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University of Warwick

The results and conclusions in this report are based on investigations conducted over a one-year period. 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 results, especially if they are used as the basis for commercial product recommendations.

Grower Summary

Headline

- Potential new pesticide and biopesticide control treatments identified for key pests, diseases and weeds on field vegetables, soft fruit, protected edibles and top fruit.
- Bandsprayed residual herbicides applied between planting rows, combined with a low dose over the row, improves weed control options in onion and cauliflower.

Background

Numerous widely used pesticides have already or are predicted to become unavailable over the next decade as new European legislation takes effect. Resultant gaps in crop protection threaten severely to reduce the profitability of growing some edible crops – carrots, lettuce and soft fruit for example – and will likely impact on the profitability of many others.

The decline in availability of approved crop protection chemicals is occurring for several reasons:

- failure of active ingredients to make Annex 1 listing (a positive list of active ingredients permitted in the EC) as they are reviewed under the Pesticide Registration Directive (91/414/EEC);
- some active ingredients were not supported by crop protection companies for economic reasons and were withdrawn from the pesticides review;
- implementation of a new approvals Regulation (EC) (1107/2009) that requires assessment of inherent hazard as well as risk;
- implementation of the Water Framework Directive (WFD), a measure that particularly impacts on herbicides and molluscicides;
- adoption of the Sustainable Use Directive (SUD) whereby crop protection chemicals must be used only to supplement alternative (non-chemical) methods of control.

The effect of these measures on future availability of pesticides, the resultant gaps in crop protection, and the likely impact on profitability of growing major crops has been estimated in studies funded by the HDC and Defra (project IF01100). The outcomes from these reports were used to help identify the highest propriety targets for research in the Sceptre project (Appendix 1).

The costs of finding and developing new pesticides are prohibitive for many crops; horticultural crops are ‘minor crops’ in a global crop protection market. Registration of products is complex and expensive and requires detailed biological and residue studies for each specific crop. Microbial pesticides and botanical pesticides (biopesticides) also face large registration costs.

New technologies and a new approach are needed to develop crop protection treatments that support sustainable production of edible crops. Opportunities available include:

- new chemical actives;
- a rapidly increasing number of biopesticides in the registration pipeline;
- better targeted application;
- greater use of non-chemical crop protection methods;
- anti-resistance strategies to prolong the life of actives;
- a coordinated approach so that the majority of products and treatments with potential are evaluated;
- interaction between researchers so that results on one pest are used to inform studies on a similar pest;
- collection of all relevant data so that results can be immediately used to support registration data packages;
- training of the next generation of applied crop protection specialists.

This project aims to identify effective chemical crop protection opportunities with the potential to fill the gaps and to develop integrated pest, disease and weed management programmes compliant with the new Sustainable Use Directive. The most promising pesticides and biopesticides now coming to the market and some new technologies, including non-chemical methods of pest control, will be evaluated.

A broad Consortium has been assembled to deliver this work comprising applied crop protection researchers and representatives of growers, agrochemical companies, biological crop protection companies, produce marketing organisations, retailers and the industry levy body; organisations outside the consortium are invited to supply products. The Consortium researchers comprise three teams (pests, diseases and weeds) working across the major organizations currently delivering applied crop protection research.

Summary

In Year 2, 48 chemical plant protection products, 15 based on microorganisms, 10 based on botanical extracts and 6 based on salts/simple chemicals were screened against pest, disease and weed problems identified as high priority targets. Twenty-seven experiments were completed and a further two are in progress.

New products/actives with good potential have been identified for various crops in all edible sectors (field vegetables, soft fruit, protected edibles and top fruit) in year 2.

An overview of the target pests investigated, by sector and crop, is given in Table 1. The numbers and types of products offered and tested in each experiment are given in Table 2. The results of individual experiments are listed in Table 3 and then described.

Table 1. Overview of crop pest combinations investigated in 2012

Sector and Pest	Crop			
Field vegetables	Brassica	Lettuce	Leek	Field veg
Powdery mildew	✓			
Ring spot	✓			
Alternaria leaf spot	✓			
Aphid	✓	✓		
Caterpillar	✓	✓	✓	
Cabbage root fly	✓			
Annual weeds				✓
Soft fruit	Strawberry	Raspberry	Bush/Cane	
Cane diseases		✓		
Crown rot	✓			
Mucor	✓			
Aphid		✓		
Capsid (Lygus)	✓			
Annual weeds	✓			
Perennial weeds	✓		✓	
Runners	✓			
Protected edibles	Cucumber	Tomato	Pepper	
Powdery mildew	✓			
Botrytis		✓		
Whitefly		✓		
Red spider		✓		
WFT			✓	
Top fruit	Apple	Pear		
Powdery mildew	✓			
Botrytis in store		✓		

Table 2a. Overview of experiments in 2012 showing numbers and types of product offered

