Project title:	Control of downy mildew on shrub and herbaceous plants
Project number:	HNS 186
Project leader:	Dr Tim O'Neill, ADAS
Report:	Final report, March 2014
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Location of project:	Commercial nurseries, Norfolk and Works
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Date project commenced:	1 April 2012
Date project completion due:	31 March 2014

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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Principal Research Scientist

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GROWER SUMMARY

Headline

1. Thirteen products, including novel fungicides and biofungicides, a fungicide incorporated in the growing medium and a foliar fertiliser, reduced downy mildew on *Geum*; nine products reduced downy mildew in *Hebe*.
2. Eleven fungicide programmes designed to reduce resistance risk and provide season-long protection against downy mildew greatly reduced the disease on *Geum.*
3. New EAMUs are available permitting the use of Fenomenal, Percos and Previcur Energy as spray treatments for control of downy mildew on ornamentals on both protected and outdoor crops.
4. Fungicides and biofungicides used in this project were shown to be safe to 11 commonly grown herbaceous plant species when used at recommended rates, however repeat applications of Fubol Gold WG damaged a small-leafed variety of *Hebe*.

Background and expected deliverables

Downy mildew diseases can seriously damage over a dozen nursery stock and herbaceous perennials including *Buddleia*, *Digitalis*, *Gaillardia*, *Labium*, *Hebe*, Rose and *Veronica*. Fungicides are the primary method of control for most growers. The availability of fungicides for use on ornamentals is currently declining due to changing legislation. Furthermore, there is a risk of some fungicides failing to control downy mildew diseases due to selection of fungicide-resistant strains; this has recently occurred with metalaxyl-M (e.g. Fubol Gold WG) failing to control impatiens downy mildew. The SCEPTRE HortLink project is evaluating a wide range of new fungicides and biofungicides for downy mildew control on edible crops. This project examined the most promising new products identified in the SCEPTRE HortLink project, and elsewhere, for control of downy mildews on two ornamental crops, and for their crop-safety to a range of ornamentals. Simple crop protection programmes, based where possible on products designed to reduce the risk of resistance build-up, were devised and tested. The HDC Factsheet on downy mildew diseases of hardy nursery stock and herbaceous plants was updated.

The overall aim of the project was to improve control of downy mildew diseases. Specific project objectives were:

1. To determine the effectiveness of selected novel fungicides and biofungicides;

2. To devise and determine the effectiveness of some simple alternating programmes;
3. To screen novel fungicides and biofungicides with good potential for control of downy mildew diseases for their safety to a range of susceptible ornamentals.

Summary of the project and main conclusions

Three fully replicated experiments were carried out in 2012, five in 2013 and one in 2014, all on commercial nurseries. Objective 1 was examined in all experiments and specifically in experiments 1, 2 and 8; Objective 2 was examined in experiments 3, 4, 5 and 7. Objective 3 was examined in all experiments and specifically in experiment 6.

Experiment 1 – Fungicides and biofungicides for control of Hebe downy mildew (Year 1)

Nine conventional fungicides, two biofungicides and a foliar fertiliser were evaluated as high volume sprays and PlantTrust (fosetyl- aluminium) as a growing medium incorporation, for control of downy mildew (*Peronospora grisea*) on *Hebe x franciscana* 'Variegata' in a low multispan tunnel on a nursery in Norfolk. The conventional fungicides comprised Fenomenal (fosetyl-aluminium + fenamidone), Fubol Gold WG (mancozeb + metalaxyl-M), Infinito (fluopicolide + propamocarb hydrochloride), Paraat (dimethomorph), Percos (ametoctradin + dimethomorph), Pergado Uni (mandipropamid), Previcur Energy (fosetyl-aluminium + propamocarb hydrochloride), Signum (boscalid + pyraclostrobin) and one coded product (F62); the biofungicides were both coded products (F60 and F61); the foliar fertiliser was Hortiphyte (potassium phosphite). Fungicides and the foliar fertiliser were applied every 14 days and the biofungicides every seven days from 6 September to 20 December 2012. The PlantTrust was incorporated and plants potted three weeks after other treatments were established due to late delivery. No downy mildew occurred despite the introduction of *Hebe* plants affected by the disease into the tunnel. No crop damage or effect on plant quality was observed.

Experiment 2 – Fungicides and biofungicides for control of Geum downy mildew (Year 1)

The same treatments as used in Experiment 1 were examined for control of downy mildew (*Peronospora potentillae*) on *Geum* 'Mrs Bradshaw' on a nursery in Norfolk.

Plug plants were already infected by a low level of downy mildew at potting. The first two applications of all treatments were therefore applied at a seven day interval (6 and 13 September 2012) as is likely to be done in good commercial practice when downy mildew occurs, and thereafter at 14 (fungicide) or seven (biofungicide) day intervals. All treatments

reduced disease incidence and severity (Figure 1). Signum and Fubol Gold WG gave the best control, with Fenomenal, Percos, Previcur Energy, Hortiphyte and F62 almost as good. The two biofungicides (F60 and F61), Paraat and PlantTrust were slightly less effective than Fubol Gold WG and Signum in this experiment. Following cold weather in December and January, patches of leaf yellowing developed on 18-47% of plants that had been treated with Infinito, F61 and F62.

It should be noted that Hortiphyte has no approval as a plant protection product and that the work done here was not done for the purpose of supporting a plant protection product claim. Hortiphyte is permitted for use on crops as a foliar fertiliser and the work reported here describes the potential side effect of Hortiphyte nutritional treatments on downy mildew.

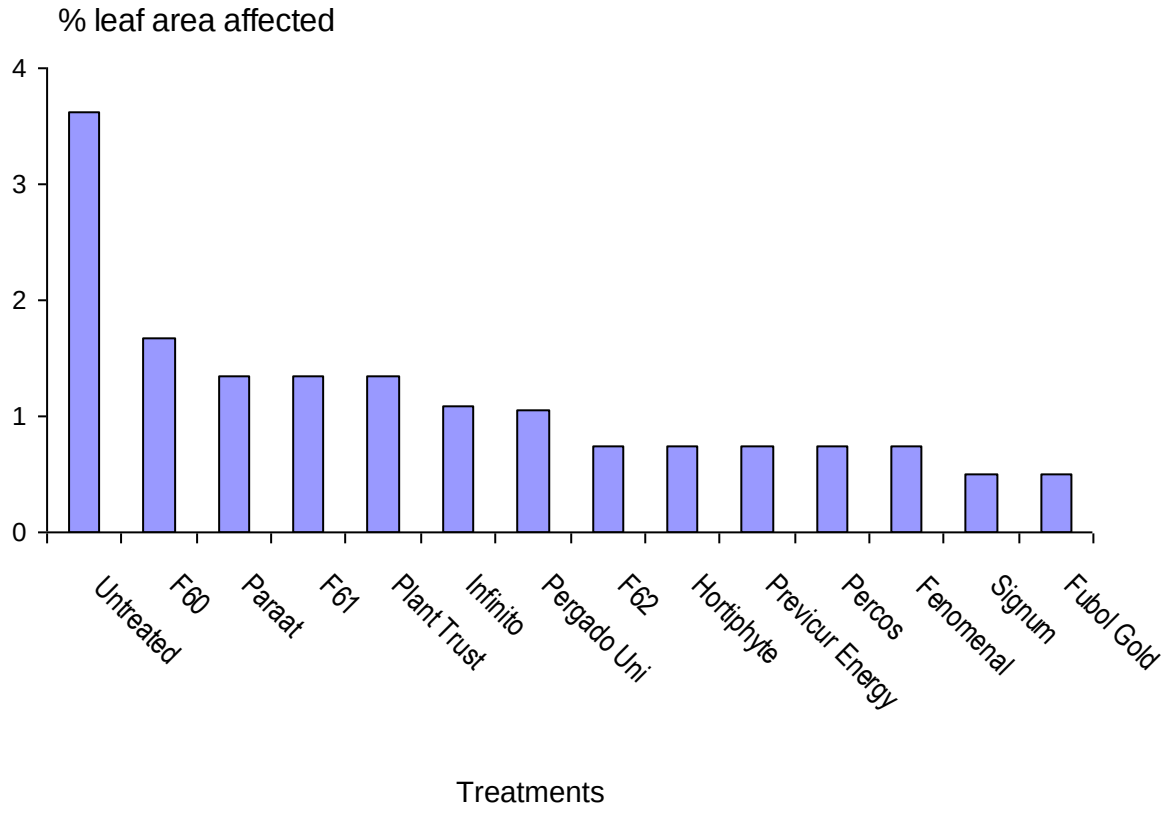


Figure 1. Effect of fungicides, biofungicides (F60 and F61) and a foliar fertiliser on *Geum* downy mildew, Norfolk – December 2012

Experiment 3 – Fungicide products and simple programmes for control of Hebe downy mildew (Year 1)

Seven treatments were evaluated for control of downy mildew on *Hebe* 'Frozen Flame' from 29 August to 19 December 2012. The treatments comprised PlantTrust incorporation in the growing medium; Fenomenal applied as a monthly drench and as a spray; programmes of

Fenomenal, Signum and Hortiphyte each alternating with Fubol Gold WG every 14 days, and Hortiphyte as a monthly foliar spray. Downy mildew was first observed in mid-September and increased in November. By 7 January 2013, downy mildew affected 14% leaf area on untreated plants. Disease severity appeared to be reduced by PlantTrust, by Fenomenal drenches and sprays, and by Hortiphyte sprays (Table 1). Fenomenal drench and spray treatments, applied at monthly intervals, were most effective and reduced the disease to around 1% leaf area affected. Treatment with Fubol Gold WG resulted in leaf tip pale discolouration, first visible one week after the third spray application (the maximum spray number); damage symptoms increased with a further spray (applied under an Experimental Permit) and some plants showed shoot tip dieback and plant collapse (Figure 2).

Table 1. Effect of fungicide programmes on *Hebe* downy mildew, Works – 2012

Product(s)	Application method and interval (days)	Total no. applications	% leaf area affected (7 Jan 2012)	% plants marketable
1. Untreated	-	0	14.3	75
2. PlantTrust	Incorporation	1	7.8	84
3. Fenomenal	Drench (28)	5	1.6	97
4. Fenomenal	Spray (28)	5	1.0	100
5. Fenomenal /Fubol Gold	Spray (14)	9	-[a]	0
6. Signum /Fubol Gold	Spray (14)	9	-	3
7. Hortiphyte /Fubol Gold	Spray (14)	9	-	25
8. Hortiphyte	Spray (14)	5	2.7	97

[a] Unable to assess downy mildew due to spray damage to plants; earlier observations indicated low disease levels; see Year 1 report.

Figure 2. Close up of *Hebe* 'Frozen Flame' leaf damage after four sprays with Fubol Gold WG at 1.9 g/L

Experiment 4 – Evaluation of fungicide and biofungicide programmes for control of downy mildew on Hebe (Year 2)

Nine alternating programmes using both fungicides and biofungicides were applied to *Hebe* plants cultivar *Hebe x franciscana* 'Variegata' on a commercial nursery in Norfolk (Table 2). To encourage infection two sets of plants previously infected with downy mildew were placed around the trial plots ('infector' plants) which remained unsprayed; and trial plants were covered with plastic sheeting for a period of 96 hours after each spray to create leaf wetness. At week 42 infection had not occurred naturally and a spore solution was used to inoculate the infector plants. Treatment applications were halted in week 46. No disease was visible at a final assessment in week 51.

Table 2. Fungicide, biofungicide and foliar fertiliser programmes applied to both *Hebe* and *Geum* plants – 2013

Treatment	Week number														
	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
1. Untreated	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Current options for growers															
2. PlantTrust (incorporation)	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3. Current fungicides +foliar fertiliser	FG	-	Hor	-	Sig	-	FG	-	Hor	-	Sig	-	FG	-	Hor
4. Foliar fertiliser only (low input programme)	Hor	-	Hor	-	Hor	-	Hor	-	Hor	-	Hor	-	Hor	-	Hor
5. Two novel fungicides programme (outdoor crops only)	Inf	-	Per	-	Inf	-	Per	-	Inf	-	Per	-	Inf	-	Per
6. Broad-spectrum programme (protected or outdoor)	Per	-	FG	-	Sig	-	Per	-	FG	-	Sig	-	Per	-	FG
7. Nil until first symptoms (then T6)	-	-	-	-	-	-	-	Per	FG	-	Sig	-	Per	-	Sig
Potential new options for growers (tested under Experimental Permit)															
8. Biological 1 (F60) until first symptoms	F60	F60	F60	F60	F60	F60	F60	Per	FG	-	Sig	-	Per	-	Sig
9. Biological 2 (F61) until first symptoms	F61	F61	F61	F61	F61	F61	F61	Per	FG	-	Sig	-	Per	-	Sig
10. Three fungicides programme (low resistance risk; O+P)	Per	-	FG	-	Fen	-	Per	-	FG	-	Fen	-	Per	-	FG
11. New chemistry	F62	-	F62	-	F62	-	F62	-	F62	-	F62	-	F62	-	F62
12. Broadening spectrum	Per+ F60	-	Inf+ F60	-	Per+ F60	-	Inf+ F60	-	Per+ F60	-	Inf+ F60	-	Per+ F60	-	Inf+ F60

Current options comply with maximum spray number, application method and all other label statutory conditions. See Table 2 for rates of use.

