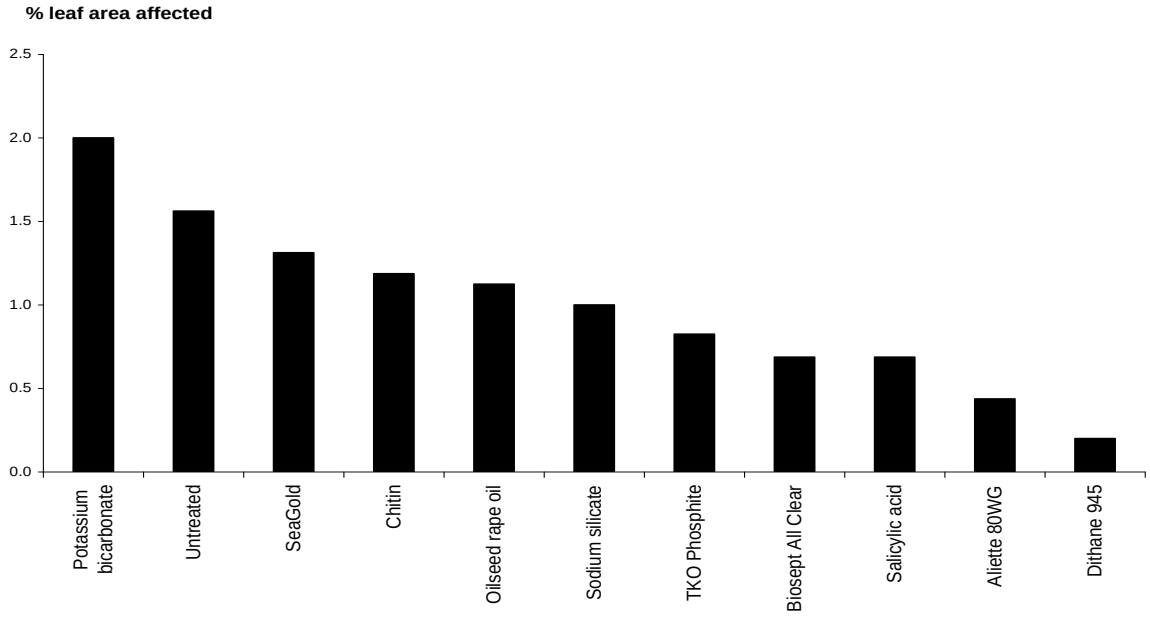


Figure 3. Effect of fungicides and natural products on blackberry downy mildew – 25 October 2005.

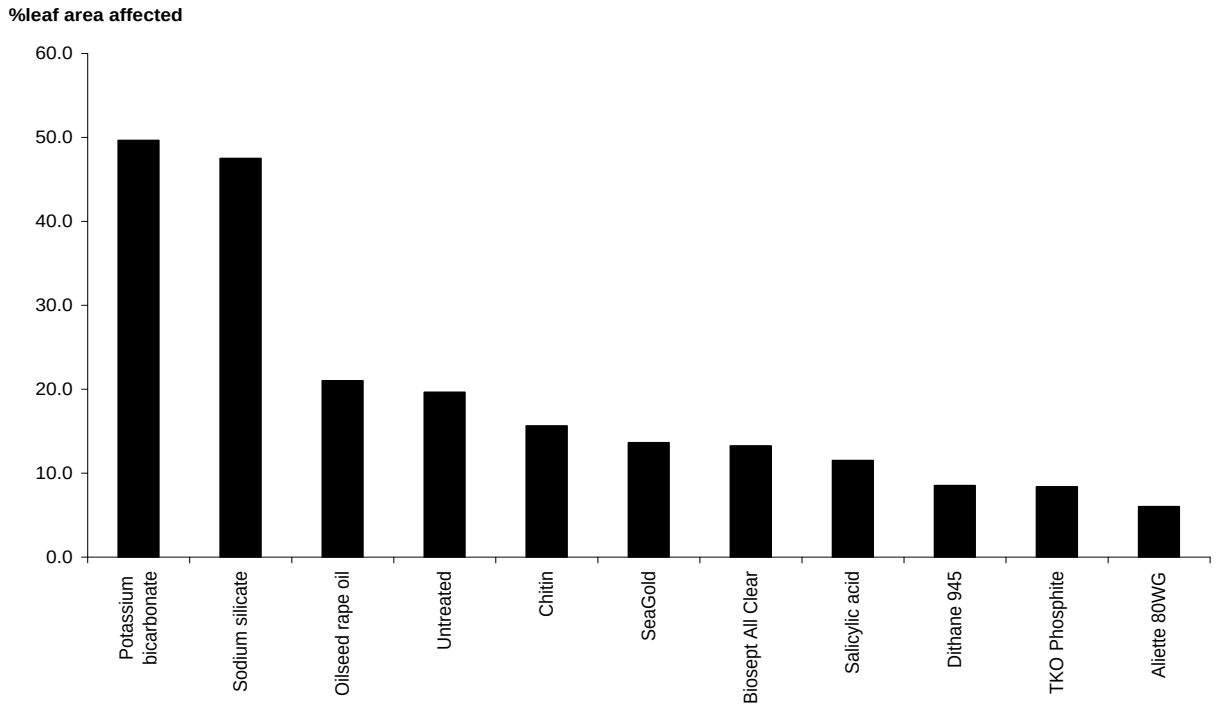


Figure 4. Effect of natural products and fungicides on downy mildew severity on rose plants (cv. Gentle Touch) – 15 June 2006.

Comparison of a fungicide and some natural products - 2006

In spring 2006, 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 in an unheated polythene tunnel: The treatments were Farm-Fos 44 spray (at 14 and 7 day intervals), Farm-Fos 44 drench (at 28 and 14 day intervals), Orophite, Milsana and Biosept All Clear (as sprays at 7 day intervals), Seagold as a growing medium incorporation, EndoRoots mycorrhiza as a drench at 28 day intervals, and Turf Vigour special as a drench at 7 day intervals.

Disease severity on cv. Gentle Touch was significantly reduced by all treatments (Figure 4). 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.