Trial	Crop	Target	Novel products offered					
			micro-org	Botanical	Salt/ other	Total bio	Chemical	TOTAL products
1.1	Swede	Powdery mildew	5	3	0	8	8	16
1.2	Brassica	Ring spot	3	3	0	6	6	12
1.3	Leek	Rust	2	3	0	5	9	14
1.4	Brassica	Alternaria programmes	N/A	N/A	N/A	N/A	N/A	N/A
1.5	Lettuce	Aphid	4	5	1	10	6	16
1.6	Lettuce	Caterpillar	N/A	N/A	N/A	N/A	N/A	N/A
1.7	Leek	Onion thrips + leek moth	7	5	2	14	4	18
1.8a	Brassica (Cauliflower)	CRF	0	0	0	0	0	0
1.8b	Brassica (Sprouts)	Pest programmes – (CRF, aphids, caterpillars)	9	9	3	21	12	33
1.9	Field Vegetables	Annual Weeds	1	1	0	2	5	7
1.10	Brassica	Band spraying for weeds	N/A	N/A	N/A	N/A	N/A	N/A
1.11	Brassica	Weed seed germination enhancers	0	0	0	0	0	0
1.12	Vegetables & Fruit	Bioherbicides & herbicides for annual/perennial weeds	1	1	0	2	0	2
1.13	Field Vegetables	Electric weed control (Demo plots)	N/A	N/A	N/A	N/A	N/A	N/A
2.1	Raspberry	Cane diseases	4	2	1	7	8	15
2.2	Strawberry	Crown rot	13	4	0	17	4	21
2.3	Strawberry	Mucor and Rhizopus	5	4	1	10	5	15
2.4	Raspberry	Aphid	5	3	1	9	5	14
2.5	Strawberry	Capsid (Lygus)	3	2	0	5	4	9
2.6	Strawberry	Crop safety (residuals) and weed control (annual weeds)	1	0	0	1	2	3
2.7	Bush & Cane Fruit	Perennial weeds	1	1	0	2	1	3
2.8	Strawberry	Bioherbicides & herbicides for runner control	1	0	0	1	2	3
2.9	Bush & Cane Fruit	Electric weed control	N/A	N/A	N/A	N/A	N/A	N/A
3.1	Cucumber	Powdery mildew	6	6	0	12	9	21
3.2	Tomato	Botrytis	7	4	1	12	9	21
3.3	Tomato	Spider mite	6	8	2	16	2	18
3.4	Pepper	WFT	8	7	2	17	6	23
3.5	Tomato	Whitefly	7	11	2	20	5	25
4.1a)	Apple	Powdery mildew – conventional	0	0	0	0	7	7
4.1b)	Apple	Powdery mildew – Biofungicides	4	3	0	7	0	7
4.2	Pear	Botrytis	6	3	1	10	8	18
	Annual unique products for FV		18	13	3	34	28	62
	Annual unique products for PE		17	13	3	33	17	50
	Annual unique products for SF		19	8	2	29	21	50
	Annual unique products for TF		8	4	1	13	11	24
	Annual unique products – herbicides		1	1	0	2	7	9
	Annual unique products – fungicides		18	7	1	26	25	51
	Annual unique products – insecticides		13	12	3	28	15	43
	TOTAL UNIQUE PRODUCTS Y2		**32**	**20**	**4**	**56**	**47**	**103**

Table 2b. Overview of experiments in 2012 showing numbers and types of products tested

Trial	Crop	Target	Novel products tested					
			micro-org	Botanical	Salt/ other	Total bio	Chemical	TOTAL products
1.1	Swede	Powdery mildew	6	2	1	9	10	19
1.2	Brassica	Ring spot	5	2	0	7	7	14
1.3	Leek	Rust	0	0	0	0	8	8
1.4	Brassica	Alternaria programmes	N/A	N/A	N/A	N/A	N/A	N/A
1.5	Lettuce	Aphid	2	2	0	4	5	9
1.6	Lettuce	Caterpillar	N/A	N/A	N/A	N/A	N/A	N/A
1.7	Leek	Onion thrips + leek moth	0	2	0	2	4	6
1.8a	Brassica (Cauliflower)	CRF	2	2	0	4	1	5
1.8b	Brassica (Sprouts)	Pest programmes – (CRF, aphids, caterpillars)	N/A	N/A	N/A	N/A	N/A	N/A
1.9	Field Vegetables	Annual Weeds	0	0	0	0	2	2
1.10	Brassica	Band spraying for weeds	N/A	N/A	N/A	N/A	N/A	N/A
1.11	Brassica	Weed seed germination enhancers	0	0	0	0	1	1
1.12	Vegetables & Fruit	Bioherbicides & herbicides for annual/perennial weeds	0	2	2	4	1	5
1.13	Field Vegetables	Electric weed control (Demo plots)	N/A	N/A	N/A	N/A	N/A	N/A
2.1	Raspberry	Cane diseases	0	0	0	0	3	3
2.2	Strawberry	Crown rot	3	1	0	4	3	7
2.3	Strawberry	Mucor and Rhizopus	3	1	1	5	3	8
2.4	Raspberry	Aphid	1	2	0	3	3	6
2.5	Strawberry	Capsid (Lygus)	0	0	0	0	4	4
2.6	Strawberry	Crop safety (residuals) and weed control (annual weeds)	0	0	0	0	4	4
2.7	Bush & Cane Fruit	Perennial weeds	0	1	0	1	5	6
2.8	Strawberry	Bioherbicides & herbicides for runner control	0	2	1	3	1	4
2.9	Bush & Cane Fruit	Electric weed control	N/A	N/A	N/A	N/A	N/A	N/A
3.1	Cucumber	Powdery mildew	3	2	1	6	6	12
3.2	Tomato	Botrytis	5	1	0	6	8	14
3.3	Tomato	Spider mite	2	2	0	4	1	5
3.4	Pepper	WFT	1	3	0	4	1	5
3.5	Tomato	Whitefly	0	3	0	3	2	5
4.1a)	Apple	Powdery mildew – conventional	0	0	1	1	7	8
4.1b)	Apple	Powdery mildew – Biofungicides	3	2	4	9	0	9
4.2	Pear	Botrytis	3	0	0	3	0	3
	Annual unique products for FV		13	8	3	24	28	52
	Annual unique products for PE		9	5	1	15	14	29
	Annual unique products for SF		6	5	2	13	20	33
	Annual unique products for TF		4	2	3	9	6	15
	Annual unique products – herbicides		0	2	2	4	8	12
	Annual unique products – fungicides		11	2	4	17	26	43
	Annual unique products – insecticides		4	6	0	10	14	24
	TOTAL UNIQUE PRODUCTS Y2		**15**	**10**	**6**	**31**	**48**	**79**