FG – Fubol Gold WG; Sig – Signum; Fen – Fenomenal; Hor – Hortiphyte; Inf – Infinito; Per – Percos.

Experiment 5 - Evaluation of fungicide and biofungicide programmes for control of downy mildew on Geum (Year 2)

The same treatments as used in Experiment 4 (see Table 2) were examined for control of downy mildew on *Geum* 'Mrs Bradshaw' on a nursery in Norfolk. Introduction of 'infector' plants and periodic covering with plastic sheeting, as detailed for Experiment 4, was sufficient to introduce downy mildew. The final spray was applied at week 47.

Downy mildew severity (Table 3) was reduced by all treatments except T2 (PlantTrust). The most effective treatment was an alternating programme of Fubol Gold WG, Hortiphyte and Signum (T3), which resulted in no recorded downy mildew and high plant vigour. Treatment 6 (Percos/Fubol Gold WG/Signum) was also very good. Application of biological treatments (F60 and F61) until first symptoms was better than no treatment until first symptoms (T6).

Table 3. Effect of spray programmes of fungicides, biofungicides and a foliar fertilizer on *Geum* downy mildew – 2 December 2013 (10 days after final spray)

Treatment (spray sequence)	Total no. sprays	% plants affected	% leaf area affected	Plant vigour (0-5) 4 Jan
1. Untreated	-	66	23.1	3.6
2. PlantTrust	-	71	19.9	3.5
3. FG/Hor/Sig	8	**0**	**0.0**	**5.0**
4. Hortiphyte	8	**7**	**0.2**	**4.8**
5. Infinito/Percos	8	**7**	**0.1**	**4.5**
6. Per/FG/Sig	8	**2**	**0.0**	**5.0**
7. Nil until symptoms, then T6	5	46	**7.4**	3.3
8. F60 until symptoms, then T6	12	**12**	**0.0**	4.3
9. F61 until symptoms, then T6	12	**16**	**0.6**	4.3
10. Per/FG/Fen	8	**12**	**0.0**	**4.5**
11. F62	8	**8**	**0.0**	**4.5**
12. Per + F60/Inf + F60	8	**5**	**0.0**	**4.5**

Figures in bold are significantly different from the untreated.

FG – Fubol Gold WG; Hor – Hortiphyte; Sig – Signum; Per – Percos; Fen – Fenomenal; Inf – Infinito.

Experiment 6 – Evaluation of novel fungicide and biofungicide products for phytotoxicity to herbaceous crop species commonly affected by downy mildew (Year 2)

None of 10 fungicides or biofungicides, or a foliar fertiliser, each applied four times at the recommended rate, was observed to cause phytotoxicity on any plant species at any point in this trial. The products were Hortiphyte, Infinito, Fenomenal, Fubol Gold WG, Paraat, Percos, Previcur Energy, and three coded products (F60, F61, F62). There was incidental occurrence of powdery mildew on *Coreopsis* which was reduced by Fenomenal, Fubol Gold WG, a coded biofungicide (F61) and the foliar fertiliser Hortiphyte.

Experiment 7 – Comparison of spray programmes to control downy mildew on Hebe (Year 2)

Experiment 7 was done on a nursery in Worcestershire. An alternating fungicide spray programme was evaluated for control of downy mildew on *Hebe* 'Heartbreaker' in comparison with the nursery standard programme (Table 4). The crop was grown on a sand bed with sub-irrigation in a glasshouse. Liners produced on the nursery were potted into 2 L pots on 8 August; fungicide spray treatments commenced around one week later and continued until 21 November. On 30 November 2013, downy mildew affected 7.5% of plants in the grower standard programme and none treated with the new broad-spectrum programme.

Table 4. Effect of two spray programmes on incidence of *Hebe* downy mildew – 30 November 2013

Treatment	Sprays applied (week no.)								% plants affected
	33	35	37	39	41	43	45	47	48
1. New programme	Per	FG	Sig	Per	FG	Sig	Per	FG	0
2. Nursery programme	Cu	Sig	Ami	FG	Sys	FG	Pro	Cu	7.5

Ami – Amistar; Cu – Headland Copper; FG – Fubol Gold WG; Per – Percos; Pro – Proplant; Sig – Signum; Sys – Systhane 20EW

Experiment 8 – Comparison of products on Hebe (Year 2)

The plants used in Experiment 4 were re-used in early 2014 to evaluate the efficacy of eight fungicides (applied twice at 14 day intervals) and two biofungicides (applied three times at seven day intervals) for control of *Hebe* downy mildew. A low level of downy mildew was first observed on 17 January 2014. Sprays were applied on 4, 11 and 18 February. At two weeks after the final spray, downy mildew severity was less than 0.5% on plants treated with

Fubol Gold WG, Hortiphyte, F62 and Previcur Energy. Infinito, Percos, F60 (biofungicide), F61 (biofungicide) and Fenomenal were almost as good. Signum did not reduce disease (Figure 3).

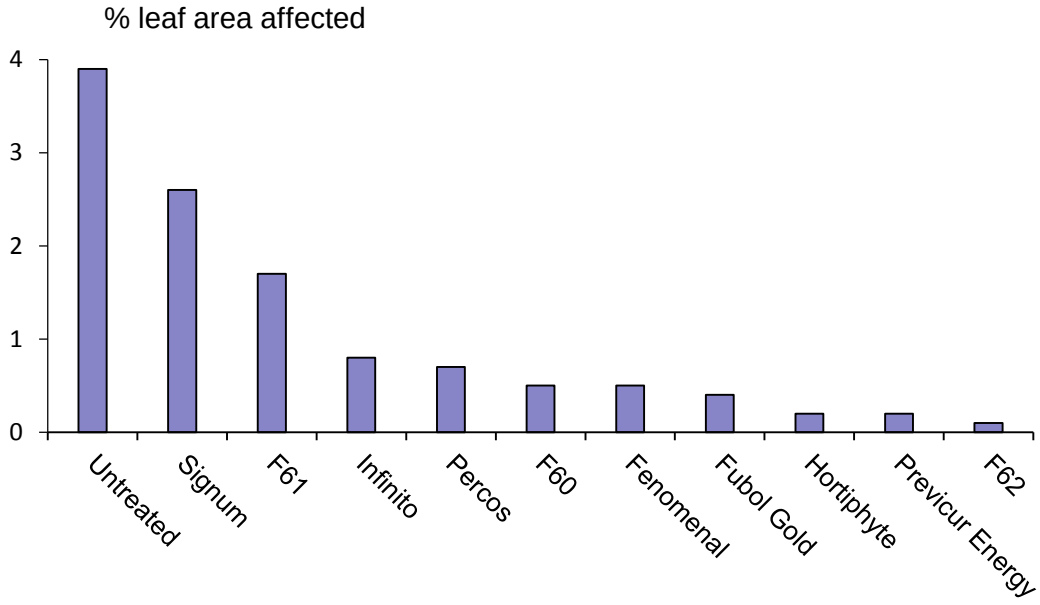


Figure 3. Effect of fungicides, biofungicides (F60 and F61), and a foliar fertiliser (Hortiphyte) on *Hebe* downy mildew, Norfolk – 3 March 2014

Table 5. Summary of products evaluated as sprays for control of downy mildew, rate of use, and their approval status (February 2014) for use on ornamental crops

Product	Active ingredient(s) (fungicide group)	Rate of use	Approval		Max spray number
			Outdoor (O)	Protected (P)	
1. Fenomenal	fosetyl-Al (33) + fenamidone (11)	2.5 kg/ha	✓ 1990/13	✓ 1990/13	2
2. Fubol Gold WG	mancozeb (M3) + metalaxyl M (4)	1.9 kg/ha	✓ 0217/12	✓ 0217/12	3
3. Hortiphyte	potassium phosphite	2.5 L/ha	✓	✓	NS
4. Infinito	fluopicolide (43) + propamocarb (28)	1.6 L/ha	✓ 0952/13	-	4 if 1.6 L rate
5. Paraat	dimethomorph (40)	0.36 kg/ha	-	✓ 2585/11	2
6. Percos	ametoctradin (45) + dimethomorph (40)	0.8 L/ha	✓ 0819/13	✓ 0819/13	4
7. Pergado Uni	mandipropamid (40)	0.6 L/ha	✓ 1605/12	✓ 1605/12	4 (O) 1 (P)
8. PlantTrust	fosetyl-aluminium (33)	2.4 kg/m^3	Label	Label	1
9. Previcur Energy	fosetyl-aluminium (33) + propamocarb (28)	2.5 L/ha	✓ 1845/13	✓ 1845/13	2
10. Signum	boscalid (7) + pyraclostrobin (11)	1.35 kg/ha	✓ 1842/09	✓ 1842/09	2
11. F60	Novel biological	-	NA	NA	-
12. F61	Novel biological	-	NA	NA	-
13. F62	Novel chemical	-	NA	NA	-

Spray applications were applied at 1000 L/ha. Fenomenal used as a drench was applied at 1.5 g/L, 200 ml/pot. NA – Not approved for use as a spray treatment; treatment applied under an Experimental Permit. NS – none stated.

Note that Fenomenal is also permitted for use on protected ornamentals as a drench with up to three applications per year at 50-150 g/100 L; Previcur Energy is also permitted for use on protected ornamentals as a drench with up to two applications at a maximum of 30 L/ha.

Use of Percos outdoors is restricted to the period June to September. Use on container plants standing on hard surfaces is prohibited.

Hortiphyte is permitted for use as a foliar fertiliser. It is not a plant protection product and makes no claims for disease control.

Before using a product for a plant protection purpose, always check that it is currently approved for the intended use and situation.

Financial benefits

Downy mildew diseases can seriously damage some major shrub and herbaceous species. Losses in *Hebe* for example are estimated to exceed £200,000 annually. This project will benefit growers through identification of some new fungicides and biofungicides with activity against downy mildew and their potential for use on ornamentals. Development of sustainable programmes using fungicide and biofungicides that are crop-safe and effective will reduce losses and downgrading due to downy mildew in ornamental plants. Quantifying risks of phytotoxicity will ensure that both efficacy and safety can be evaluated.

Action points for growers

- Consider use of the products detailed in Table 5 as protectant treatments for control of downy mildew on *Geum, Hebe* and other hardy nursery stock and herbaceous plants.
- Use two or more fungicides from different mode of action groups to reduce the risk of selecting resistant strains of downy mildew. Example programmes applied in alternation that gave good control of downy mildew in this project were:
    - Percos, Fubol Gold WG, Signum
    - Fubol Gold WG, Hortiphyte (foliar fertiliser), Signum
    - Percos, Infinito
    - Percos, Fenomenal, Fubol Gold WG
- An alternating spray programme of Percos, Fubol Gold WG and Signum should give some protection of some other diseases (e.g. powdery mildew, leaf spots) in addition to downy mildew.
- Test treat a small number of plants to check for phytotoxicity before using a fungicide widely on a new species or variety for the first time if not one of the species found to have no reactions in this study.
- Some novel fungicides and biofungicides (F60, F61, F62) with activity against downy mildew were identified in this project; HDC will issue publicity if and when these products are approved for use on ornamental crops.
- Note that Fenomenal and Previcur Energy have previously been permitted on ornamentals only as drench treatments; applications made during the course of this project resulted in EAMU 1990/13 and EAMU 1845/13 authorising these products for use as foliar sprays.

- Note that use of Percos outdoors is restricted to applications between June and September and that use on hard surfaces is prohibited.
- Note that Hortiphyte applied as a foliar fertiliser can give useful incidental control of downy mildew on *Geum* and *Hebe*.
- Note that Fubol Gold WG may cause slight damage to some varieties of *Hebe* if the maximum number of permitted sprays (three) is used; and severe damage if this spray number is exceeded.
- Note that multiple applications of Infinito and cold (frosty) weather can result in leaf yellowing on *Geum*.