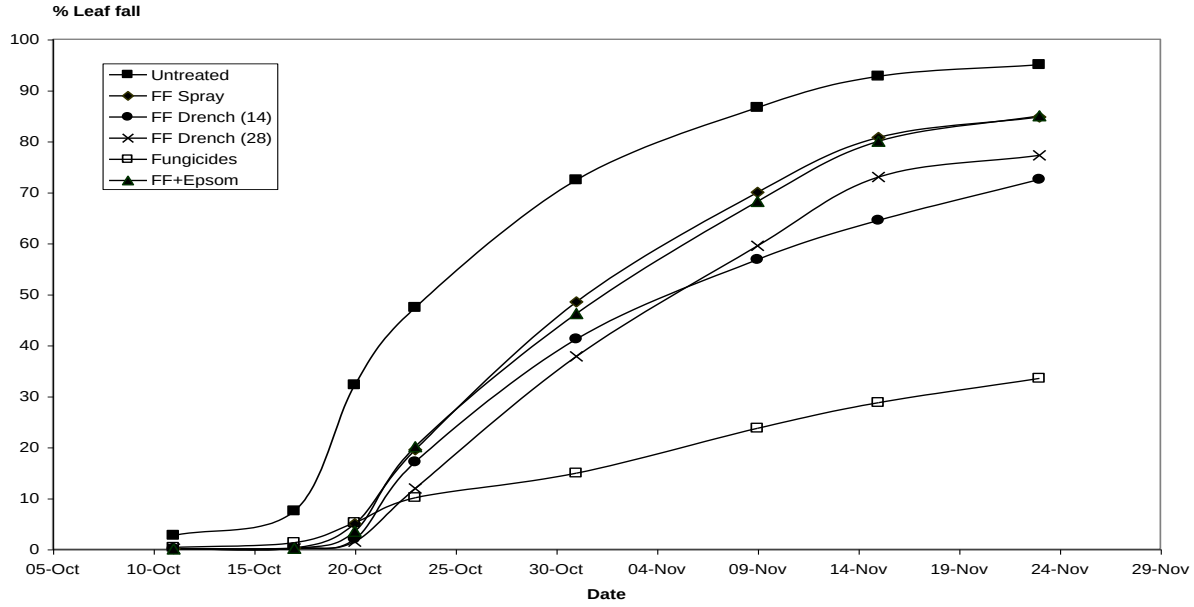


Figure 5. Effect of programmes of Farm-Fos 44 and fungicides on severity of rose downy mildew - 2006 (for clarity, treatments that did not differ significantly from the untreated control are omitted)

Evaluation of some natural products applied in programmes - 2006

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 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 (Figure 5). Leaf fall was significantly reduced by a fungicide programme (Fubol Gold WG (mancozeb + metalaxyl-M), Aliette 80WG (fosetyl-aluminium) and Amistar (azoxystrobin) applied alternately every 7 days. Farm-Fos 44 spray and drench treatments also significantly reduced leaf fall. 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.

Evaluation of programmes of natural products and fungicides - 2007

In 2007, programmes of natural products and fungicides for control of downy mildew were examined in two replicated experiments and an unreplicated comparison. Downy mildew was confirmed at all sites but remained at relatively low levels.

In an experiment on outdoor container-grown rose cvs Silver Jubilee and Scarlett Patio in Suffolk, treatments were applied from 12 April to 12 July. The mean proportion of marketable plants at 4 weeks after the final treatment was increased from 27% (untreated) to 60% by a fungicide programme (based on Aliette 80 WG, Amistar and Fubol Gold) and to the same level by Farm-Fos 44 foliar fertiliser applied as a spray at 10 ml/L with Silwet L-77 wetter. Plant marketability at this time was not significantly increased by Farm-Fos 44 spray without the wetter, or by the same treatment alternating with Biosept All Clear or Dithane. Farm-Fos 44 applied as a drench every 14 days at 20 ml/L reduced plant quality (Figure 6).

In an experiment on protected container grown rose cv. Gentle Touch, in Cambridgeshire, treatments were applied from 10 April to 30 May. The mean proportion of marketable plants at 4 weeks after the final treatment was increased from

86% (untreated) to more than 95% by a fungicide programme, Farm-Fos 44 (10 ml/L) spray with Silwet L-77 wetter and by Farm-Fos 44 sprays alternating with Biosept All Clear, Orophite and Turf Vigour Special. Farm-Fos 44 applied as a drench every 14 days at 20 ml/L (reducing to 10 ml/L) reduced plant quality. Plant marketability was not increased by a Farm-Fos 44 spray without the wetter, or by the same treatment alternating with Dithane, or by EndoRoots alternating with Turf Vigour Special.

In an observation study on container-grown cv. Gentle Touch on a garden centre in Nottinghamshire, plant quality at 3 weeks after the final treatment was greatest following an alternating spray programme of Farm Fos-44 and Dithane, and with Dithane alone.

A summary of the effectiveness of natural products for control of downy mildew as determined in this project is given in Table 1.

Table 1. Summary of foliar fertilisers and natural products evaluated individually for control of downy mildew on rose or blackberry in this project: 2005-2007

Product (applied as a spray unless stated otherwise)	Rate used	Frequency of use (days)	Some control of downy mildew at:		Crop damaged by treatment [a]
			Moderate disease pressure	Severe disease pressure	
Biosept All Clear	4 ml/L	7	4	**NT**	No
Chitin (incorporated)	10 g /L compost (1% w/v)	-	**×**	**NT**	No
EndoRoots (drench)	1.13 g/L	-	4	**×**	No
Farm-Fos 44	2.5 – 10 ml/L	7	4	4	Slight at 10 ml/L
Farm-Fos 44	2.5 – 10 ml/L	14	4	**NT**	No
Farm-Fos 44 + Epsom salt	2.5 ml/L + 5.0 g/L	7	4	4	No
Farm-Fos 44 + Silwet L77	10 ml/L + 0.6 ml/L	7	4	4	Slight
Farm-Fos 44 (drench)	5.0 – 20 ml/L	14	4	4	Yes at 20 ml/L
Farm-Fos 44 (drench)	5.0 – 20 ml/L	28	4	4	Yes at 20 ml/L
Garshield Biostimulant	10 ml/L	7	**NT**	**×**	No
Milsana + wetter at 1.25% (Trifolio Forte)	3 ml/L	7	4	**NT**	Yes
Orophite	3 ml/L	7	4	**NT**	No
Oilseed rape oil	20 ml/L	7	**×**	**NT**	No
Potassium bicarbonate	5 g /L + 1 ml Silwet L-77 per litre of spray solution	7	**×**	**NT**	Yes
Salicylic acid	0.2 g/L	7	**×**	**NT**	Yes
Seagold (incorporated)	68 g/m^2 incorporated to 10 cm	-	4	**NT**	No
Sodium silicate	10 g/L water	7	4	**NT**	Yes
TKO Phosphite	2.5 ml/L	14	4	**-**	No
Turf Vigour Special	4 ml/L	7	4	**NT**	No

4 some control; × no control; NT not tested

[a] The occurrence of crop damage is affected by product rate, spray or drench volume, frequency of use and rose variety. Test treat a small area before using a product widely.