Table 3. Overview of experiment results – 2012

Topic	Number treatments demonstrating control*			Pest level on untreated
	Pesticides	Bio-pesticides	Other method	
Field vegetables				
1.1 Brassica: Powdery mildew	10 (9)	9 (7)	-	High
1.2 Brassica: Ring spot	7 (7)	5 (0)	-	High
1.3 Leek: Rust	4 (4)	-	-	Low
1.4 Brassica: Alternaria (programmes)	5 (5)	3 (0)	-	Moderate
1.5 Lettuce: Currant lettuce aphid	0	0	-	Low
1.6 Lettuce: Caterpillar	-	-	-	Low
1.7 Leek: Moth	1 (1)	2 (ND)	-	Low/Mod
1.8a Brassica: Cabbage root fly	-	-	-	In progress
1.8b Brassica: Pest IPM programmes	2 (2)	0	-	High
1.9 Vegetables: Annual weeds	2 (ND)	-	-	High
1.10 Vegetables: Band spraying	-	-	✓	High
1.11 Vegetables: Germination enhancer	-	-	?	High
1.12 Vegetables/Fruit: Herbicides/ bioherbicides	1 (1)	1 (0)	-	Moderate
1.13 Vegetables: Electrical weed control	-	-	✓	High
Soft fruit				
2.1 Raspberry: Cane diseases	-	-	-	In progress
2.2 Strawberry: Crown rot	1 (1)	2 (2)	-	High
2.3 Strawberry: Soft rots				High
2.4 Raspberry: Aphid	3 (3)	3 (0)	-	High
2.5 Strawberry: European tarnished bug	4 (4)	-	-	High
2.6 Strawberry: Herbicides	0	-	-	Low
2.7 Bush and cane fruit: Herbicides	4 (4)	-	-	High
2.8 Strawberry: Runner control	0	(1) (1)	-	High
2.9 Fruit: Electrical weed control	-	-	✓	High
Protected edibles				
3.1 Cucumber: Powdery mildew	6 (6)	3 (ND)	-	High
3.2 Tomato: Grey mould	3 (3)	0	-	Low
3.3 Tomato: Spider mites	1 (1)	4 (4)	-	Mod
3.4 Tomato: Whitefly	2 (2)	3 (3)	-	Mod
3.5 Pepper: Western flower thrips	-	5 (5)	-	Mod
Top fruit				
4.1 Apple: Powdery mildew	8 (8)	9 (2)	-	High
4.2 Pear: Botrytis rot in store (2011/12)	-	3 (0)	-	High

* Compared with untreated; excludes approved reference products. ( ) – number equal to or better than the chemical reference product. ND – not determined.

Field vegetables

1.1. Brassicas: Evaluation of fungicides and biofungicides for control of powdery mildew

Two trials were conducted simultaneously in summer 2012 to evaluate 11 fungicides (Trial 1) and 10 biofungicides (Trial 2) for control of powdery mildew (*Erysiphe cruciferarum*) on swede cv. Emily. Rudis (prothioconazole) was included as a standard in both. Fungicides were applied once on the day of inoculation; biofungicides every 7 days from one week before inoculation to 3 weeks after inoculation. Severe powdery mildew developed in both trials. At 21 days after inoculation, disease was reduced in Trial 1 from 42% leaf area affected to <10% by all treatments; SF2012-SWE-24 was the most effective (2% leaf area affected). In Trial 2, two biofungicides (SF2012-SWE-90 and SF2012-SWE-136) reduced powdery mildew severity by around 50% at 7 days after the final spray. These two products also resulted in moderate phytotoxicity. Most of the biofungicides gave significant control early in the experiment when disease pressure was lower.