SCIENCE SECTION

Introduction

Downy mildews, although more sporadic than powdery mildews, are often the more damaging disease. They can spread rapidly through a crop often affecting new growth and make plants unmarketable through leaf blotches, yellowing and distortion, premature leaf fall and stunted growth. HDC Factsheet 04/04 listed 14 susceptible nursery stock and herbaceous perennial species. From time to time new downy mildew problems arise through evolution, introduction from overseas or due to a change in cropping practices; Aquilegia downy mildew (*Peronospora aquiligae*) was recently found in the UK for the first time.

Fungicides are the cornerstone of downy mildew control for most growers. Due to the rapid and severe damage that can occur from downy mildew attack, it is usual to apply a programme of protective sprays to highly susceptible crops, rather than wait for the disease to occur before commencing treatment. Recent work on impatiens downy mildew (PC 230) for example, showed that fungicides applied from first symptoms gave virtually no control once it was present in a crop. Consequently it is necessary to have a range of fungicide products from different mode of action groups available for use in protectant programmes. However, the number of products available in the UK has recently declined and is likely to continue to decline, due especially to new EU pesticide regulation EC1107/2009.

Availability of products for control of downy mildew diseases on edible crops was identified as one of the crop protection gaps likely to arise in the near future as the new EU regulation EC1107/2009 takes effect. The Defra sponsored HortLINK SCEPTRE project (HL01109) supported by HDC (CP 77) in liaison with agrochemical and biopesticide suppliers, is screening a wide range of potential new pesticides and biopesticides on the most economically significant crop protection gaps of edible crops. A first screen of fungicides and biofungicides for control of brassica downy mildew has been completed; further work with focus on programmes has been done on onions and lettuce. The work reported here aimed to capitalise on results from SCEPTRE in order to identify as efficiently as possible the most effective new treatments for use on ornamentals.

PlantTrust, a new product containing fosetyl aluminium as a slow release granule for incorporation in growing media, has recently been launched for control of Phytophthora root rot in container-grown plants. It is known that foliar sprays and drenches of fosetyl aluminium (e.g. as Aliette 80WG) control downy mildew. It would be useful to determine if

fosetyl aluminium incorporated into growing media controls downy mildew, and to what extent.

Since Year 1 of this study EAMUs have been granted for use of both Fenomenal and Previcur Energy as foliar sprays to control downy mildew, but finding novel products remains a priority because of the loss of mancozeb and chlorothalonil as stand-alone products for use on protected crops and the restriction on spray number of all current alternative products.

The overall aim of this work is to improve control of downy mildew diseases on shrubs and herbaceous ornamentals. The specific objectives in Year 2 were: to devise and determine the effectiveness of some simple alternating programmes, and to screen novel fungicides and biofungicides with good potential for control of downy mildew diseases for their safety to a range of susceptible woody and herbaceous ornamentals

Materials and methods

Four fully replicated experiments were done on commercial nurseries in Norfolk and Suffolk in Year 2; a further small scale, comparison study was done on a nursery in Worcestershire (Table 6).

Table 6. Overview of experiments conducted in year 2 (April 2013 – March 2014)

Experiment	Crop and variety	Location	Objective
4.	*Hebe x franciscana* 'Variegata'	Norfolk	Evaluation of programmes
5.	*Geum* 'Mrs Bradshaw'	Norfolk	Evaluation of programmes
6.	Herbaceous species (x 11)	Suffolk	Crop safety
7.	*Hebe* 'Heartbreaker'	Works	Comparison of programmes
8.	*Hebe x franciscana* 'Variegata'	Norfolk	Evaluation of products

Note: Experiments 1-3 were done in Year 1 (April 2012 – March 2013).

Site and crop details

Experiments 4 and 5:

Novel fungicides and biofungicides were evaluated for control of downy mildew on *Hebe x franciscana* 'Variegata' (Experiment 4) and *Geum* 'Mrs Bradshaw' (Experiment 5) on a nursery in Norfolk. The crops were grown on a sandbed with overhead irrigation in a multispan polytunnel with curtain sides. The *Hebe* plants were grown from nursery cuttings in 1 L pots; the *Geum* were grown from bought-in plug plants in 1.5 L pots. The nursery standard growing medium was used with reduced controlled release fertiliser (CRF) as appropriate in pots containing PlantTrust. Plants were potted in early August and the first

sprays were applied on 15 August 2013. A full crop diary is given in Appendix 1. The final spray to *Hebe* plants (Experiment 4) was applied on 7 November; no further sprays were applied due to lack of downy mildew in the trial. These plants were subsequently used for Experiment 8 (see below). The final spray was applied to the *Geum* on 21 November (Experiment 5) and a final disease assessment was done on 30 November 2013.

Experiment 6:

Experiment 6 was carried out on a Suffolk based nursery on 11 crop plant species (Table 7), supplied by the nursery. Plants were laid out in the same arrangement in each plot with a row of 5 plants of each species and were assessed for phytotoxicity and plant quality after treatment with a variety of plant protection products with activity against downy mildew.

Table 7. Detail of herbaceous plant species susceptible to downy mildew used in examination of fungicides and biofungicides for crop safety – 2013

1. *Agastache rugosa* 'Licorice Blue'	Seed raised
2. *Coreopsis grandiflora* 'Sunray'	Seed raised
3. *Digitalis purpurea albiflora*	Seed raised
4. *Gaillardia x grandiflora* 'Dazzler'	Seed raised
5. *Geranium himalayense* 'Gravetye'	Cutting raised
6. *Labium maculatum* 'Chequers'	Cutting raised
7. *Papaver orientale* 'Allegro'	Seed raised
8. *Potentilla atrosanguinea*	Seed raised
9. *Salvia x jamensis* 'Hot Lips'	Cutting raised
10. *Verbena bonariensis*	Seed raised
11. *Veronica spicata*	Cutting raised

Experiment 7:

Experiment 7 was done on a nursery in Worcestershire. An alternating fungicide spray programme was evaluated for control of downy mildew on *Hebe* 'Heartbreaker' in comparison with the nursery standard programme. The crop was grown on a sandbed with sub-irrigation in a glasshouse. Liners produced on the nursery were potted into 2 L pots on 8 August; fungicide spray treatments commenced around one week later and continued until 21 November. Downy mildew first appeared in the trial on 5 November. A crop diary is given in Appendix 1.

Experiment 8:

Experiment 8 used the *Hebe* plants from Experiment 4, all of which were unaffected by downy mildew at the end of Experiment 4. Plants were left *in situ*. There was an interval of 12 weeks between the last spray of Experiment 4 and the first spray of Experiment 8. Plants were left pot thick and a dense leaf canopy developed.

Treatments

Products used are detailed in Table 8. Treatments are given in Tables 9 (Exps 4 and 5), Table 10 (Exp 6), Table 11 (Exp 7) and Table 12 (Exp 8). For Experiments 4 and 5, all sprays were applied every 14 days, except for the biofungicides (F60 and F61) which were applied weekly when used alone and every 14 days when used in mixture with a fungicide, at 1,000 L/ha using an Oxford Precision sprayer at 2-3 Bar pressure with medium spray quality (04F110 nozzles). In Experiment 4, the spray interval was reduced to 7 days for treatments 8-9 for two applications after the disease was confirmed in these treatments. For Experiment 6, sprays were applied four times at 14-day intervals as shown (Table 10) from 1 August to 12 September.

Previously infected *Hebe* and *Geum* plants were placed around the trials to introduce inoculum. When infection failed to establish in the *Hebe*, a spore suspension was sprayed on to these 'infector plants' as well as infected leaf debris and new infector plants being placed at plot edges.

Table 8. Summary of products evaluated for control of downy mildew in Year 2 (April 2013 – March 2014)

Product	Active ingredient(s) (fungicide group)	Rate of use
1. Amistar	azoxystrobin (11)	1 L/ha
2. F60	Novel biological	-
3. F61	Novel biological	-
4. F62	Novel chemical	-
5. Fenomenal	fosetyl-aluminium (33) + fenamidone (11)	2.5 kg/ha
6. Fubol Gold WG	mancozeb (M3) + metalaxyl M (4)	1.9 kg/ha
7. Headland Copper	copper oxychloride (M1)	20 L/ha
8. Hortiphyte	potassium phosphite	2.5 L/ha
9. Infinito	fluopicolide (43) + propamocarb hydrochloride (28)	1.6 L/ha
10. Paraat	dimethomorph (40)	0.36 kg/ha
11. Percos	ametoctradin (45) + dimethomorph (40)	0.8 L/ha
12. Pergado Uni	mandipropamid (40)	0.6 L/ha
13. PlantTrust	fosetyl-aluminium (33)	2.4 kg/m^3
14. Previcur Energy	fosetyl-aluminium (33) + propamocarb hydrochloride (28)	2.5 L/ha
15. Proplant	propamocarb hydrochloride (28)	1.5 L/ha
16. Signum	boscalid (7) + pyraclostrobin (11)	1.35 kg/ha

Table 9. Treatment applied to *Hebe* and *Geum* – Experiment 4 and 5, Norfolk

Treatment	Week number														
	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
1. Untreated	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Current options for growers															
2. PlantTrust (incorporation)	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3. Current fungicides +foliar fertiliser	FG	-	Hor	-	Sig	-	FG	-	Hor	-	Sig	-	FG	-	Hor
4. Foliar fertiliser only (low input programme)	Hor	-	Hor	-	Hor	-	Hor	-	Hor	-	Hor	-	Hor	-	Hor
5. Two novel fungicides programme (outdoor crops only)	Inf	-	Per	-	Inf	-	Per	-	Inf	-	Per	-	Inf	-	Per
6. Broad-spectrum' programme (protected or outdoor)	Per	-	FG	-	Sig	-	Per	-	FG	-	Sig	-	Per	-	FG
7. Nil until first symptoms (then T6)	-	-	-	-	-	-	-	Per	FG	-	Sig	-	Per	-	Sig
Potential new options for growers (tested under Experimental Permit)															
8. Biological 1 (F60) until first symptoms	F60	F60	F60	F60	F60	F60	F60	Per	FG	-	Sig	-	Per	-	Sig
9. Biological 2 (F61) until first symptoms	F61	F61	F61	F61	F61	F61	F61	Per	FG	-	Sig	-	Per	-	Sig
10. Three fungicides programme (low resistance risk; O+P)	Per	-	FG	-	Fen	-	Per	-	FG	-	Fen	-	Per	-	FG
11. New chemistry	F62	-	F62	-	F62	-	F62	-	F62	-	F62	-	F62	-	F62
12. Broadening spectrum	Per+ F60	-	Inf+ F60	-	Per+ F60	-	Inf+ F60	-	Per+ F60	-	Inf+ F60	-	Per+ F60	-	Inf+ F60

Current options comply with maximum spray number, application method and all other label statutory conditions. See Table 2 for rates of use.

FG – Fubol Gold WG; Sig – Signum; Fen – Fenomenal; Hor – Hortiphyte; Inf – Infinito; Per – Percos.

Downy mildew was first observed on *Geum* on 26 September (week 39)

Experiment 7 compared 2 treatment programmes, a standard programme currently used on the nursery, and a new programme designed to provide control of downy mildew with protection against other fungal diseases. No untreated plots were included in this experiment.

Table 10. Treatments applied to outdoor herbaceous species for examination of crop safety – Experiment 6, Suffolk (O-outside; P-protected)

Treatment	Dates applied				Max spray number permitted
	1 Aug	14 Aug	27 Aug	12 Sep	
1. Untreated	-	-	-	-	-
2. Fubol Gold WG	✓	✓	✓	✓	3
3. Fenomenal	✓	✓	✓	✓	2
4. Infinito	✓	✓	✓	✓	4(0), 1(P)
5. Percos	✓	✓	✓	✓	4
6. Pergado Uni	✓	✓	✓	✓	4(0), 1(P)
7. Previcur Energy	✓	✓	✓	✓	2
8. Hortiphyte	✓	✓	✓	✓	NA
9. Paraat	✓	✓	✓	✓	2
10. F60	✓	✓	✓	✓	-
11. F61	✓	✓	✓	✓	-
12. F62	✓	✓	✓	✓	-

NA – not applicable.