Figure 6. Leaf damage on cvs Silver Jubilee and Scarlet Patio after repeat drench treatment with Farm-Fos 44 at a high rate.

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. Furthermore, 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. Grower and garden centre manager experience indicates sporadic substantial losses.

Action points for growers (years 1-3)

Disease identification

- 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 (though not always) angular, bounded by the leaf veins (see HDC

Factsheet 12/04). Inform garden centres and other customers that downy mildew can be mistaken for black spot.

- If rose plants show sudden severe leaf yellowing and premature leaf fall, check for downy mildew as a possible cause. Note that sporulation by downy mildew can occur on apparently healthy green leaves (check the lower surface).

Cultural control

- 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.

- Remove fallen leaves and any trimmings before re-stocking an area. These may act as a source of pathogen carry-over between seasons.

Control with fungicides

- 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.

Use of natural products to improve crop health and marketability

- 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, TKO Phosphite or Uncle Tom's Rose Tonic), Biosept All Clear, EndoRoots Soluble, Orophite, Seagold or Turf Vigour Special. Regular treatment with these substances was associated with reduced levels of downy mildew. See Appendix 5 for more information on use of Uncle Tom's Rose Tonic.

- The efficacy of Farm-Fos 44 (10 mL/L) applied as a foliar spray against downy mildew on young rose plants was significantly improved by addition of Silwet L-77 (a silicon-based wetter) and not by Epsom salts.

- Under moderate downy mildew pressure, Farm-Fos 44 at the maximum recommended rate (10 mL/L), mixed with Silwet-L77 (2.5 mL/L) and applied as a spray every 7-14 days, resulted in a high proportion of marketable plants at four weeks after the final spray. The proportion of marketable plants at this time was similar to that following use of a fungicide programme of Aliette 80WG, Amistar and Fubol Gold

- Under severe downy mildew pressure, treatment with Farm-Fos 44 or an equivalent phosphite product can give a small though significant reduction in disease and an associated increase in plant vigour. Treatment with phosphite products under severe disease pressure is generally likely to be less effective than a programme of foliar sprays using fungicides with known activity against downy mildew (e.g. Aliette 80WG, Amistar, Fubol Gold).

- On young, micropropagated rose plants, drench treatment with Farm-Fos 44 (5 ml/L) at 28-day intervals was as effective as foliar sprays at (2.5 ml/L) at 7-day intervals in reducing downy mildew.

- There is a risk that frequent application of a phosphite fertiliser at the maximum rate may cumulatively cause slight leaf yellowing; in our experiment this had largely disappeared 4 weeks after the final spray.

- **Do not apply phosphite fertiliser above the recommended rate.** Farm-Fos 44 applied every 14 days as a drench at 20 ml/L caused severe leaf yellowing, browning and distortion, and premature leaf fall on rose cvs. Gentle Touch, Silver Jubilee and Scarlet Patio.

SCIENCE SECTION

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, which 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. Downy mildew was severe on container-grown roses in several garden centres following wet weather in spring 2005, and on some field-grown roses during the wet summer of 2007.

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. The overall aim is to reduce the risk of severe downy mildew and maintain plant quality.

A literature review in the 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. Eight natural products were evaluated and two of them (Biosept All Clear and TKO Phosphite) reduced downy mildew without adversely affecting growth of rose or blackberry.

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

In this third year of the project, experiments were conducted to determine the effects of natural products on control of downy mildew and shelf-life under natural disease pressure on a commercial nursery and a garden centre, and under severe disease pressure at an ADAS site.

Methods

Site and crop details

1. Commercial Nursery, Weybread, Suffolk.

   The experiment was located outside in a sheltered area separate from the main production site. Container-grown plants of Silver Jubilee in 3L pots and of Scarlet Patio in 3L pots were arranged on gravel and irrigated as required by overhead sprinklers.

2. ADAS Arthur Rickwood, Mepal, Cambs.

The experiment was located in an unheated polythene tunnel. Container-grown plants cv. Gentle Touch in 1L pots were arranged on Mypex matting and irrigated as required by overhead spraylines, supplemented by hand watering. Rose and blackberry naturally infected by downy mildew were introduced into the tunnel on 10 May. All plants were irrigated with water and covered with polythene for 48h on 25 April, 8 and 16 May, to produce conditions more conducive to downy mildew development.

3. Garden Centre, Southwell, Notts.

This observation study was located in a net tunnel away from the main area of roses on the site. Container-grown plants of cv. Gentle Touch in 1L pots were arranged on gravel and irrigated using an overhead irrigation line, supplemented by hand-watering.

At site 1, plants were supplied by the nursery. For sites 2 and 3, plug-grown micropropagated plants were potted into Levington M2 compost mixed with 9-month slow release fertiliser.

Treatments

The treatments tested were products and programmes that had resulted in significant control of rose downy mildew in years 1 and 2. There was a set of five core treatments (1-5) at all three sites with supplementary treatments at the individual sites.

No.	Treatment	Suffolk	Cambs	Notts
1.	Untreated (control)	✓	✓	✓
2.	Farm-Fos 44 spray	✓	✓	✓

3.	Farm-Fos 44 drench (at 14 day intervals)	✓	✓	✓
4.	Farm-Fos 44 spray alternating with Biosept All Clear	✓	✓	✓
5.	Farm-Fos 44 spray alternating with Dithane	✓	✓	✓
6.	Farm-Fos 44 spray + Silwet L-77	✓	✓	
7.	Fungicide programme	✓	✓	
8.	Farm-Fos 44 spray alternating with Orophite spray		✓	
9.	Farm-Fos 44 spray alternating with Turf Vigour Special spray		✓	
10.	EndoRoots drench alternating with Turf Vigour Special spray		✓	
11.	Farm-Fos drench (at 28 day intervals)		✓	
12.	Dithane (mancozeb) spray			✓

Rates of product application were as follows:

Farm-Fos 44 spray at 10 ml/L

Farm-Fos 44 drench at 10 ml/L*

Biosept All Clear spray at 4 ml/L

Dithane spray at 1.7 g/L (home garden product, marketed by Bayer)

Orophite spray at 3.0 ml/L

Turf Vigour Special spray at 4 ml/L

EndoRoots drench at 1.13 g/L

Fubol Gold WG spray at 0.19 g/75 ml/m^2 (2.5 g/L)

Aliette 80WG spray at 2.5 g/L

Amistar spray at 1.0 ml/L

Silwet L-77 wetter at 2.5 ml/L

*applied in error at 20 ml/L at sites 1 and 2. Rate reduced to 10 ml/L at site 1 following the appearance of leaf damage; rate maintained at 20 ml/L at site 2 as damage was initially slight.