1.2 Brassicas: Evaluation of fungicides and biofungicides for control of ring spot

Two trials were conducted simultaneously in autumn 2012 to evaluate seven fungicides (Trial 1) and seven biofungicides (Trial 2) for control of ring spot (*Mycosphaerella brassicicola*) in Spring greens cv. Caraflex. Fungicides were applied once, biofungicides were applied three times at 7d intervals. Each trial included an untreated control and Signum (boscalid + pyraclostrobin) and Amistar (azoxystrobin) as standard treatments. Severe disease (>10% leaf area affected) developed on untreated plants in both trials. The disease was reduced by all the fungicides and most novel treatments were better than Signum and Amistar; SF2012-BRA-10 reduced infection to <1%. Five of the biofungicides reduced ring spot, with SF2012-BRA-90 the most effective (4% leaf area infected). Some treatments also affected low levels of downy mildew (*Hyaloperonospora parasitica*), light leaf spot (*Pyrenopeziza brassicae*) and dark leaf spot (*Alternaria* sp.).

1.3 Leek: Evaluation of funigicides for control of rust

A trial was conducted in summer 2012 to evaluate eight fungicides for control of rust (*Puccinia allii*) on leek cv. Darwin. An untreated control and a grower standard, Amistar (azoxystrobin), were included. Fungicides were applied once. Disease severity was low with 1% leaf area affected on untreated plants. Amistar and five of the novel products reduced rust severity; SF2012-LEE-10 was most effective reducing the disease to 0.1%.

1.4 Brassicas: Evaluation of fungicide and biofungicide programmes for control of dark leaf spot

A trial was conducted in autumn 2012 to evaluate five fungicide programmes, three biofungicide/fungicide programmes and three biofungicide products in comparison with a standard fungicide programme (Signum and Rudis) for control of dark leaf spot (*Alternaria brassicicola*) on Chinese cabbage cv. Bilko. Biofungicides were applied every 7 days from 1 week before inoculation, fungicides every 14 days from inoculation. Disease levels reached 2% leaf area (around 80 spots/plant) on untreated plants at 6 weeks after inoculation. All treatments except one reduced the disease. Two programmes consisting of biofungicide products alone appeared less effective than the same programmes incorporating a spray of Signum instead of the biofungicide applied at first sign of the disease.

1.5 and 1.6 Lettuce: Evaluation of insecticides and bio-insecticides for control of currant-lettuce aphid and caterpillar

Four x 2 field trials (1 x insecticides and 1 x bio-insecticides on each of 4 occasions) were conducted in 2012 to evaluate the efficacy of insecticides in an IPM programme for control of currant-lettuce aphid (*Nasonovia ribisnigri*) and caterpillars on lettuce cv. Saladin. Although plants were infested artificially, aphids occurred at only low levels and with an uneven distribution in three of the four trials. There were no significant differences between treatments. No caterpillars were observed in any of the trials. The low colonisation of plants by pest insects was due to very wet weather.

1.7 Leek: Evaluation of insecticides and bio-insecticides for control of onion thrips and leek moth caterpillar

Two field trials were conducted in 2012 to evaluate the efficacy of insecticides (Trial 1) and bio-insecticides (Trial 2) for control of onion thrips (*Thrips tabaci*) on leek. Wet weather prevented establishment of thrips but the uncommon pest, leek moth caterpillar (*Acrolepiosis assectella*), occurred in both trials. In Trial 1, caterpillar damage was reduced by around 60% by the standard treatment, Tracer, and by SI2012-LEE-50, and to a lesser extent by SI2012-LEE-48. In Trial 2 both SI2012-LEE-62 and SI2012-LEE-130 reduced caterpillar damage (up to 36%) at two spray volumes (200 and 1000 L/ha).

1.8 a) Brassica: Evaluation of bio-insecticides against cabbage root fly

A trial was conducted in winter 2012-13 to evaluate the efficacy of five bio-insecticides compared with standard Tracer (spinosad) treatments. Each product was examined at two application timings, for control of cabbage root fly (*Delia radicum*) on cauliflower cv. Skywalker. The trial is on-going but initial results suggest that Tracer is as effective when applied at sowing as when applied to plant propagation modules pre-transplanting. Of the bio-insecticides, SI2012-CAU-130 appears to have some efficacy against cabbage root fly larvae when applied as a post-transplating drench (liquid formulation) or to the soil surface post-transplanting (granular formulation). However, when incorporated in the plant propagation module pre-sowing the granular product was very phytotoxic at the dose tested.