Table 11. Treatment programmes applied to *Hebe* plants – Experiment 7, Works

Treatment	Sprays applied (week no.)							
	33	34	37	39	41	43	45	47
1. New programme	Per	FG	Sig	Per	FG	Sig	Per	FG
2. Nursery programme	Cu	Sig	Ami	FG	Sys	FG	Pro	Cu

Ami – Amistar; Cu – Headland Copper; FG – Fubol Gold WG; Per – Percos; Pro – Proplant; Sig – Signum; Sys – Systhane 20EW

Experiment 8 compared the efficacy of eight fungicides and two biofungicides (Table 12). Fungicides were applied twice at an interval of 14 days; biofungicides were applied three times at an interval of 7 days.

Table 12. Treatments examined for control of *Hebe* downy mildew - Experiment 8, Norfolk

Treatment	Application date (2014)		
	4 Feb	11 Feb	18 Feb
1. Untreated	-	-	-
2. PlantTrust	-	-	-
3. Fubol Gold WG	✓	-	✓
4. Hortiphyte	✓	-	✓
5. Infinito	✓	-	✓
6. Percos	✓	-	✓
7. Signum	✓	-	✓
8. F60	✓	✓	✓
9. F61	✓	✓	✓
10. Fenomenal	✓	-	✓
11. F62	✓	-	✓
12. Previcur Energy	✓	-	✓

Experiment design and data analysis

Experiments 4-6 and 8 consisted of randomised block designs with four replicates. In Experiment 4, 5 and 8 there was extra replication (eightfold) of the untreated. Plots consisted of 24 plants, arranged pot thick as four rows of six. In Experiment 6, each plot contained five plants of each of the 11 crop species arranged in a row, resulting in 55 plants per plot. Results were examined by Generalised linear modelling or ANOVA as appropriate. Experiment 7 was not randomised, and consisted of two adjacent blocks of 400 individual plants subjected to different treatment regimes for comparison.

Assessments

In Experiments 4 and 5, untreated plants were examined at each weekly visit for symptoms of downy mildew (blotchy yellowing on upper leaf surface, grey sporulation on lower surface; distorted young leaves). At monthly intervals downy mildew was assessed as the number of plants affected per plot (all 24 plants examined), and estimated % leaf area affected per plant (five plants from the central eight).

On 1 November, plant quality in Experiments 4 and 5 was recorded on a 1-5 scale:

1 – severely stunted growth, severe mildew (unsaleable)

2 – stunted growth, obvious mildew (unsaleable)

3 – average growth, slight mildew

4 – good growth, trace mildew

5 – excellent growth, no mildew

On 4 January 2014 plant vigour in these Experiments was recorded on a 1-5 scale based on the size and density of healthy green leaves, where 1 = severely stunted and/or sparse foliage and 5 = excellent dense green foliage.

In Experiment 6 plants were examined weekly by ADAS staff for the presence of downy mildew. Plants were also checked for leaf yellowing, necrosis, stunted growth or other symptoms of phytotoxicity. Phytotoxicity on the 11 crop species was assessed each week. The presence of other non-target diseases was also noted.

In Experiment 7, plants were inspected weekly by nursery staff for downy mildew and crop damage. A full assessment was done by ADAS staff on 30 November 2013. Downy mildew was assessed as present or absent.

In Experiment 8, the incidence of affected plants and severity of downy mildew (% leaf area affected) was assessed at application of the first spray and at one and two weeks after the final spray. All plants in each plot were assessed. Additionally at the final assessment, plant quality (1-5 scale) and disease severity was recorded on five plants from the central eight.

Results and discussion

Experiment 4– Fungicides and biofungicides for control of Hebe downy mildew

No downy mildew occurred in the trial. This was despite the introduction of *Hebe* infector plants bearing downy mildew sporulation partway through the trial, the use of overhead irrigation to create leaf wetness conducive to infection, and covering the plots with polythene for periods of 24-96 h to create high humidity (see photograph Appendix 4). The use of polythene covers was shown to increase the relative humidity and temperature around plants (Appendix 3). The variety used, *Hebe x franciscana* 'Variegata', is known to be susceptible to downy mildew. The reason for the lack of downy mildew is unknown. Possibly air movement in the multispan tunnel was sufficient to dry leaves of the small plants quite quickly after irrigation and leaf wetness periods were of insufficient duration. No leaf yellowing, leaf necrosis, stunted growth or other possible symptoms of phytotoxicity were observed on treated plants. There were no differences ($p > 0.05$) between treatments in plant vigour (Table 13).

Table 13. Effect of fungicide, biofungicide and foliar fertiliser programmes on *Hebe* plant vigour (Experiment 4)

Treatment	Plant vigour (1-5) 6 Jan
1. Untreated	4.9
Current options for growers	
2. PlantTrust	4.8
3. Current fungicides +foliar fertiliser	5.0
4. Foliar fertiliser only (low input programme)	5.0
5. Two novel fungicides programme (outdoor crops only)	4.8
6. Broad-spectrum' programme (protected or outdoor)	4.5
7. Nil until first symptoms (then T6)	5.0
Potential new options for growers	
8. Biological 1 (F60) until first symptoms	4.8
9. Biological 2 (F61) until first symptoms	5.0
10. Three fungicides programme (low resistance risk)	4.8
11. New chemistry (F62)	5.0
12. Broadening spectrum	4.5
Significance (37 df)	0.852
LSD vs untreated	0.726
between treatments	0.629

Experiment 5 – Fungicides and biofungicides for control of Geum downy mildew

Disease control

When the first spray was applied (15 August 2013) there were no downy mildew symptoms present. The disease first occurred in late September.

At the assessment on 3 October 2013, after 4-7 spray applications there were significant differences between treatments in both disease incidence ($p = <0.001$, Table 14) and severity ($p <0.001$; Table 15). A high incidence of disease was recorded in the untreated control (25%), and in Treatment 2 (PlantTrust (32%)). Downy mildew severity was reduced by all the treatment programmes under test, apart from Treatment 2 and Treatment 7 (nil until first symptoms). At the final assessment on 2 December, all treatments except T2 had significantly ($p <0.001$) reduced disease severity.

The incidence of affected plants increased with time, and across four assessments between 17 October and 2 December incidence rose so that over 65% of untreated plants showed symptoms of downy mildew. All treatments except PlantTrust and nil until first symptoms (Treatment 7) reduced disease incidence significantly at all assessments (Table 14). Notably, Treatment 3 (current fungicides and the foliar fertiliser Hortiphyte) was the only treatment where downy mildew was never recorded.

Disease severity on untreated plants also rose gradually throughout the trial, reaching a peak on 2 December, at over 20% leaf area affected. PlantTrust (T2) remained the least effective treatment, with all other treatments being significantly better than the untreated at this final assessment. Most treatment programmes succeeded at holding downy mildew at a low severity, and levels either failed to climb or were reduced over time in all treatments but Treatment 7 and Treatment 9. Treatment 7, nil until first symptoms, only resulted in downy mildew levels significantly different from the untreated at the final assessment (2 December), showing that pre-emptive treatment for downy mildew is prudent, as the disease is hard to eradicate once given a chance to establish. Treatment 9 was based on the biological F61 until first symptoms, from when the same programme as Treatment 6 (broad spectrum) was commenced. Treatment 6 was the second most effective in the experiment, so it must be concluded that the biological treatment (F61) allowed downy mildew to enter the plots at low levels. However, in terms of sustainable crop management, only a low leaf area was affected in Treatments 8 and 9, considerably less than in Treatment 7 where no treatment was applied until first symptoms. The incidence of affected plants also remained less in Treatments 8 and 9 compared with Treatment 7. These results indicate it was beneficial to apply one of the biological treatments (F60 and F61) as protectants rather than do nothing until first symptoms. Treatments 3, 6, 8, 10, 11 and 12 were all showing zero leaf area affected in the 5 plants per plot assessed by the final assessment. Disease incidence and severity progress curves are shown in Appendix 2.

Table 14. Effect of fungicides, biofungicides and a foliar fertiliser on *Geum* downy mildew disease incidence, Norfolk – 2013 (Experiment 5)

Treatment	Mean % plants affected				
	3 Oct	17 Oct	30 Oct	14 Nov	2 Dec
1. Untreated	25.0	30.2	50.5	59.9	66.1
Current options for growers					
2. PlantTrust[a]	32.3	37.5	63.5	63.5	70.8
3. Current fungicides +foliar fertiliser	**0**	**0**	**0**	**0**	**0**
4. Foliar fertiliser only (low input programme)	**7.3**	**7.3**	**7.3**	**7.3**	**7.3**
5. Two novel fungicides programme (outdoor crops only)	**6.3**	**6.3**	**7.3**	**7.3**	**7.3**
6. Broad-spectrum' programme (protected or outdoor)	**0**	**0**	**2.1**	**2.1**	**2.1**
7. Nil until first symptoms (then T6)	30.2	33.3	45.8	45.8	45.8
Potential new options for growers					
8. Biological 1 (F60) until first symptoms (then T6)	**6.2**	**6.2**	**11.5**	**11.5**	**11.5**
9. Biological 2 (F61) until first symptoms (then T6)	**8.3**	**8.3**	**13.5**	**15.6**	**15.6**
10. Three fungicides programme (low resistance risk)	**3.1**	**3.1**	**11.5**	**11.5**	**11.5**
11. New chemistry (F62)	**5.2**	**5.2**	**7.3**	**8.3**	**8.3**
12. Broadening spectrum	**2.1**	**2.1**	**5.2**	**5.2**	**5.2**
Significance (37 df)	<.001	<.001	<.001	<.001	<.001
LSD vs untreated	12.97	6.48	23.65	24.25	26.03
between treatments	14.97	7.48	20.48	21.00	22.54

[a] Plants potted into amended growing medium on 15/08/13.

Values shown in bold are significantly different from the untreated.

Table 15. Effect of fungicides, biofungicides and a foliar fertiliser on *Geum* downy mildew disease severity, Norfolk – 2013 (Experiment 5)

Treatment	Mean % leaf area affected (of 5 plants)				
	3 Oct	17 Oct	30 Oct	14 Nov	2 Dec
1. Untreated	2.6	3.6	8.0	14.22	23.1
Current options for growers					
2. PlantTrust	2.4	3.6	10.9	14.2	19.9
3. Current fungicides +foliar fertiliser	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
4. Foliar fertiliser only (low input programme)	0.1	**0.2**	**0.3**	**0.3**	**0.2**
5. Two novel fungicides programme (outdoor crops only)	**0.1**	**0.1**	**0.1**	**0.05**	**0.05**
6. Broad-spectrum' programme (protected or outdoor)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
7. Nil until first symptoms (then T6)	3.1	3.3	5.7	5.9	**7.4**
Potential new options for growers					
8. Biological 1 (F60) until first symptoms, then T6	**0.0**	**0.1**	**0.1**	**0.1**	**0.0**
9. Biological 2 (F61) until first symptoms, then T6	**0.0**	**0.1**	**0.2**	**0.4**	**0.6**
10. Three fungicides programme (low resistance risk)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
11. New chemistry (F62)	**0.0**	**0.0**	**0.1**	**0.1**	**0.0**
12. Broadening spectrum	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Significance (37 df)	<.001	<.001	<.001	<.001	<.001
LSD vs untreated	2.2	2.7	6.4	8.613	13.28
between treatments	2.6	3.1	5.6	7.459	11.5

Novel options

It is noteworthy that all four programmes tested under experimental permit (Treatments 8, 9, 11 and 12) resulted in useful reductions in disease severity. This indicates there is potential for these novel biological and conventional products, and the fungicide + biofungicide mixture, to be used as foliar sprays for control of downy mildew on ornamentals, whilst lowering resistance risks. The novel programme (Treatment 5) currently available to growers for outdoor use was also successful, making use of recent authorisations for Percos (EAMU 0819/13) and Infinito (EAMU 0952/13).

Infinito (fluopicolide + propamocarb hydrochloride) is permitted for use on outdoor ornamental crops. Potentially this is a very useful product for downy mildew control as it

contains two active ingredients, both of which are active against downy mildew diseases, thereby reducing the risk of resistance development; and one of the actives (fluopicolide) is in a novel mode of action group (Group 43) compared with the other fungicides used for downy mildew control (see Table 5).

Other downy mildew fungicides used in this work that also contain two active ingredients both with activity against downy mildews are Fubol Gold WG, Fenomenal, Percos, Previcur Energy and F62.

Foliar fertiliser

Hortiphyte (potassium phosphite) applied every 14 days as a foliar fertiliser gave incidental control of downy mildew at a level equivalent to that of many of the fungicides tested.