In previous experiments in this project, Farm-Fos 44 was applied at 2.5 ml/L as a spray and at 5 ml/L as a drench. Following discussion with the product supplier, it was decided to apply it at 10 ml/L, its maximum recommended rate, with the aim of achieving better control of downy mildew.

The fungicide programme consisted of eight sprays applied in the following sequence: Fubol Gold WG, Aliette 80 WG, Fubol Gold WG, Aliette 80 WG, Fubol Gold WG, Amistar, Aliette 80 WG, Amistar (rates as above).

Spray treatments were applied at 7 day intervals, Farm-Fos 44 drench treatments at 14 day (T3) and 28 day intervals (T11), and Endo Roots drench at 28 day intervals. Sprays were applied using an Oxford Precision sprayer with a single 03F110 nozzle at around 1,000 L/ha (100 ml/m^2) except for Fubol Gold (75 ml/m^2). Drenches were applied at 10% of pot volume (i.e. 100 ml for /L pots; 300 ml for 3L pots), applying the drench over the leaves.

The actual dates of treatment application are shown in Appendix 1. At the Norfolk site treatment intervals were extended from 7 to 14 days during dry weather in April and May.

Experimental design and statistical analysis

Site 1, Suffolk

There were seven treatments arranged in a randomised block, split-plot design, with variety as sub-plot. There were four randomised blocks and each plot contained 12 plants, six each of Silver Jubilee and Scarlet Patio.

Site 2, Cambs

There were 11 treatments arranged in four randomised blocks, with the untreated control represented twice in each block. Each plot contained 10 plants of cv. Gentle Touch.

Site 3, Notts

There were six observation plots, each containing 10 plants of cv. Gentle Touch.

Results from sites 1 and 2 were examined by analysis of variance in Genstat, following data transformation where required to comply with conditions of normality, or by Friedman's non-parametric test where appropriate.

Disease and quality assessments

At sites 1 and 2, plants were assessed for disease every 14 days from the first spray until 4 weeks after the final spray. At site 3, plants were assessed twice during the treatment programme and at three weeks after the final spray. Plants were assessed for occurrence of downy mildew (number of plants affected), severity of downy mildew (% leaf area affected and % leaf fall), visible spray residue (0-9 scale), phytotoxicity (0-9 scale). Marketability was assessed at 1, 2 and 4 weeks after the final spray application, using the following scores:

1 - unmarketable; dead or dying

2 - unmarketable: very sparse live foliage

3 - marketable; moderate quality; many healthy green leaves

4 - marketable; good plant with slight defect (isolated spot of downy mildew, or leaf loss).

5 - marketable; excellent plant, no defects

Samples of symptomatic and apparently healthy green leaves were collected from sites 2 and 3 and tested for rose downy mildew by a Polymerase Chain Reaction (PCR) test at NIAB, Cambridge.

Results

Site 1, Suffolk

Downy mildew control

Downy mildew treatments were applied from 10 April to 12 July. No downy mildew was observed in the experiment until 29 June, probably due to the warm, dry weather during April and May. On 19 July, one week after the final sprays had been applied, downy mildew was present at trace levels on around 4% of Silver Jubilee plants and 28% of Scarlet Patio plants, with significant differences between varieties (P = 0.004). The fungicide programme and the Farm-Fos 44 + Silwet L77 spray appeared to reduce both the incidence (Table 1) and the severity (Table 2) of downy mildew, although these differences were not significant at the 5% level. Full details of all assessments are shown in Appendix 2.

At 4 weeks after the final treatment application, over 50% of cv. Silver Jubilee and over 90% of Scarlet Patio had low levels of downy mildew. Disease severity was significantly reduced by the fungicide programme and by Farm-Fos 44 spray + Silwet L-77 (Table 3) and not by any other treatment.

Plant quality and marketability

Marketability was significantly influenced by treatment (Table 4). Plants drenched with Farm-Fos 44 had the least proportion of marketable plants at all assessment dates due largely to increased leaf yellowing and fall. None of the treatments were significantly better than the untreated control at 1 and 2 weeks after the final spray application, when the majority of plants (except for treatment 3) were marketable. However, at 4 weeks after the final spray, the proportion of marketable plants had fallen to 27% in untreated plots and was significantly greater following treatment with Farm-Fos 44 + Silwet L-77 and the fungicide programme (60% marketable in

each). This result indicates that the decline in marketability with time after the final spray or drench treatment was probably due to downy mildew. The two varieties also differed at this time, the mean % marketable, over all treatments, being greater for Silver Jubilee (45.8%) than Scarlet Patio (33.3%) (P = 0.03). The effect of treatment on marketability of the individual varieties is shown in Appendix 3.

At *four* weeks after the final treatment, the programmes consisting of sprays or drenches of Farm-Fos 44 alone appeared to increase leaf fall, although this was not quite significant at P = 0.05. (Table 5). Farm-Fos 44 + Silwet L-77 had the least leaf fall. Results for the individual varieties are shown in Appendix 4.

Crop damage was visible to a degree in all treatments at 1 week after the final spray application, but most plants had grown away from these symptoms by 3 weeks later, with only the Farm-Fos 44 drench treatment showing a significant number of damaged plants (Table 6). The main symptoms of crop damage were leaf scorch, yellowing and distortion following Farm-Foss 44 drench treatment. Some plants treated with fungicide programme (T7) initially showed chlorosis. Dithane was the only spray to leave a clearly visible deposit on leaves. Apart from the Farm-Fos 44 drench treatment, damage symptoms were slight and most plants in all treatments were marketable at 1 week after the final treatment (Table 4).

Table 1. Effect of programmes of natural products and fungicides on incidence of rose downy mildew - Suffolk, 2007

	Programme	Interval (days)	Mean % plants with downy mildew – 19 July (1 week after final spray)		
			Scarlet Patio	Silver Jubilee	Mean
1.	Untreated	-	33.3	8.3	20.8
2	Farm-Fos 44 – spray	7	37.5	4.2	20.8
3	Farm Fos 44 – drench	14	29.2	0	14.6
4	FF/Biosept All Clear	7	20.8	8.3	14.6
5	FF/Dithane	7	45.8	4.2	25.0
6	FF + Silwet L-77	7	12.5	4.2	8.3
7	Fungicide programme	7	16.7	0	8.3
	Significance (18 df)		-	-	NS

Data analysed after log 10 transformation; untransformed data are shown. FF – Farm-Fos 44 spray.