1.8 b) Brassica: Evaluation of insecticide and bio-insecticide programmes in an IPM programme against cabbage root fly, caterpillars and aphids

Two trials were conducted simultaneously in summer 2012 to evaluate six insecticide programmes (Trial 1) and five bio-insecticide programmes (Trial 2) for control of cabbage root fly (*Delia radicum*), caterpillars and aphids (*Myzus persicae* and *Brevicoryne brassicae*) on Brussels sprout cv. Doric. A standard programme of Tracer for cabbage root fly, Steward (indoxacarb) for caterpillars and Movento (spirotetramat) for aphids was included. Cabbage root fly infestation was high in untreated plots and was reduced by all the insecticide treatments (Tracer, SI2012-BRU-55 and SI2012-BRU-50). Levels of aphids and caterpillars were very low. Aphid treatments were applied in the autumn as cabbage whitefly (*Aleyrodes proletella*) numbers were increasing. In Trial 1, Movento, SI2012-BRU-54, SI2012-BRU-60, and SI2012-BRU-59 significantly reduced whitefly infestation. There was also evidence that all of these products and SI2012-BRU-50 (applied as a drench pre-planting) also reduced aphid infestation but aphid numbers were very low and statistical analysis was not possible. None of the bio-insecticide products tested in Trial 2 significantly reduced either pest. No caterpillar treatments were applied.

1.9 Field vegetables: Evaluation of herbicides for crop safety and weed control

This study was carried out to evaluate SH2012-FVS-76 and SH2012-FVS-123 for crop safety and weed control on 14 crops. Additionally, volunteer potatoes were planted to determine if the herbicides suppressed their growth. In a season with high rainfall, SH2012-FVS-76 applied post-emergence or post transplanting at 2.0 L/ha was safe to carrot, parsnip, coriander and celery; at 1.0 L/ha it was safe to onion and leek. This herbicide at 2.0 L/ha gave excellent control of mayweeds, small nettle, fat hen, annual meadow grass and shepherd's purse. It gave no long-term suppression of potato growth. SF2012-FVS-123 at 0.75 L/ha was safe to iceberg lettuce transplants, vining peas and broad beans; at 0.375 L/ha it was safe to onion and leek. This herbicide at 0.75 L/ha gave excellent control of knotgrass, redshank and pale persicaria. SH2012-FVS-123 at 0.75 L/ha severely stunted potato growth and there were no flowers or berries produced and few tubers.

1.10 Vegetable: Evaluation of bandsprayed residual herbicides for control of annual broad-leaf weeds

Field trials were conducted in 2012 to evaluate the efficacy and crop safety of herbicide treatments on bulb onions cvs Centro and Hytech (Trials 1 and 2) and cauliflower cvs Boris and Chassiron (Trials 3 and 4). Relatively high doses of residual herbicides were applied as a band between planting rows in combination with a lower dose in a 10 cm band over the row. On bulb onion, at both sites all of the bandsprayed treatments had less weed cover than the commercial standard Stomp Aqua (pendimethalin) applied over the whole plot. Some of the bandsprayed treatments reduced onion plant populations at one site. Phytotoxicity was minimised by use of the less water soluble herbicides such as Stomp Aqua and Defy (prosulfacarb). On cauliflower, all of the bandsprayed treatments were at least as good as the standard treatment Rapsan (metazachlor) + Gamit 36CS (clomazone). None of the bandsprayed treatments were phytotoxic. Label conditions restrict the use of metazachlor to 1,000 g ai/ha over a three year period. By targeting use over the crop row at just 125 g ai/ha, in conjunction with potentially phytotoxic residual herbicides between the rows, this very effective and crop safe herbicide could be used on eight brassica crops in a 3 year period.

1.11 Vegetables: Evaluation of a weed seed germination enhancer

The product Smoke Master, marketed in Australia as a weed seed germination enhancer, was evaluated for its effect on germination of eight annual weeds and oilseed rape. The ultimate aim to improve the 'stale seedbed' technique for weed control. Spray treatment to trays of soil in a glasshouse enhanced germination of chickweed by around 20%, while there was no effect on charlock, fat hen, groundsel, shepherd's purse, mayweed, sowthistle, annual meadow grass or oilseed rape.

1.12 Vegetables/Fruit: Evaluation of a herbicide and some bioherbicides for control of annual and perennial weeds and strawberry runners

Two pot experiments were conducted in summer 2012 to evaluate the efficacy of one herbicide and four bioherbicides on annual weeds (Exp 1) and one herbicide and three bioherbicides on perennial weeds and strawberry runners (Exp 2). On annual weeds, the standard herbicide treatment Roundup (glyphosate) gave complete control of all target weeds. The bioherbicide SH2012-FVF-116 gave good control of fat hen and groundsel and some control of redshank but was ineffective on shepherd's purse, annual meadow grass and volunteer potatoes. On perennial weeds, the standard treatment (Roundup) gave complete or near-complete control of all target species. The conventional herbicide SH2012-FVF-124 applied once gave excellent control of common nettle and good control of broad-leaf dock and creeping thistle, the bioherbicide SH2012-FVF-116 gave moderate to good control of these weed species when applied twice. The novel herbicide SH2012-FVF-124 and the bioherbicide SH2012-FVF-116 gave some control of strawberry runners but were not as effective as the standard treatment Harvest (glufosinate ammonium).