In this work Hortiphyte (6:31:11 w/v N:P:K) was applied at 2.5 L/ha in a spray volume of 1,000 L/ha (i.e. 2.5 ml product/L). A recent review of the use of phosphonates (another name for phosphites) to manage foliar potato late blight (*Phytophthora infestans*, an oomycete like downy mildew) concluded that rates of 2.5 g a.i./L produced efficacy similar to that of the conventional contact fungicides mancozeb and chlorothalonil used at similar rates (Kromann *et al.*, 2012). The rate used in our work (1.6 g w/v phosphorus/L) was less than that found effective on potato blight. Possibly a greater effect could have been obtained with a higher rate, but in previous work we found there is a risk of crop damage with high rates used repeatedly. The Hortiphyte label recommends a rate of 1 L/ha for pot and bedding plants, 3 L/ha for hardy nursery stock and 4 L/ha for trees, with treatment every 3 weeks (pot and bedding) or monthly (hardy nursery stock).

It should be noted that Hortiphyte has no approval as a plant protection product and that the work done here was not done for the purpose of supporting a plant protection product claim. Hortiphyte is permitted for use on crops as a foliar fertiliser and the work reported here describes the potential side effect of Hortiphyte nutritional treatments on downy mildew.

Novel biofungicides

The biological products (F60, F61), resulted in useful and significant reductions in downy mildew in 2012 and when applied prior to appearance of downy mildew in 2013 resulted in better control than nil until first symptoms. It is understood that these products have been submitted for registration in the UK as biofungicides. The products are also known to have activity against some other common diseases of ornamentals. The availability of biofungicides with activity against downy mildew will permit a reduction in the use of conventional fungicides for control of downy mildew. Once such products are registered,

further work will be required to determine how best to combine the use of biofungicides and fungicides in spray programmes.

Label approvals

In this study, Infinito, Fenomenal, Percos and Previcur Energy were used; all four of these products were approved for use as high volume sprays on ornamentals under EAMUs issued in 2013 (see Table 5).

Plant quality

When assessed on 2 December after the completion of spray programmes, *Geum* plant quality was significantly increased ($p < 0.001$) by all treatments except T2 (PlantTrust) and T7 (nil until first symptoms) (Table 16). In 2012 the biofungicide F60 was found to reduce Geum plant quality, as was also discovered when evaluated for control of brassica downy mildew (*Hyaloperonospora parasitica*) in the SCEPTRE project (CP 77). However, plants treated with F60 in 2013 (Treatments 8 and 12) gained high plant quality scores. All other treatments resulted in 100% of plants scoring 3 or more, with mean plant quality scores at or approaching 5/5.

Phytotoxicity

No phytotoxicity was observed in the trial at any point. Reports of Fubol Gold WG leaving strong residues on plants may have been avoided through the lack of repeated sprays in treatment programmes.

Table 16. Effect of fungicides, biofungicides and a foliar fertiliser on *Geum* plant quality (2 December 2013) and vigour (4 January 2014) (Experiment 5)

Treatment	Plant quality score (1-5)	% plants with score 3 or more	Plant Vigour (1-5)
	2 Dec	2 Dec	4 Jan
1. Untreated	2.7	56.2	3.6
Current options for growers			
2. PlantTrust	2.5	40.6	3.5
3. Current fungicides +foliar fertiliser	**5.0**	**100**	**5.0**
4. Foliar fertiliser only (low input programme)	**4.9**	**100**	**4.8**
5. Two novel fungicides programme (outdoor crops only)	**5.0**	**100**	**4.5**
6. 'Broad-spectrum' programme (protected or outdoor)	**5.0**	**100**	**5.0**
7. Nil until first symptoms (then T6)	3.4	65.6	3.3
Potential new options for growers			
8. Biological 1 (F60) until first symptoms (then T6)	**5.0**	**100**	4.3
9. Biological 2 (F61) until first symptoms (then T6)	**4.9**	**100**	4.3
10. Three fungicides programme (low resistance risk)	**5.0**	**100**	**4.5**
11. New chemistry (F62)	**5.0**	**100**	**4.5**
12. Broadening spectrum	**5.0**	**100**	**4.5**
Significance (37 df)	<0.001	0.003	<0.001
LSD vs untreated	1.124	36.72	0.804
between treatments	0.973	31.8	0.697

Experiment 6 – Evaluation of novel fungicide and biofungicide products for phytotoxicity to 11 herbaceous crop species commonly affected by downy mildew

No phytotoxicity was observed on any of the 11 plant species sprayed with any of the fungicides under test. Though all the plants included were known to be susceptible to downy mildew, downy mildew did not establish on any species in the trial. Downy mildew was only observed in the trial once, on an individual *Digitalis purpurea* plant, and it was not actively sporulating in the field.

Though no negative effects were observed as a result of repeated fungicide sprays, differences in plant quality were observed at the final assessment (Table 17). However, this was seen to be due to the plant variety ($p<0.001$), rather than the different fungicide treatments (Table 18).

Table 17. Effect of fungicides on quality of selected herbaceous plants susceptible to downy mildew – 2013 (Experiment 6)

Plant species	Mean plant quality (1-5) after 3 sprays												
	Unt	Fub	Fen	Inf	Per	Peg	Pre	Hor	Par	F60	F61	F62	Mean
Agastache rugosa	3.0	3.5	3.8	2.8	2.8	3.4	3.3	2.8	3.3	3.3	3.5	2.5	3.13
Coreopsis grandiflora	2.9	2.9	2.6	2.8	2.0	2.7	2.3	2.5	2.3	3.7	3.3	2.0	2.7
Digitalis purpurea	3.9	3.8	3.8	3.8	3.5	3.7	3.4	3.1	4.0	3.7	4.0	4.0	3.7
Gaillardia x grandiflora	3.5	3.3	3.5	3.0	2.5	3.3	2.8	3.8	2.3	3.2	2.5	3.5	3.1
Geranium himalayense	3.8	3.5	4.3	2.8	3.0	3.5	3.5	3.7	2.5	3.4	3.0	3.0	3.3
Labium maculatum	2.9	3.2	3.0	2.8	3.3	3.0	3.0	3.6	2.5	2.8	2.8	3.3	3.0
Papayer orientale	3.0	3.3	3.3	2.8	3.8	3.3	3.3	4.0	3.0	3.3	3.3	3.4	3.3
Potentilla atrosanguinea	4.9	4.9	4.5	4.5	5.0	4.8	4.8	5.0	5.0	4.1	4.5	5.0	4.8
Salvia x jamensis	5.0	5.0	5.0	4.8	5.0	5.0	5.0	5.0	5.0	4.9	5.0	5.0	5.0
Verbena bonariensis	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.8	5.0	5.0	4.9	5.0
Veronica spicata	3.9	4.0	3.7	3.8	4.0	3.8	4.0	4.0	3.8	3.9	3.8	4.0	3.9
Mean	3.8	3.8	3.8	3.5	3.6	3.8	3.7	3.9	3.5	3.7	3.9	3.7	3.7

Unt – untreated; Fub – Fubol Gold WG: Fen – Fenomenal; Inf – Infinito; Per – Percos; Peg – Pergado Uni; Pre – Previcur Energy; Hor – Hortiphyte; Par – Paraat; F60, F61 – coded novel Biofungicides; F62 – coded novel fungicide.

Table 18. Analysis of variance on the effect of fungicide treatment and herbaceous plant species on plant quality

Source of variation	df	Variance ratio	F probability	LSD
Replicate block	3	0.69	0.56 (NS)	-
Fungicide treatment	11	1.38	0.22 (NS)	-
Residual	37	1.10	-	-
Plant species	10	78.51	<0.001	0.261
Fungicide x species	110	0.94	0.65 (NS)	-
Residual	400		-	-

NS = not significant.

Though levels of downy mildew in the trial were insufficient for assessment, powdery mildew was observed on *Coreopsis* from 12 September, affecting the plant quality scores given to this species at the final assessment. By 25 September, significant differences (p=0.005) were observed in powdery mildew severity (Table 19). Fubol Gold WG, Fenomenal, Hortiphyte and the third experimental product (F61) resulted in significantly less powdery mildew than in the untreated. Possibly the reduction in powdery mildew following treatment with Fubol Gold WG was due to the mancozeb component of this fungicide; the reduction with Hortiphyte may have been associated with phosphite affecting the plant's ability to resist infection; and the reduction with Fenomenal due to the strobilurin component of this fungicide.

Notably, treatment with Infinito, Percos and Previcur Energy resulted in powdery mildew levels worse than in the untreated at over 17% leaf area affected. This could be due to the increased levels and frequency of leaf wetness caused by repeated spraying of the plants with fungicides that have no known activity against powdery mildew. These fungicides are specifically active against oomycetes, as are Paraat and Pergado Uni which also proved ineffective at powdery mildew (an ascomycete) control.

Table 19. Effect of fungicide treatments on *Coreopsis* powdery mildew – 2013 (Experiment 6)

Fungicide treatment (for downy mildew)	Mean % leaf area affected by powdery mildew	
	12 Sept	25 Sept
1. Untreated	6.3	14.9
2. Fubol Gold WG	5.5	**3.2**
3. Fenomenal	0.8	**5.1**
4. Infinito	11.3	28.8
5. Percos	1.3	17.5
6. Pergado Uni	6.8	12.8
7. Previcur Energy	4.0	17.9
8. Hortiphyte	3.0	**4.2**
9. Paraat	3.8	10.5
10. F62 (chemical)	2.5	5.5
11. F60 (biological)	1.3	7.0
12. F61 (biological)	1.0	**3.5**
Significance	NS	0.005
LSD vs untreated	-	9.79
between treatments		11.30

*Bold- significantly different from untreated

Experiment 7 – Fungicide programmes for control of Hebe downy mildew

The two programmes examined in this experiment were designed to compare a grower programme currently in use to that of a new programme designed to give good control of downy mildew, and also some control of other fungal diseases through the inclusion of two broad spectrum fungicides (Signum and mancozeb in Fubol Gold WG). The experiment consisted of two adjacent blocks of 400 plants treated under the two programmes. Downy mildew first appeared in the nursery's *Hebe* crop on 12 September, on cultivar Magic Summer. It subsequently appeared on cultivars Pink Pixie and Purple Pixie on 1 November. Downy mildew did not appear on the cultivar Heartbreaker, used in the trial, until 5 November. At the final assessment on 30 November (Week 49), no plants treated with the experimental programme (Percos / Fubol Gold WG / Signum) were showing symptoms of downy mildew, compared to 30 plants of the 400 (7.5%) treated with the grower standard programme (detailed in Table 11).

Treatment with Fubol Gold WG by the nursery staff was observed to leave a heavy white spray deposit on plants of a dark-leaved *Hebe* variety in the same glasshouse

Experiment 8 – Evaluation of products for Hebe downy mildew

Disease control

At the start of this experiment downy mildew affected 1-16% of plants and around 0.1% leaf area (Table 20). The incidence and severity of downy mildew was slightly but significantly greater ($p < 0.024$); $p < 0.006$) in treatments 1 (untreated) and 2 (PlantTrust) than most other treatments. PlantTrust was incorporated 6 months previously in August 2013, and no additional incorporation was done for Experiment 8, so this treatment can effectively be considered as untreated at the start of Experiment 8. In order to reduce variability introduced by the slightly different initial levels of downy mildew between treatments, results of subsequent disease assessments were expressed as increased in disease over the baseline (4 February 2014) levels.

At one and two weeks after the final spray application, there were significant reductions in disease incidence and severity compared with the untreated (Table 21). At the final assessment on 3 March, the increase in disease incidence was reduced ($p < 0.001$) from 46% on untreated plants to <5% by Hortiphyte and novel fungicide F62. The increase in disease severity was reduced ($p < 0.001$) from 3.9% on untreated plants to <0. 5% by Fubol Gold WG, Hortiphyte, F62 and Previcur Energy. Infinito, Percos, F60 (biofungicide) and

Fenomenal were almost as good. The only treatment not to reduce downy mildew was Signum.