Table 2:. Effect of programmes of natural products and fungicides on severity of rose downy mildew - Suffolk 2007

	Programme	Mean % leaf area with downy mildew – 19 July (1 week after final spray)		
		Scarlet Patio	Silver Jubilee	Mean
1.	Untreated	0.67	0.04	0.35
2	Farm-Fos 44 - spray	0.44	0.02	0.23

3.	Farm-Fos 44 - drench	0.44	0	0.22
4.	FF/Biosept All Clear	0.33	0.06	0.20
5.	FF/Dithane	0.31	0.08	0.20
6.	FF + Silwet L-77	0.08	0.02	0.07
7.	Fungicide programme	0.15	0	0.05
	Significance (18 df)	-	-	NS

FF Farm-Fos 44 spray

Table 3. Effect of programmes of natural products and fungicides on severity of rose downy mildew at 4 weeks after the final treatment - Suffolk 2007

	Programme	Mean % leaf area affected		
		Scarlet Patio	Silver Jubilee	Mean
1.	Untreated	5.4	2.3	3.8 (0.644)
2.	Farm-Fos 44 spray	4.6	1.8	3.2 (0.511)
3.	Farm-Fos 44 drench	7.9	1.2	4.6 (0.545)
4.	FF/Biosept All Clear	7.2	1.4	4.3 (0.595)
5.	FF/Dithane	5.0	1.2	3.1 (0.467)
6.	FF + Silwet L-77	0.9	0.4	0.7 (0.195)
7.	Fungicide programme	2.6	1.3	1.5 (0.354)
	Significance (18 df)	-	-	0.03
	SED			(0.127)

FF Farm-Fos 44 spray; ( ) = Log10 transformed data

Table 4. Effect of programmes of natural products and fungicides on marketability of rose - Suffolk, 2007

	Programme	Mean % plants marketable at intervals after final treatment		
		1 week	2 week	4 weeks
1.	Untreated	95.8	81.2	27.1
2.	Farm-Fos 44 spray	89.6	70.8	39.6

3	Farm-Fos 44 drench	22.9	4.2	4.2
4	FF/Biosept All Clear	83.3	87.5	43.7
5	FF/Dithane	91.7	75.0	41.7
6	FF + Silwet L-77	93.7	85.4	60.4
7	Fungicide programme	97.9	89.6	60.4
	Significance (18 df)	<0.001	<0.001	0.008
	SED	8.53	10.45	13.45

Table 5. Effect of programmes of natural products and fungicides on leaf fall of rose – Suffolk 2007

	Programme	Mean % leaf fall at intervals after final treatment		
		2 weeks	4 weeks	
1.	Untreated	1.9	9.5	(0.922)
2.	Farm-Fos 44 spray	1.8	24.2	(1.062)
3.	Farm-Fos 44 drench	2.6	31.2	(1.315)
4.	FF/Biosept All Clear	1.7	7.6	(0.812)
5.	FF/Dithane	1.7	9.7	(0.888)
6.	FF + Silwet L-77	1.3	5.7	(0.723)
7.	Fungicide programme	1.7	7.9	(0.822)
	Significance (18 df)	0.097		0.071
	SED	0.40		- (0.181)

( ) – Log_{10} transformed data

Table 6. Effect of programmes of natural products and fungicides on crop damage – Suffolk, 2007

	Programme	Mean % plants with crop damage at intervals after final treatment		
		1 week	2 week	4 weeks
1.	Untreated	0	0	0
2.	Farm-Fos 44 spray	8.3	4.2	0
3.	Farm-Fos 44 drench	100.0	100.0	97.9
4.	FF/Biosept All Clear	14.6	10.4	0
5.	FF/Dithane	18.8	14.6	2.1

6	FF + Silwet L-77	18.8	14.6	2.1
7	Fungicide programme	29.2	4.2	0
	Significance (18 df)	<0.001	<0.001	<0.001
	SED	9.24	6.54	2.03

Site 2, Cambs

Downy mildew control

Treatments were applied from 10 April to 30 May. Downy mildew symptoms were first observed in early May and by one week after the final spray the disease was visible on 41% of untreated plants. On 27 June, 4 weeks after the final spray, there were significant differences between treatments in the proportion of plants affected (Table 7). Downy mildew affected 55% of untreated plants and significantly fewer following treatment with Farm-Fos 44 drench (6.3 - 12.5%), the fungicide programme (9.4%), Farm-Fos 44 spray alternating with Biosept All Clear or Dithane (18.8%) and Farm-Fos 44 spray with Silwet L-77 (21.9%).

Disease severity assessed as leaf spotting was very low, affecting less than 1% leaf area; leaf fall was less than 10% at all assessments (data not shown). There were no consistent significant differences between treatments.

Downy mildew was confirmed in leaves with typical downy mildew symptoms, and also in some green leaves, by PCR test; full results are given in the annual report for HNS 150.

Plant quality and marketability

Leaf damage developed in plants drenched with Farm-Fos at 20.0 ml/litre and consequently the treatment rate was reduced to 10 ml/litre after 15 May, when 3 and 2 drenches had been applied to treatment 3 and 11 respectively. Symptoms were yellowing of leaves (Fig. 6). Damage symptoms were still visible at four weeks after the final application, reducing plant marketability (Table 8). Damage was also visible, to a much lesser extent, on plants sprayed with Farm-Fos 44 (treatment 2, 4, 5, 6, 8, 9) by the end of treatment applications, although this had largely disappeared (except for the Farm-Fos 44 drench treatments) by four weeks after the final treatment (Table 8). The fungicide programme did not cause any obvious crop damage.

The overall effect of treatment on plant marketability is shown in Table 9. The best treatments, with all plants marketable at 1, 2 and 4 weeks after treatment, were spray programmes of Farm-Fos 44/Biosept All Clear, Farm-Fos 44 / Turf Vigour Special, Farm-Fos 44 + Silwet L-77 and the fungicide programme. Farm-Foss 44 drench applied at a high rate every 14 days resulted in a significant reduction in marketability ($p<0.001$).

Untreated plants, and those treated with Farm-Fos 44 spray, Farm-Fos 44 alternating with Dithane, and Endo Roots alternating with Turf Vigour Special, showed a trend for the proportion of marketable plants to decrease with time after the final treatment possibly due to increased levels of downy mildew. Plants treated with Farm-Fos 44 drench at the high rate, showed little improvement in marketability with time from the last application (Table 9).