1.13 Field vegetables: Electrical treatment for control of annual weeds

A novel tractor mounted electrical weeder was demonstrated at Elsoms in June 2012. A shrouded electrode was run between rows of cauliflower to demonstrate the potential for inter-row weed control. Good control of weeds with a high water content was achieved (groundsel, redshank, volunteer potatoes) although more fibrous weeds such as knotgrass were not so well controlled by one pass. This illustrated a need for adjustment according to weed species. Later inspections revealed that any cauliflower plants which had one leaf damaged at the time of the trial later also died. Trials did highlight limitations with current electrodes. In dense weed situations the voltage will go down the first hit weed with adjacent weeds receiving possibly a non-lethal dose. Further development will look at breaking up the bar and applying a consistent voltage to individual sections.

Soft fruit

2.1 Raspberry: Evaluation of fungicides for control of cane spot and spur blight

Laboratory tests were conducted in 2012 to evaluate the efficacy of seven fungicides for control of spur blight (*Didymella applantata*) and cane spot (*Elsinoe veneta*). Signum (boscalid + pyraclostrobin), Switch (cyprodinil + fludioxonil), Folicur (tebuconazole), SF2012-RAS-77 and SF2012-RAS-32 all reduced mycelial growth of *D. applantata* in culture. *Elsinoe veneta* grew very slowly in culture and alternative test methods are being examined. The most promising products will be taken forward to field trials on raspberry.

2.2 Strawberry: Evaluation of fungicides and biofungicides for control of crown rot

A trial was conducted in summer 2012 to evaluate the efficacy of three fungicides and four biofungicides for control of crown rot (*Phytophthora cactorum*) in strawberry cv. Elsanta grown in peat growbags. Two plants infected by *P. cactorum* were planted in each bag after the first drench application of treatments. A moderate level of crown rot developed with 45% of untreated plants affected (14% dead) at the end of the trial. Occurrence of crown rot was reduced by the reference product Paraat (dimethomorph) one novel fungicide (SF2012-STR-24) and two biofungicides (SF2012-STR-98, SF2012-STR-40). Occurrence of dead plants was reduced by Paraat and SF2012-STR-40.

2.3 Strawberry: Evaluation of fungicides and biofungicides for control of Mucor and Rhizopus soft rots

A field trial was conducted in summer 2012 to evaluate the efficacy of five fungicides and five biofungicides for control of fruit soft rots in a tunnel crop of strawberry cv. Finesse. Treatments were compared with an untreated control and the fungicide Signum (boscalid + pyraclostrobin) was included as a standard. Products were applied on five occasions to green fruit and the resultant mature fruit were assessed in post harvest tests. Over 60% of fruit in the untreated control developed soft rot and both Mucor and Rhizopus were recovered from affected tissues. None of the treatments gave complete control. Signum, Switch and SF2012-STR-77 were consistently the best treatments, reducing the disease by over 50%. None of the biofungicides gave any control.

2.4 Raspberry: Evaluation of insecticides and bio-insecticides for control of large raspberry aphid

A glasshouse trial was conducted in summer 2012 to evaluate three insecticides and three bio-insecticides for control of large raspberry aphid (*Amphorophora idaei*) on raspberry cv. Glen Ample. Treatments were compared with a water control and the standard insecticide Calypso (thiacloprid). A high population of the pest occurred. The three insecticides (SI2012-RAS-60, SI2012-RAS-50, SI2012-RAS-54) gave good control, similar to Calypso. The three bio-insecticides (SI2012-RAS-130, SI2012-RAS-51, SI2012-RAS-62) also gave control, though were less effective than the conventional insecticides; they look promising if compatible with biocontrol agents.

2.5 Strawberry: Evaluation of insecticides for control of European tarnished plant bug

A trial was conducted in summer 2012 to evaluate seven insecticides for control of European tarnished plant bug (*Lygus rugulipennis*) on strawberry cv. Finesse. A high level of infestation occurred. Pest levels were reduced by Calypso (thiacloprid), Spruzit (pyrethrins), SI2012-STR-149 and SI2012-STR-60. Spruzit used at the maximum label rate for protected crops (higher than is used in commercial practice) caused damage on this variety.

2.6 Strawberry: Evaluation of herbicides for control of annual weeds

Four residual herbicides were evaluated for control of annual weeds in strawberry when applied overall to a matted row crop of cv. Symphony in March 2012. None of the treatments at the rates used reduced levels of weeds (mainly groundsel) compared with the untreated, although there was a trend for reduced weed numbers. Three of the products (SH2012-STR-74, SH2012-STR-119 and SH2012-STR-76) reduced yield. SH2012-STR-119 caused obvious crop damage both on treated rows and adjacent plots. SH2012-STR-74 is being taken forward for off label approval as a short term residual herbicide for use on strawberry.

2.7 Bush and cane fruit: Evaluation of herbicides for control of perennial weeds

Six herbicide treatments (predominantly sulfonylureas) were examined for control of creeping thistle and common nettle in blackcurrant (cvs Ben Lomond and Ben Dorain) and raspberry (cv. Octavia). All herbicides were effective against nettle; five of the herbicides (SH2012-CAF-72, SH2012-CAF-102, SH2012-CAF-109, SH2012-CAF-135 and Roundup) had some effect on thistle. SH2012-CAF-72 was particularly effective against both weeds, more so than the standard treatment Roundup (glyphosate) and did not result in crop damage. SH2012-CAF-102 caused obvious damage to both blackcurrant and raspberry.