In the original trial (Experiment 4), treatment 7 remained untreated as no treatments were due to be applied until downy mildew was found in the crop, and none was found. All other treatments received applications of one or more fungicides or biofungicide (Table 20). Possibly therefore plants in treatment 7 (Signum) were more susceptible to downy mildew at the start of Experiment 8 than other treatments. However, the baseline levels of downy mildew when the first spray of Signum was applied were no higher than most other treatments (Table 20). This suggests that the failure of Signum to reduce downy mildew in this experiment is a real effect. Although Signum performed well against *Geum* downy mildew in 2012 in this project, and against other downy mildew diseases in previous work (e.g. *Hyaloperonospora brassicae* on cauliflowers in CP 77), it failed to control downy mildew on onion (*Peronospora destructor*) in a field trial in 2013 (see HDC project CP 77). Possibly these results indicate the emergence of *Hebe* and onion downy mildew strains resistant to boscalid + pyraclostrobin. Further work is required to investigate this possibility.

The most effective product on *Hebe* downy mildew was F62. This project has recently been authorised for use on *Allium* species, although is not yet being marketed in the UK. It is recommended that the possibility of an EAMU for use of F62 on ornamentals be investigated. Of the two biofungicides evaluated, F60 appears slightly more effective than F61.

The PlantTrust treatment significantly increased ($p<0.001$) incidence and severity of downy mildew compared with the untreated control (Tables 21 and 22). This product contains both the fungicide fosetyl aluminium and a slow release fertiliser. Possibly greater nitrate availability as a result of PlantTrust incorporation increased susceptibility to downy mildew. Work elsewhere has reported that increased nitrate nutrition increases susceptibility of plants to obligate pathogens, such as downy mildew.

Plant quality

Plant quality was significantly increased ($p <0.001$) by all treatments apart from Signum (Table 22). The increase in plant quality largely corresponded with the efficacy of treatments against downy mildew (Table 22). No symptoms of crop damage were observed from any of the treatments during or after spray application.

Table 20. Baseline levels of downy mildew at application of first spray – 4 February 2014 (Experiment 8)

Treatment in 2014	Original programme (2013)	Mean % plants affected	Mean % leaf area affected
1. Untreated	Untreated	15.6	0.13
2. PlantTrust	PlantTrust	15.6	0.14
3. Fubol Gold WG	FG/Hor/Sig	**4.2**	**0.03**
4. Hortiphyte	Hortiphyte	9.4	0.07
5. Infinito	Inf/Per	7.3	**0.04**
6. Percos	Per/FG/Sig	6.3	**0.05**
7. Signum	Untreated	7.3	**0.04**
8. F60	F60	**2.1**	**0.01**
9. F61	F61	6.3	**0.05**
10. Fenomenal	Per/FG/Fen	8.3	0.07
11. F62	F62	**4.2**	**0.02**
12. Previcur Energy	Per + F60	**1.0**	**0.01**
Significance (37 df)		0.024	0.006
LSD vs untreated		8.33	0.07
between treatments		9.62	0.08

FG – Fubol Gold WG; Hor – Hortiphyte; Sig – Signum; Inf – Infinito; Per – Percos; Fen – Fenomenal.

Table 21. Effect of fungicides, biofungicides and a foliar fertiliser on increase in downy mildew from 3 February to 3 March 2014 (Experiment 8)

Treatment	Number of sprays	Mean % plants affected		Mean % leaf area affected[a]	
		25 Feb	3 Mar	25 Feb	3 Mar
1. Untreated	0	25.0	45.8	2.1	3.9
2. PlantTrust	0	50.0	70.8	4.1	7.8
3. Fubol Gold WG	2	**4.2**	**12.5**	**0.2**	**0.4**
4. Hortiphyte	2	**2.1**	**4.2**	**0.2**	**0.2**
5. Infinito	2	12.5	**21.9**	**0.5**	**0.8**
6. Percos	2	**10.4**	**18.8**	**0.4**	**0.7**
7. Signum	2	28.1	46.9	1.4	2.6
8. F60 (biological)	3	14.6	**17.7**	**0.5**	**0.5**
9. F61 biological)	3	21.9	31.2	**0.8**	**1.7**
10. Fenomenal	2	**8.3**	**14.6**	**0.3**	**0.5**
11. F62	2	**3.1**	**4.2**	**0.1**	**0.1**
12. Previcur Energy	2	**9.4**	**12.5**	**0.2**	**0.2**
Significance (37 df)		<0.001	<0.001	<0.001	<0.001
LSD vs untreated		13.27	16.75	1.27	2.09
between treatments		15.32	19.34	1.46	2.41

[a] Based on all plants.

Table 22. Effect of fungicides, biofungicides and a foliar fertiliser on plant quality and downy mildew severity on 3 March 2014 – (Experiment 8) [a]

Treatment	Mean plant quality (0-5)	% leaf area affected
1. Untreated	3.4	3.3
2. PlantTrust	2.0	8.5
3. Fubol Gold WG	**4.9**	**0.2**
4. Hortiphyte	**4.9**	**0.2**
5. Infinito	**4.8**	**0.3**
6. Percos	**4.8**	**0.3**
7. Signum	3.9	1.9
8. F60 (biological)	**4.6**	**0.6**
9. F61 biological)	**4.1**	1.7
10. Fenomenal	**4.4**	**0.8**
11. F62	**5.0**	**0**
12. Previcur Energy	**4.8**	**0.2**
Significance (37 df)	<0.001	<0.001
LSD vs untreated	0.65	1.93
between treatments	0.75	2.23

[a] Based on assessment of 5 central plants per plot.

Conclusions

1. *Geum* downy mildew (*Peronospora potentillae*) was reduced by high volume sprays of the fungicides Signum (boscalid + pyraclostrobin), Previcur Energy (propamocarb hydrochloride + fosetyl aluminium), Infinito (fluopicolide + propamocarb hydrochloride), Fubol Gold WG (metalaxyl + mancozeb), Paraat (dimethomorph), Pergado Uni (mandipropamid), Fenomenal (fosetyl aluminium + fenamidone), Percos (ametoctradin + dimethomorph), one novel fungicide product (F62), the foliar fertiliser Hortiphyte (potassium phosphite) and two novel biofungicides (F60 and F61); and by growing medium incorporation of PlantTrust (fosetyl aluminium).
2. Hebe downy mildew (*Peronospora grisea*) was reduced by high volume sprays of the foliar fertiliser Hortiphyte, the fungicides Fenomenal, Fubol Gold WG, Infinito, Percos, Previcur Energy and the coded fungicide F62, and by the coded biofungicides F60 and F61.
3. In one experiment on *Hebe* two sprays of Signum failed to reduce downy mildew compared with levels on untreated plants; the possibility that some strains of *P.*

sparsa are resistant to the active ingredients of Signum (boscalid + pyraclostrobin) warrants investigation.

4. There was a trend for reduced *Hebe* downy mildew (*Peronospora grisea*) with Fenomenal applied monthly as a drench or as a high volume spray, by Hortiphyte applied monthly as a spray, and by incorporation of PlantTrust in the growing medium.
5. The foliar fertiliser potassium phosphite used to improve plant nutrition was observed to have an incidental beneficial effect in reducing downy mildew. The use of such a foliar fertiliser interspersed between fungicides applied for downy mildew control permits an increase in the interval between fungicide treatments and hence potentially extends the period between first spray of a product and reaching maximum spray number.
6. Eight fungicides with proven activity against downy mildew (on *Hebe* and *Geum*) are available for use in programmes to control downy mildew diseases on ornamentals. Five of the products each contain two actives with both components active on downy mildew (Fubol Gold WG, Fenomenal, Infinito, Percos and Previcur Energy). Such products are at less risk of reduced efficacy due to the development of strains of downy mildew with reduced sensitivity to fungicides.
7. Four spray programmes using fungicides from different groups in alternation all gave good control of *Geum* downy mildew:
    - Fubol Gold WG / Hortiphyte fertiliser / Signum
    - Infinito / Percos
    - Percos / Fubol Gold WG / Signum
    - Percos / Fenomenal / Fubol Gold WG
8. An alternating programme of Percos, Fubol Gold WG and Signum gave excellent control of *Hebe* downy mildew and caused no crop damage.
9. Evidence was gained that it may be beneficial to apply a biofungicide (F60 or F61) to protect plants against downy mildew until first symptoms of the disease, and then switch to a conventional fungicide effective against downy mildew, rather than apply no treatments before disease occurrence.
10. None of the 11 herbaceous species tested exhibited a phytotoxic reaction to any of eight fungicides, two biofungicides or a potassium phosphate foliar fertiliser when applied four times as high volume sprays at label or EAMU recommended rate.

11. A glasshouse crop of *Hebe* 'Frozen Flame' was damaged by high volume sprays of Fubol Gold at 1.9 g/L, with leaf tip pale discolouration appearing after three sprays, and leaf scorch, shoot dieback, poor colour and occasional plant collapse when applied more than the label maximum of three sprays.
12. A polytunnel crop of *Hebe* x *franciscana* 'Variegata' was not damaged by nine high volume sprays of Fubol Gold WG at 1.9 g/L.
13. Multiple applications of Infinito, F61 and F62 followed by cold weather were associated with patches of leaf yellowing on *Geum*.

Technology transfer

Presentations

Control of downy mildew on shrubs and herbaceous plants. Herbaceous Perennials Technical Discussion Group, London, 21 February 2013 (Tim O'Neill)

Sceptre – Filling crop protection gaps and application to ornamentals. British Protected Ornamentals Association Conference, Oxford, 6 February 2013 (Tim O'Neill)

Downy mildew control in protected ornamentals. British Protected Ornamentals Association Conference, Oxford, 22 January 2014 (Tim O'Neill)

Articles

O'Neill TM (2014). Increasing downy mildew control options. *HDC News* (in preparation)

O'Neill TM (2012). Programmed protection. *HDC News* **182**, 24-26.

Project meetings

Project review meeting, ADAS Boxworth, 21 February 2014.

Site meeting, Darby Nursery Stock, 5 February 2013

Initiation discussions, Darby Nursery Stock, 15 August 2012.

References

Kromann P, Perez WG, Taipe A, Schulte-Geldermann E, Sharma BP, Andrada-Piedra JL & Gorbes GA (2012). Use of phosphates to manage foliar potato late blight in developing countries. *Plant Diseases* **96**, 1008-1015.

APPENDIX 1 – CROP DIARIES

Experiments 4 and 5

Date	Comment	Initials
15.08.13	Trial set up and first spray applied (Week 33), weather station set up.	KD, SA
22.08.13	Second spray applied (Week 34) and plastic cover put over trials to try and encourage infection.	KD, SW
23.08.13	Cover removed after 24 hours.	KD
29.08.13	Third spray applied (Week 35), little evidence of downy mildew.	KD
05.09.13	Fourth spray applied (Week 36), still little evidence of downy mildew. Cover put on again will be removed after 24hrs.	KD
11.09.13	Fifth spray applied (Week 37), still little evidence of downy mildew. Cover put on again will be removed after 48hrs. PlantTrust treatment has now been added to the trial.	KD
19.09.13	Sixth spray applied (Week 38), still little evidence of downy mildew. Cover put on again will be removed after 96hrs, Monday morning.	KD
26.09.13	Seventh spray applied (Week 39), downy mildew has now become established within some of the untreated *Geum* plots (P48, 35, 14). However there is only on a low level of infection, 1 leaf with about 5% area. No infection visible in the *Hebe* plants.	KD
3.10.13	(Week 40) spray applied & first disease assessment carried out. Disease levels ranging from 0.5% to 20% of the plant infected, mainly in the untreated, nil until 1st symptoms & PlantTrust plots. Still no evidence of DM in *Hebe* plants, so cover was put on and will be removed after 96 hours.	KD
10.10.13	(Week 41) spray applied. Downy mildew has spread through the plots where it was recorded at the last assessment. There doesn't seem to be infection of previously uninfected plots. Appears to be mainly in the untreated, nil until 1st symptoms & PlantTrust plots. Still no evidence of DM in *Hebe* plants, so cover was put on and will be removed after 96 hours.	KD
16.10.13	Inoculum added to *Hebe* infector plants.	SM
17.10.13	(Week 42) spray applied on the *Hebe* plants, no sprays on *Geum*. 2nd disease assessment completed. Cover put on *Hebe* plants for 96 hrs, as no evidence of DM.	KAM
24.10.13	(Week 43) Spray applied. Still no evidence of DM on *Hebe* plants, despite added inoculum. Cover put on *Hebe* plants for 96 hrs.	KD
31.10.13	(Week 44) Spray applied to *Hebe*, no sprays on *Geum*. 3rd disease assessment completed. Incidence of DM is increasing within infected plots. Treatment 3 has shown no incidence as yet. Cover put on *Hebe* plants for 96 hrs, as no DM.	KD
07.11.13	(Week, 45) Spray applied to both *Hebe* & *Geum*. Still no evidence of DM. Cover put on Hebe plants for 9hrs.	KD