Table 7. Effect of programmes of natural products and fungicides on the incidence of rose plants affected by downy mildew - Cambs, 2007

	Treatment	% plants affected by downy mildew		
		15 May	12 June	27 June[a]
1.	Untreated	3.1	51.6	54.7
2.	Farm-Fos 44 – spray (7d)	0	46.9	43.8
3.	Farm-Fos 44 – drench (14d)	0	12.5	12.5
4.	Farm-Fos 44/Biosept All Clear	0	21.9	18.8
5.	Farm-Fos 44/Dithane	15.6	12.5	18.8
6.	Farm-Fos 44 + Silwet L-77	0	20.8	21.9
7.	Fungicide programme	0	9.4	9.4
8.	Farm-Fos 44/Orophite	9.4	25.0	25.0
9.	Farm-Fos 44/TVS	0	21.9	25.0
10.	Endo Roots /TVS	0	46.9	50.0
11.	Farm-Fos 44 drench (28 d)	0	0	6.3
	Significance (33 df)	NS	0.081	0.036
	SED	-	-	16.97

[a] 4 weeks after final spray application.

Table 8. Effect of programmes of natural products and fungicides on leaf damage to roses - Cambs, 2007

	Treatment	% plants affected at intervals after final spray		
		1 week	2 weeks	4 weeks
1.	Untreated	0	0	0
2.	Farm-Fos 44 - spray	18.7	25.0	0
3.	Farm-Fos 44 - drench (14 d)	96.9	96.9	65.6
4.	FF/Biosept All Clear	34.4	28.1	9.4
5.	FF/Dithane	62.5	56.2	0
6.	FF + Silwet L-77	8.3	8.3	0
7.	Fungicide programme	0	0	0
8.	FF/Orophite	3.1	3.1	0
9.	FF/TVS	3.1	3.1	0
10.	Endo Roots/TVS	3.1	3.1	0
11.	FF drench (28 d)	56.2	53.1	50.0
	Significance (33 df)	<0.001	<0.001	<0.001
	SED	9.64	12.39	13.21

FF Farm-Fos 44 spray

Table 9. Effect of programmes of natural products and fungicides on marketability of roses at 1, 2 and 4 weeks after final treatment for downy mildew - Cambs, 2007

	Treatment	% plants marketable at intervals after final spray		
		1 week	2 weeks	4 weeks
1.	Untreated	98.4	93.8	85.9
2.	Farm-Fos 44 - spray	100.0	90.6	81.2
3.	Farm-Fos 44 - drench (14 d)	43.7	59.4	62.5
4.	FF/Biosept All Clear	100.0	100.0	100.0
5.	FF/Dithane	84.4	81.2	75
6.	FF + Silwet L-77	100.0	100.0	100.0
7.	Fungicide programme	100.0	100.0	100.0
8.	FF/Orophite	96.9	93.8	100.0
9.	FF/TVS	100.0	100.0	96.9
10.	Endo Roots/TVS	93.8	87.5	84.4
11.	FF drench (28 d)	81.2	78.1	84.4
	Significance (33 df)	<0.001	NS	0.064
	SED	11.22		12.31

Site 3, Notts

Downy mildew control

Downy mildew control treatments were applied from 15 April to 30 July. Downy mildew was confirmed in fallen leaves, and in leaves showing blotches suggestive of downy mildew, collected on 29 June and tested by a PCR test at NIAB. At this time, the severity of downy mildew leaf symptoms was less than 1%, and leaf fall was less than 5%, with no obvious difference between treatments.

At three weeks after the final application of treatments, downy mildew severity and leaf fall were least in the Farm-Fos 44 / Dithane spray programme (Table 11).

Plant quality and marketability

On 29 June, there was slight damage visible on half of the plants drenched with Farm-Fos 44, visible as pinching of leaf margins. The two treatments that gave the best control of downy mildew also resulted in the best quality plants (Table 12). On 17 August, three weeks after the final treatment, all plants were marketable.

Table 11. Effect of programmes of natural products and fungicides on rose downy mildew and leaf fall – Notts, 2007

	Programme	Mean % leaf area affected			Mean % leaf fall		
		29 Jun	3 Aug	17 Aug	29 Jun	3 Aug	17 Aug
1	Untreated	0.6	4.2	2.4	3.8	0.5	2.8
2	Farm-Fos 44 spray	1.1	2.4	4.6	2.7	1.9	1.8
3	Farm-Fos 44 drench	0.3	2.3	2.1	2.0	1.5	0.4
4	FF/Biosept All Clear	0.1	1.8	3.9	1.9	1.2	0.9
5	FF/Dithane	0.4	1.1	1.7	3.2	1.0	0.5
6	Dithane	0.2	2.9	1.8	2.2	1.8	0.6

Treatments applied 15 April – 30 July

Table 12. Effect of programmes of natural products and fungicides on quality of rose plants – Notts, 2007

Programme	Mean plant quality (0-5)		
	29 Jun	3 Aug	17 Aug

1	Untreated	3.3	3.6	3.8
2	Farm-Fos 44 spray	3.2	4.0	3.7
3	Farm-Fos 44 drench	2.5	3.6	3.8
4	FF / Biosept All Clear	2.9	3.7	3.6
5	FF / Dithane	3.0	4.1	4.5
6	Dithane	3.2	4.3	4.5

Conclusions (year 3)

1. On an outdoor crop of container-grown roses cvs. Silver Jubilee and Scarlet Patio, under low to moderate disease pressure (up to 4% leaf area affected on untreated plants), marketability was significantly improved by a fungicide programme and by Farm-Fos 44 foliar fertiliser applied weekly as a spray at 10 ml/L with a silicon-based wetter (Silwet L-77).

2. Farm-Fos 44 applied weekly as a foliar spray without Silwet-L77, or applied every 14 days as a drench, and alternating spray programmes of Farm-Fos 44 with Biosept All Clear and Dithane, did not improve plant marketability in this experiment.

3. Farm-Fos 44 applied every 14 days as a drench, initially at 20 ml/L (above the recommended maximum rate) using a volume equal to 10% of the container capacity, was phytotoxic to rose cvs Silver Jubilee and Scarlet Patio, causing severe leaf yellowing and premature leaf fall.

4. On a protected crop of container-grown rose cv. Gentle Touch under low disease pressure (<1% leaf area affected on untreated plants), the incidence of plants affected by downy mildew at 4 weeks after the final spray was significantly reduced by Farm-Fos 44 applied as a drench (both at 14 and 28 d intervals), by Farm-Fos 44 as a spray mixed with a silicon-based wetter, by alternating programmes of Farm-Fos 44 with Biosept All Clear and Dithane, and by a fungicide programme.