2.8 Strawberry: Bioherbicides and herbicides for runner control

See 1.12

2.9 Bush and cane fruit: Electrical weed control

A field trial was conducted in spring 2012 to evaluate the efficacy of a tractor-mounted high power electrode for control of perennial weeds between rows of blackcurrant bushes, cv. Ben Hope. Irrespective of tractor speed (1.6-3.9 km/hr), all creeping thistles (*Cirsium arvense*) that were tall enough to receive contact with the electrode were killed. Effect of treatment on re-growth was not assessed in this experiment.

Further work is planned on different electrode deisgns to maximise contact with weeds and to determine the effect of thistle stem treatment on viability of rhizomes.

Protected edibles

3.1. Cucumber: Evaluation of fungicides and biofungicides for control of powdery mildew

Six fungicides and seven biofungicides were compared with untreated controls and a standard programme of Systhane 20EW (myclobutanil) and Nimrod (bupirimate) for control of powdery mildew (*Podosphaera xanthii*) on cucumber cv. Roxanna. Fungicides were applied four times from the day of inoculation and biofungicides eight times from one week before inoculation. Severe powdery mildew developed on untreated plants. All of the fungicides gave very good cotnrol. SF2012-CUC-77 and SF2012-CUC-25 were particularly effective keeping the crop clean throughout the trial. One biofungicide (SF2012-CUC-105) reduced disease for one month after inoculation and two biofungicides (SF2012-CUC-90; SF2012-CUC-154) reduced it for two weeks. The biofungicide SF2012-CUC-135 reduced disease slightly by the end of the trial. Three of the conventional fungicides (SF2012-CUC-77, SF2012-CUC-14 and SF2012-CUC-88) and Systhane 20EW caused phytotoxicity after the first application, to young plants; damage was nil or slight on older plants.

3.2. Tomato: Evaluation of fungicides and biofungicides for control of grey mould

Eight fungicides and six biofungicides were compared with an untreated control and a standard programme of Rovral WP (iprodione), Switch (cyprodinil + fludioxonil) and Signum (boscalid + pyraclostrobin) for control of grey mould (*Botrytis cinerea*) on a late sown crop of tomato cv. Elegance. Fungicides were applied seven times from the day of inoculation, and biofungicides 14-times from one week before inoculation, between August and November 2012. Levels of grey mould were low despite repeat inoculation. At the end of the trial, a low level of grey mould was reduced by around 50% by SF2012-TOM-08, SF2012-TOM-25 and SF2012-TOM-118; the standard programme and the other fungicides had no effect. None of the biofungicices reduced the disease.

3.3. Tomato: Evaluation of insecticides and bio-insecticides for control of spider mites

Two trials were conducted in summer (Trial 1) and autumn (Trial 2) on glasshouse tomato cv. Dometica to evaluate some insecticides and bio-insecticides for control of two spotted mite (*Tetranychus urticae*). Five treatments in Trial 1 reduced numbers of one or more stages (adults, nymphs or eggs) of the pest compared with an untreated control; the insecticide SI2012-TOM-131 was most effective. In Trial 2, six treatments reduced numbers of nymphs and two treatments, Borneo (etoxazole) and SI2012-TOM-131, also reduced numbers of eggs after two sprays. The four bio-insecticides in Trial 2 (SI2012-TOM-91, SI2012-TOM-62, SI2012-TOM-51 and SI2012-TOM-92), applied when pest densities were low, gave similar control to that of the two insecticides.

3.4. Tomato: Evaluation of insecticides and bio-insecticides for control of glasshouse whitefly

Two insecticides and three bio-insecticides were compared with an untreated control and a standard insecticide Chess WG (pymetrozine) for control of glasshouse whitefly (*Trialeuroides vaporarorium*) on tomato cv. Dometica. After two sprays at a 7 day interval, all products had reduced the numbers of adult whiteflies and the numbers of eggs and scales; all products were as effective as Chess WG.

3.5. Pepper: Evauation of insecticides and bio-insecticides for control of Western flower thrips (WFT)

Six treatments, comprising the insecticide Pyrethrum 5EC (pyrethrins) and five bio-insecticides, were evaluated in comparison with a water control for control of WFT (*Frankliniella occidentalis*) on pepper cv. Ferrari. Three sprays were applied at 7-day intervals. The numbers of adults and nymphs per plot on the water sprayed control reached 18 and 21 respectively. Five of the products reduced numbers of adults and all products reduced numbers of nymphs. The biological products (SI2012-PEP-01, SI2012-PEP-62, SI2012-PEP-91, SI2012-PEP-60 and SI2012-PEP-51) were as effective as the standard treatment, Pyrethrum 5EC.