14.11.13	(Week 46) Spray held off for *Hebe* and no spray for *Geum*. 4th disease assessment completed.	KD
21.11.13	(Week 47) final spray on *Geum*, spray held off on *Hebe*.	KD
02.12.13	Final disease assessment carried out and Plant quality assessment.	KD
04.01.14	Plant vigour assessment	TO

Experiment 6

Date	Comment	Initials
19.07.13	Set up trial, no problems.	SA
01.08.13	Applied first application of sprays, no problems.	SA
14.08.13	Applied the second application, no phytotoxicity.	SA
27.08.13	Applied third application, still no evidence of phytotoxicity visible. Powdery mildew on *Coreopsis grandiflora* from 2 - 10% of leaf area. Downy mildew visible in plot 20 only on one leaf of *Digitalis purpurea albiflora.*	KD
12.09.13	Applied fourth and last application, still no evidence of phytotoxicity visible. Powdery mildew on *Coreopsis grandiflora* from 5 - 20% of leaf area. No further downy mildew apparent, samples checked under microscope.	KD
25.09.13	Plant quality & disease assessment carried out. Still no evidence of phytotoxicity visible. Powdery mildew on *Coreopsis grandiflora* from 5 - 40% of leaf area. No downy mildew apparent. Plant quality scores given reflect the saleability of the plant species which have been affected by issues such as wilting, general decline and close spacing of plants to each other.	KD

Experiment 7

Date	Comment	Initial
12.08.13	Spray 1.	Nursery staff
15.08.13	Only been potted one week.	Nursery staff
23.08.13	One plant in trial dying.	Nursery staff

26.08.13	Spray 2.	Nursery staff
09.09.13	Spray 3.	Nursery staff
12.09.13	Downy mildew found in Magic Summer crop.	Nursery staff
23.09.13	Spray 4.	Nursery staff
07.10.13	Spray 5.	Nursery staff
10.10.13	All plants in trial trimmed as crop needed it (All Heartbreaker trimmed).	Nursery staff
17.10.13	Downy mildew still active in Hebe Magic Summer.	Nursery staff
21.10.13	Spray 6.	Nursery staff
01.11.13	Downy mildew appearing on Pink/Purple Pixie.	Nursery staff
04.11.13	Spray 7.	Nursery staff
05.11.13	Found downy mildew in normal batch (Heartbreaker). Downy mildew found in control (grower programme) batch on a number of plants.	Nursery staff
14.11.13	Still downy mildew in control (grower) batch.	Nursery staff
18.11.13	Spray 8.	Nursery staff
21.11.13	Still downy mildew in control (grower) batch.	Nursery staff
30.11.13	Final assessment.	TO

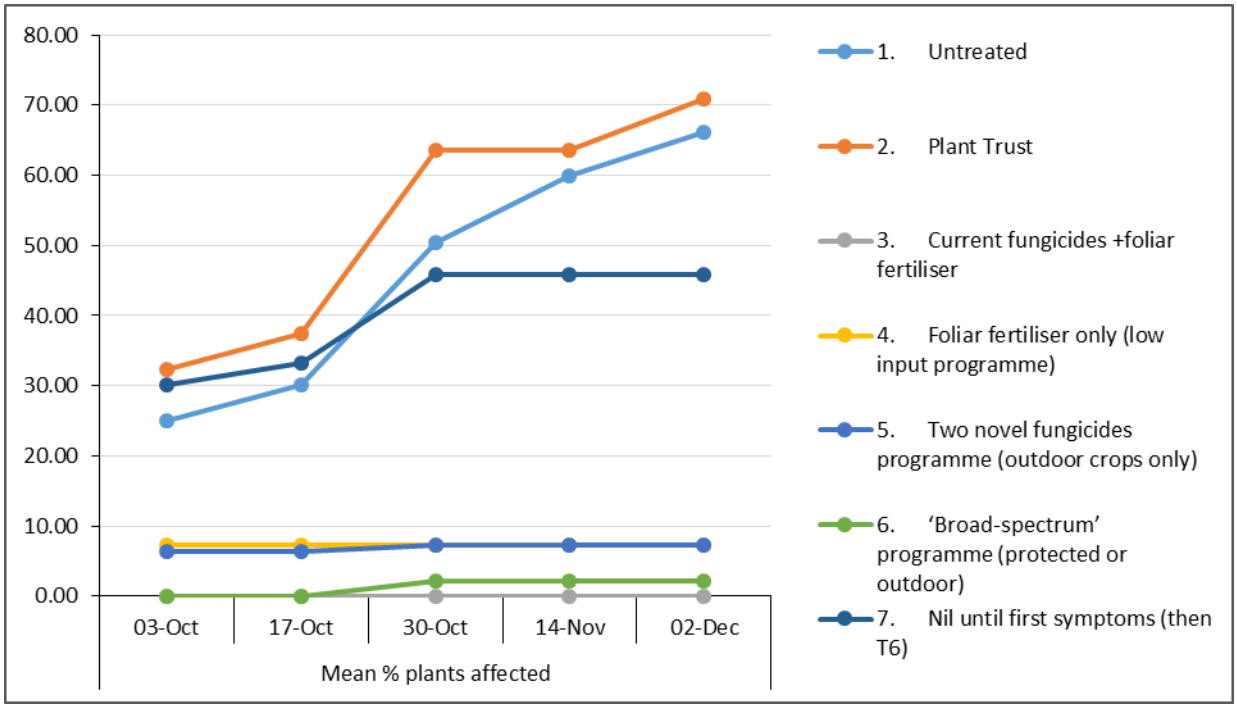
Experiment 8

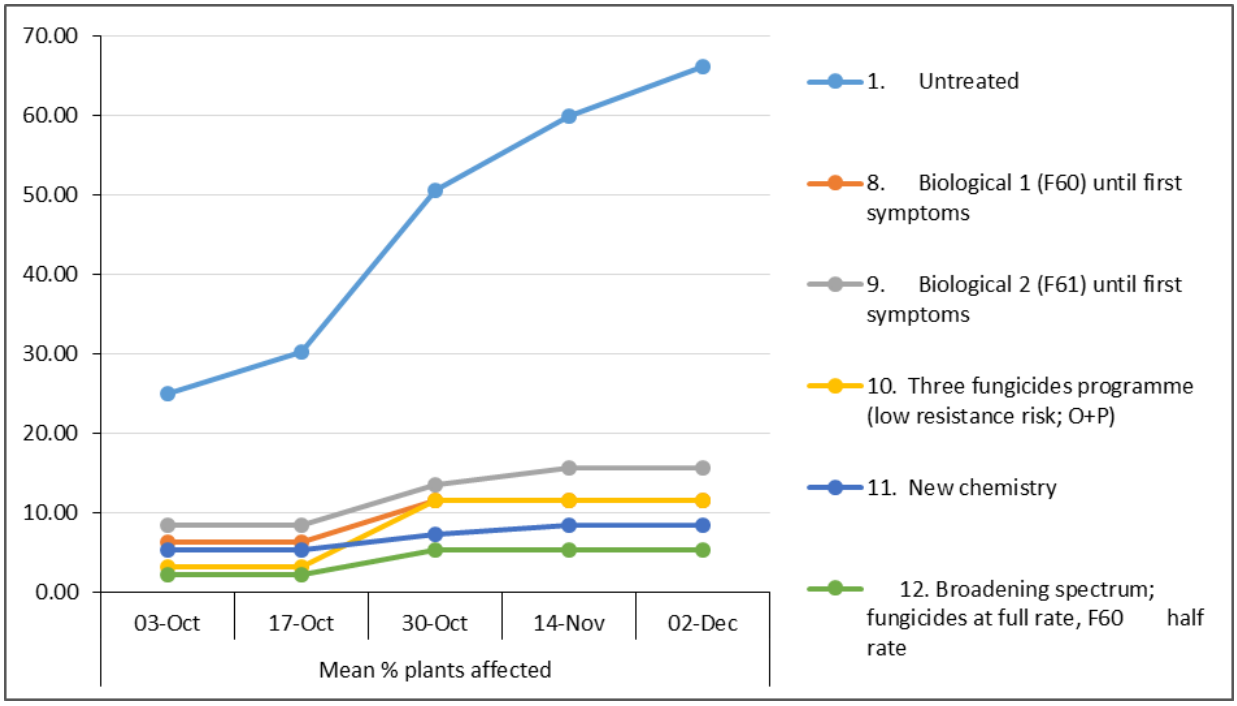
Date	Comment	Initial
4.2.14	Baseline disease assessment. Application of first sprays.	KS, TW
11.2.14	Biofungicides applied	KD
18.2.14	All treatments applied	KD, TW
25.2.14	Disease assessment – one week after final spray	KD, TW
28.2.14	Trial visit	TMO
3.3.14	Final disease assessment – two weeks after final spray. Quality assessment. Site cleared.	KD, TW