5. In this experiment, plant marketability was reduced compared with untreated plants, by Farm-Fos 44 applied as a drench every 14 days at 20 ml/L (reduced to 10 ml/L part-way through the programme). Plant marketability was greatest with a fungicide programme, and using Farm-Fos 44 as a spray (10 ml/L) alternating

with Biosept All Clear, or Turf Vigour Special, or by itself mixed with a silicon based wetter.

6. In a comparative study in a net tunnel on a garden centre, downy mildew occurred on rose cv, Gently Touch at a low level. Plant quality at 2.5 weeks after the final spray appeared better using a Farm-Fos 44 / Dithane programme, or Dithane alone, compared with untreated plants.

Suggested areas for possible future work

1. Determine the effect of phosphite fertiliser products on rose black spot, powdery mildew and rust.
2. Develop a rapid on-site test (such as a Lateral Flow Device) for identification of downy mildew in rose leaves.
3. Seek to develop improved control of rose downy mildew through better spray timing based on weather criteria and knowledge of the protectant and curative activities of different fungicides.

Technology transfer

Downy mildew control comes naturally. *HDC News* **132,** 26-27 (April 2007).

Rose R&D Forum. *HDC News* **140**, p. 12 (January 2008).

New results on control of rose downy mildew. Presentation at HTA British Rose Group meeting, NIAB, Cambridge, 29 November 2007.

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APPENDICES

Appendix 1: Dates of spray application

Rose Downy Mildew 2007. Site 1, Commercial nursery, Weybread, Suffolk.

Trt	Week 15	Week 16	Week 18	Week 20	Week 21	Week 22	Week 23	Week 25	Week 27	Week 28
Date applied	12/04/07	19/04/07	03/05/07	17/05/07	24/05/07	31/05/07	07/06/07	21/06/07	05/07/07	12/07/07
1.	-	-	-	-	-	-	-	-	-	-
2.	FarmFos (s)	FarmFos (s)	FarmFos (s)	FarmFos (s)	FarmFos (s)	FarmFos (s)	FarmFos (s)	FarmFos (s)	FarmFos (s)	FarmFos (s)
3.	FarmFos (d)*	-	FarmFos (d)*	-	FarmFos (d)*	-	FarmFos (d)*	-	FarmFos (d)*	-
4.	FarmFos (s)	Biosept (s)	FarmFos (s)	Biosept (s)	FarmFos (s)	Biosept (s)	FarmFos (s)	Biosept (s)	FarmFos (s)	Biosept (s)
5.	FarmFos (s)	Dithane (s)	FarmFos (s)	Dithane (s)	FarmFos (s)	Dithane (s)	FarmFos (s)	Dithane (s)	FarmFos (s)	Dithane (s)
6.	FarmFos + Silwet (s)	FarmFos + Silwet (s)	FarmFos + Silwet (s)	FarmFos + Silwet (s)	FarmFos + Silwet (s)	FarmFos + Silwet (s)	FarmFos + Silwet (s)	FarmFos + Silwet (s)	FarmFos + Silwet (s)	FarmFos + Silwet (s)
7.	Fubol Gold	Aliette	Fubol Gold	Aliette	Fubol Gold	Amistar	Aliette	Amistar	Fubol Gold	Aliette

(s)=spray

(d)=drench

* Applied at 20 ml/L in error

Rose Downy Mildew 2007. Site 2, ADAS Arthur Rickwood, Cambs.

Trt	Week 13	Week 15	Week 16	Week 17	Week 18	Week 19	Week 20	Week 21	Week 22
Date applied	26/03/07	10/04/07	17/04/07	24/04/07	01/05/07	08/05/07	15/05/07	23/05/07	30/05/07
1.	-	-	-	-	-	-	-	-	-
2.	-	FarmFos (s)	FarmFos (s)	FarmFos (s)	FarmFos (s)	FarmFos (s)	FarmFos (s)	FarmFos (s)	FarmFos (s)
3.	-	FarmFos (d)*	-	FarmFos (d)*	-	FarmFos (d)*	-	FarmFos (d)	-
4.	-	FarmFos (s)	Biosept (s)	FarmFos (s)	Biosept (s)	FarmFos (s)	Biosept (s)	FarmFos (s)	Biosept (s)
5.	-	FarmFos (s)	Dithane (s)	FarmFos (s)	Dithane (s)	FarmFos (s)	Dithane (s)	FarmFos (s)	Dithane (s)
6.	-	FarmFos + Silwet (s)	FarmFos + Silwet (s)	FarmFos + Silwet (s)	FarmFos + Silwet (s)	FarmFos + Silwet (s)	FarmFos + Silwet (s)	FarmFos + Silwet (s)	FarmFos + Silwet (s)
7.	-	Fubol Gold (s)	Aliette (s)	Fubol Gold (s)	Aliette (s)	Fubol Gold (s)	Amistar (s)	Aliette (s)	Amistar (s)
8.	-	FarmFos (s)	Orophite (s)	FarmFos (s)	Orophite (s)	FarmFos (s)	Orophite (s)	FarmFos (s)	Orophite (s)
9.	-	FarmFos (s)	TVS (s)	FarmFos (s)	TVS (s)	FarmFos (s)	TVS (s)	FarmFos (s)	TVS (s)
10.	EndoRoots (d)	EndoRoots (d)	TVS (s)	TVS (s)	TVS (s)	TVS (s)	EndoRoots (d)	TVS (s)	TVS (s)
11.	-	FarmFos (d)*	-	-	-	FarmFos (d)*	-	-	-
12.	-	-	-	-	-	-	-	-	-

*applied at 20 ml/L in error; reduced to 10 ml/L following appearance of crop damage

(s) – spray; (d) - drench

Rose Downy Mildew 2007. Site 3, Garden Centre, Southwell, Notts

Trt	Week 15	Week 16	Week 17	Week 18	Week 19	Week 20	Week 22
Date applied	15th April 07	22nd April 07	29th April 07	6th May 07	13th May 07	20th May 07	28th May 07
1.	-	-	-	-	-	-	-
2.	FarmFos (s)	FarmFos (s)	FarmFos (s)	FarmFos (s)	FarmFos (s)	FarmFos (s)	FarmFos (s)
3.	FarmFos (d)	-	FarmFos (d)	-	FarmFos (d)	-	FarmFos (d)
4.	FarmFos (s)	Biosept (s)	FarmFos (s)	Biosept (s)	FarmFos (s)	Biosept (s)	FarmFos (s)
5.	FarmFos (s)	Dithane (s)	FarmFos (s)	Dithane (s)	FarmFos (s)	Dithane (s)	FarmFos (s)
6.	Dithane (s)	Dithane (s)	Dithane (s)	Dithane (s)	Dithane (s)	Dithane (s)	Dithane (s)

Trt	Week 22	Week 23	Week 24	Week 25	Week 27	Week 29	Week 31
Date applied	3rd June 07	10th June 07	17th June 07	24th June 07	5th July 07	18th July 07	30th July 07
1.	-	-	-	-	-	-	-
2.	FarmFos (s)	FarmFos (s)	FarmFos (s)	FarmFos (s)	FarmFos (s)	FarmFos (s)	FarmFos (s)
3.	-	FarmFos (d)	-	FarmFos (d)	-	FarmFos (d)	-
4.	Biosept (s)	FarmFos (s)	Biosept (s)	FarmFos (s)	Biosept (s)	FarmFos (s)	Biosept (s)
5.	Dithane (s)	FarmFos (s)	Dithane (s)	FarmFos (s)	Dithane (s)	FarmFos (s)	Dithane (s)
6.	Dithane (s)	Dithane (s)	Dithane (s)	Dithane (s)	Dithane (s)	Dithane (s)	Dithane (s)

Appendix 2: Downy mildew - Suffolk, 2007

Effect of programmes of natural products and fungicides on incidence and severity of rose downy mildew at intervals after the final treatment

	Programme	Mean % plants affected			Mean % leaf area affected		
		1 wk	2 wk	4 wk	1 wk	2 wk	4 wk
	Silver Jubilee						
1.	Untreated	8.3	45.8	91.7	0.04	-	2.3
2.	Farm-Fos 44 Spray	4.2	25.0	79.2	0.02	-	1.8
3.	Farm-Fos 44 drench	0	4.2	45.8	0	-	1.2
4.	FF / Biosept All Clear	8.3	25.0	66.7	0.06	-	1.4
5.	FF / Dithane	4.2	20.8	54.2	0.08	-	1.2
6.	FF + Silwet L-77	4.2	16.7	33.3	0.02	-	0.4
7.	Fungicide programme	0	4.2	41.7	0	-	1.3
	Scarlet Patio						
1.	Untreated	33.3	83.3	100.0	0.67	-	5.4
2.	Farm-Fos 44 Spray	37.5	83.3	75.0	0.44	-	4.6
3.	Farm-Fos 44 drench	29.2	87.5	95.8	0.44	-	7.9
4.	FF / Biosept All	20.8	79.2	100.0	0.33	-	7.2

.	Clear						
5	FF / Dithane	45.8	83.3	100.0	0.31	-	5.0
.							
6	FF + Silwet L-77	12.5	37.5	66.7	0.08	-	0.9
.							
7	Fungicide programme	16.7	87.5	95.8	0.15	-	2.6
.							

Appendix 3: Plant marketability - Suffolk, 2007

Effect of programmes of natural products and fungicides on marketability or rose – 2007

	Programme	% plants marketable at intervals after final treatment		
		1 week	2 weeks	4 weeks
	Silver Jubilee			
1.	Untreated	95.8	91.7	37.5
2	Farm-Fos 44 Spray	100	91.7	37.5
3	Farm-Fos 44 drench	4.2	0	0
4	FF / Biosept All Clear	79.2	95.8	54.2
5	FF / Dithane	91.7	91.7	50.0
6	FF + Silwet L-77	87.5	95.8	70.8
7	Fungicide programme	100.0	91.7	70.8
	Scarlet Patio			
1.	Untreated	95.8	70.8	16.7
2	Farm-Fos 44 Spray	79.2	50.0	41.7
3	Farm-Fos 44 drench	41.7	8.3	8.3
4	FF / Biosept All Clear	87.5	79.2	33.3

5	FF / Dithane	91.7	58.3	33.3
6	FF + Silwet L-77	100.0	75.0	50.0
7	Fungicide programme	95.8	87.5	50.0

Appendix 4: Leaf fall - Suffolk, 2007

Effect of programmes of natural products and fungicides on leaf fall of rose – 2007

	Programme	% leaf fall at intervals after final treatment	
		2 weeks	4 weeks
	Silver Jubilee		
1.	Untreated	1.5	5.8
2.	Farm-Fos 44 Spray	1.5	18.1
3.	Farm-Fos 44 drench	2.8	34.2
4.	FF / Biosept All Clear	1.4	3.8
5.	FF / Dithane	1.3	8.5
6.	FF + Silwet L-77	1.6	3.0
7.	Fungicide programme	1.8	4.0
	Scarlet Patio		
1.	Untreated	2.3	13.1
2.	Farm-Fos 44 Spray	2.1	30.3
3.	Farm-Fos 44 drench	2.5	28.3
4.	FF / Biosept All Clear	2.0	11.4

5.	FF / Dithane	2.1	10.9
6.	FF + Silwet L-77	0.9	8.5
7.	Fungicide programme	1.6	11.8

Appendix 5: Web information on Uncle Tom's Rose Tonic

Uncle Tom's™ ROSE TONIC

is a concentrated plant food new to gardening

It contains potassium phosphite as a pure aqueous salt.
Its official EC Fertiliser Value is 0:23:21 in other words it has 10% P and 9% K
It has nothing else in it all, and is free from additives, wetters, dyes and impurities.
It is made here in England, where I can make sure everything is done properly.
It hasn't been transported half way round the world and it hasn't been tested on animals

DILUTE TO USE

It can be used as a plant drencher or a foliar spray.
It must be diluted at least 1 in 100 before using.
Add 10mls of Rose Tonic to at least 1 litre of water to cover 10 square metres.
For larger quantities mix 100mls of Rose Tonic in a minimum of 10 litres of water.
Repeat at regular intervals every week or two, depending on growth.
Like all remedies and tonics, check plant safety yourself and never overdose.
It mixes OK with most diluted garden chemicals, but always check it first.

Store out of direct sunlight

Uncle Tom's™ ROSE TONIC is recommended by the British Rose Growers Association®

Uncle Tom says 'Say goodbye to lush lank growth prone to disease, and say hello to healthy plants with more flowers'

KEEP OUT OF REACH OF CHILDREN

Caution: Harmful if swallowed. Avoid contact with eyes, skin or clothing. In case of contact immediately rinse with copious quantities of water for at least 10 minutes, and seek medical advice. Contain any spills with earth or sand don't pour any down the drain.

Ingredients: aqueous potassium phosphite

Supplied by FarmFos Limited, Builth Wells, Eau Withington, Hereford HR1 3NQ