Appendix 2 – disease progress charts

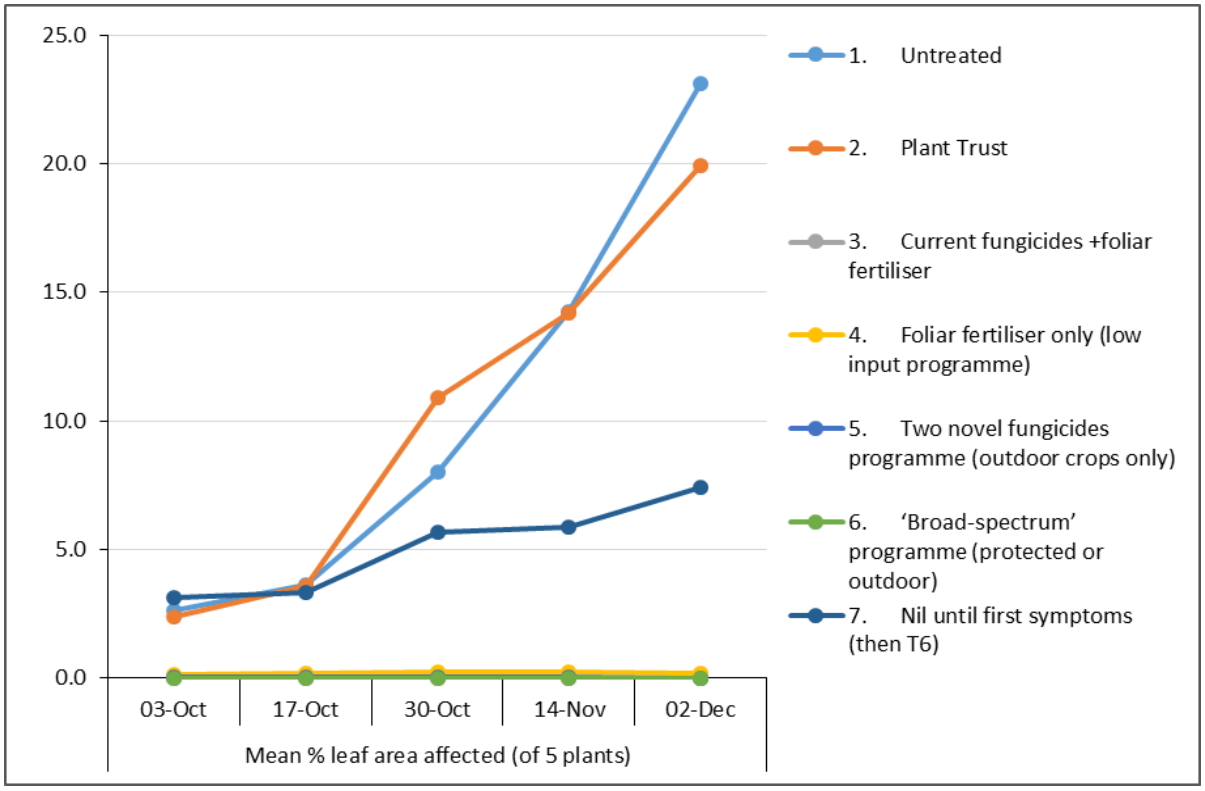
Experiment 5: Geum downy mildew, 2013

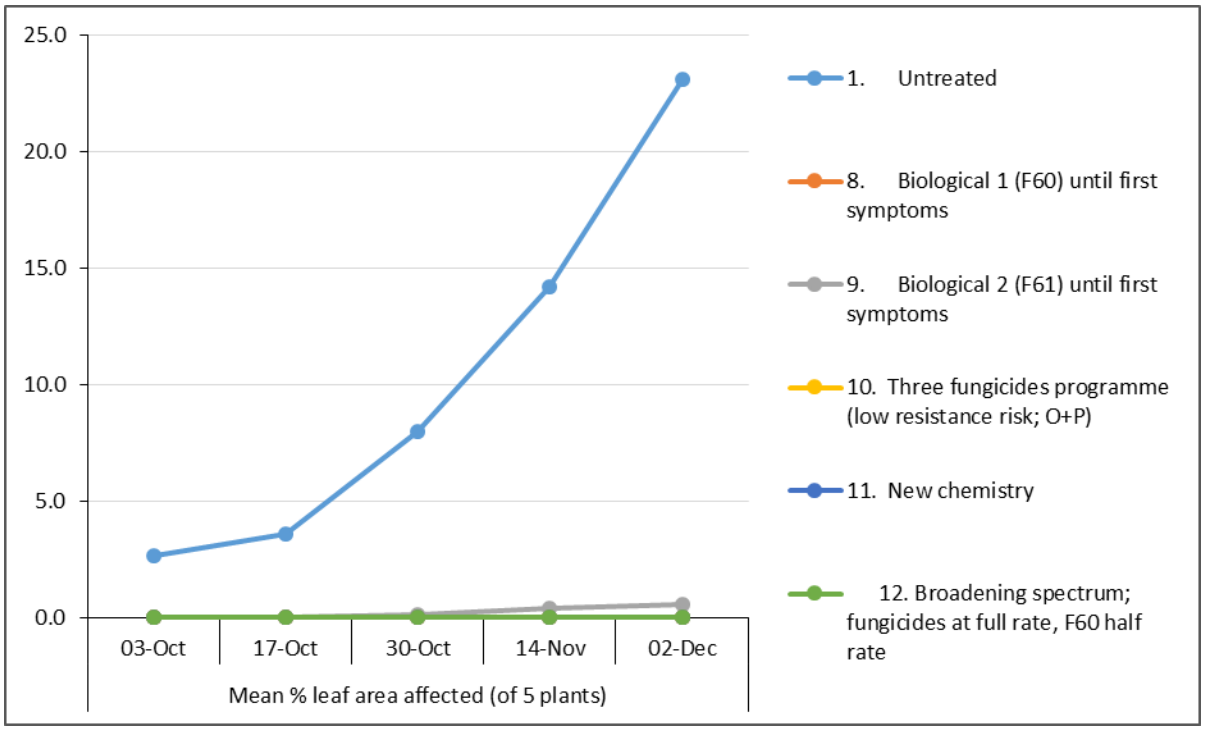
Disease incidence





Disease severity





Appendix 3 – logger temperature data

Experiments 4 and 5

Month	Max of Celsius (°C)	Min of Celsius (°C)	Average of Celsius (°C)	Average of humidity (%RH)
August	28.65	9.45	18.9	74.0
September	32.37	4.49	14.3	80.0
October	21.1	3.2	12.4	84.3
November	15.2	-2.0	6.3	86.6

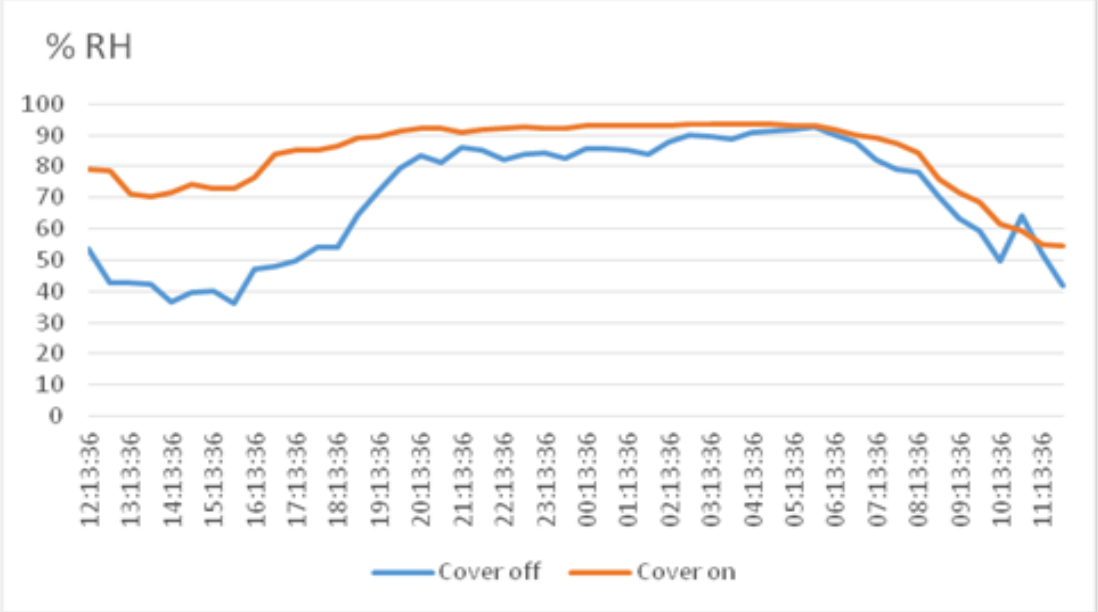


Figure 4. Effect of covering *Geum* plants with polythene on the %RH in the plant canopy. Data shown are for the cover on (22 – 23 August, top line) and cover off (20 – 21 August, bottom line) for a 24 h period.

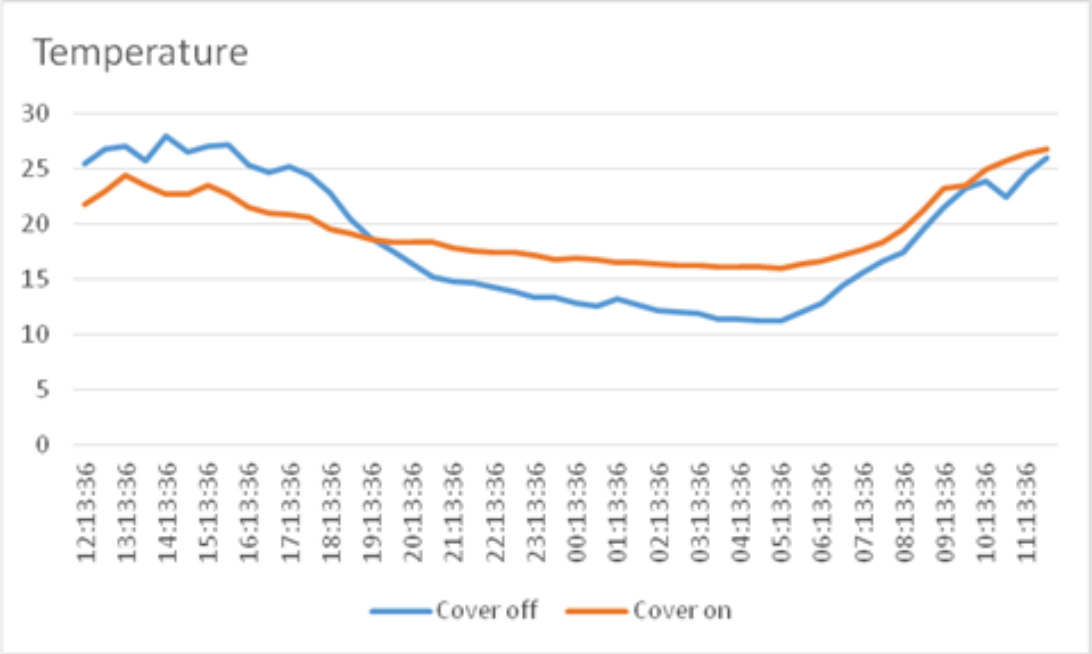


Figure 5. Effect of covering *Geum* plants with polythene on temperature (°C) in the plant canopy. Data shown are for the cover on (22 – 23 August, top line) and cover off (20 – 21 August, bottom line) for a 24 h period.

Experiment 6

Month	Max of Celsius (°C)	Min of Celsius (°C)	Average of Celsius (°C)
July	42.0	12.5	22.0
August	39.5	8.5	19.8
September	34.5	5.5	15.3

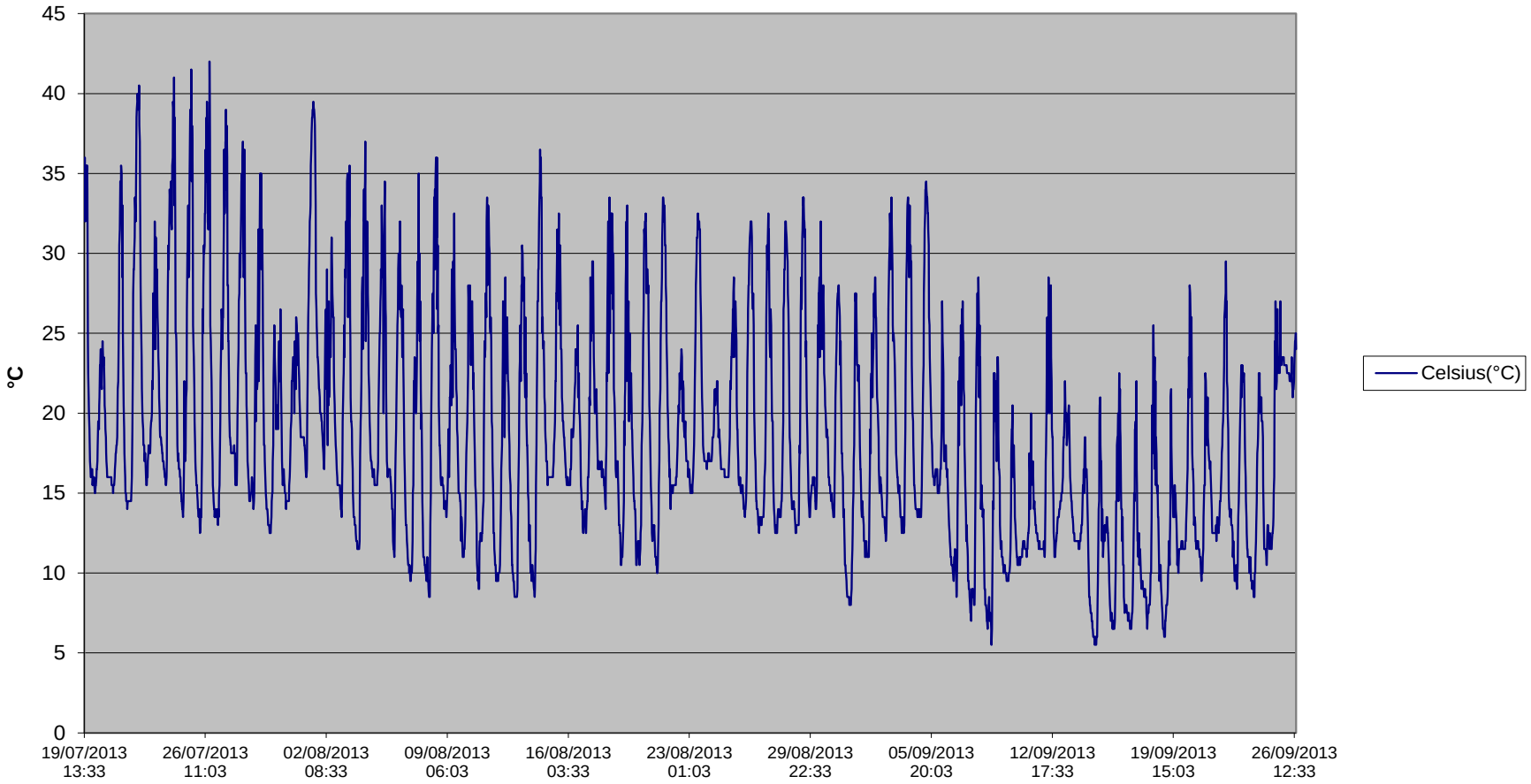


Figure 6. Diurnal temperature in the polytunnel hosting *Geum* and *Hebe* trials, 2013 (Experiments 4 and 5).

Appendix 4 – Photographs of Experiments 4-6

Figure 7. Hebe downy mildew trial - 2013 (Experiment 4)

Figure 8. Geum downy mildew trial - 2013 (Experiment 5)

Figure 9. Herbaceous crop phytotoxicity trial, Suffolk - 2013 (Experiment 6)

Figure 10. Hebe downy mildew trial, Norfolk – 2014 (Experiment 8) showing trial layout and symptoms of downy mildew.