Top fruit

4.1 Apple: Evaluation of fungicides and biofungicides for control of powdery mildew

Two trials was conducted in summer 2012 to evaluate the efficacy of eight fungicides (Trial 1) and nine biofungicide treatments (Trial 2), in comparison with a standard fungicide Systhane 20EW (myclobutanil) for control of powdery mildew (*Podosphaera leucotricha*) on apple cvs Cox (Trial 1) and MM106 (Trial 2). Fungicides were applied five times at 7-22 day intervals; biofungicide treatment was applied five times at 6-8 day intervals. Weather conditions were conducive to mildew development and in both trials over 60% of leaves on untreated plants were affected by secondary mildew. In

Trial 1 (fungicides) all treatments reduced powdery mildew compared with the untreated control. The best treatment (SF2012-APL-32) reduced mildew by over 50%. In Trial 2 (biofungicides), the reference product Systhane 20EW was the most effective. The biofungicides SF2012-APL-158, SF2012-APL-160 and SF2012-APL-162 were almost as good. Three biofungicides based on microorganisms gave a small reduction in powdery mildew.

4.2 Pear: Evaluation of biofungicides for control of Botrytis rot in stored pear

A trial was established in September 2011 to evaluate four biofungicides in comparison with Rovral WG (iprodione) for control of Botrytis storage rot (*Botrytis cinerea*) in pear cv. Conference. Crates of fruit were dipped in the relevant treatment, or left untreated, and then stored at -1 to 0ºC until February 2012. A high level of Botrytis rot (53%) occurred in untreated fruit. The disease was reduced by Rovral WG, SF2011-1238, SF2011-1299 and SF2011-1298. None of the biofungicides was as effective as Rovral WG. Storing crates of dipped fruit for 24 h at ambient temperature before storage did not improve efficacy of any treatment.

Milestones

Milestone	Target month	Title	Status	Further work required*
P2.2	24	Disease and pest efficacy tests for Y2 completed		
		Brassica powdery mildew	Complete	-
		Brassica ring spot	Complete	-
		Leek rust	Complete	Yes
		Lettuce aphid	Complete	Yes
		Lettuce caterpillar	Complete	Yes
		Leek thrips and moth	Complete	Yes
		Brassica cabbage root fly	In progress	
		Raspberry cane diseases	In progress	
		Strawberry crown rot	Complete	-
		Strawberry soft rots	Complete	-
		Raspberry aphid	Complete	-
		Strawberry European tarnished bug	Complete	-
		Cucumber powdery mildew	Complete	-
		Tomato grey mould	Complete	Yes
		Tomato spider mites	Complete	-
		Tomato whitefly	Complete	-
		Pepper WFT	Complete	-
		Apple powdery mildew	Complete	-
		Pear botrytis rot in storage (2011/12)	Complete	-
P3.2	24	Disease and pest IPM work for Y2 completed		
		Brassica Alternaria programmes	Complete	-
		Brassica cabbage root fly programmes	Complete	-
P4.2	24	Herbicide efficacy and crop safety tests for Y2 completed		
		Vegetables herbicide crop safety	Complete	-
		Weed seed germination enhancer	Complete	Yes
		Vegetables/fruit herbicide/bioherbicide screens	Complete	-
		Strawberry herbicides	Complete	-
		Bush and cane fruit herbicides	Complete	-
	24	Sustainable weed control work for Y2 completed		
		Vegetables herbicide band spraying	Complete	Yes
		Vegetables electrical weed control	Complete	Yes
		Fruit electrical weed control	Complete	Yes

*Original objectives not fully met due to lack of sufficient pest attack or other reason.

Science Section

Individual experiments are summarised below. Unless stated otherwise:

- No problems were encountered during mixing or application of any of the products under test;
- No phytotoxicity or treatment related crop vigour differences were observed;
- The results for the standard treatment were as expected and it can be considered a valid trial.
- Trials were carried out on young plants which were not taken to maturity and therefore no observations were made on yield.
- Products currently approved for use on the test crop and included as standard treatments are shown underlined in the Tables.
- Results of treatments that are significantly ($p < 0.05$) better than the untreated control are shown in bold in tables.

1. Field vegetables

1.1 Assessment of the efficacy of several fungicides and biofungicides against powdery mildew in brassica crops

One replicated trial was conducted in 2012 in unheated polytunnels at ADAS Boxworth to screen fungicides (Trial 1) and biofungicides (Trial 2) for the control of powdery mildew (*Erysiphe cruciferarum*) on Swede seedlings cv. Emily. The results obtained were compared with an untreated control and an industry standard fungicide Rudis.

Fungicides were applied as single sprays and allowed to dry briefly before inoculation later on the same day, biofungicides were applied at -7 days before, on the day of inoculation, 7 days after inoculation and 14 days after inoculation. Treatments applied are listed below:

Trial 1.1.1. Fungicide products for powdery mildew control in brassica (swede) seedlings cv. Emily – ADAS Boxworth 2012 (Trial 1)

Treatment number	SCEPTRE code	Product	Rate of product	Active ingredient	Timing (days)
1 + 2	Untreated	Untreated			
3	Rudis	Rudis	0.4 L/ha	Prothioconazole	0
4	SF2012-SWE-137	-	-	-	0
5	SF2012-SWE-29	-	-	-	0
6	SF2012-SWE-46	-	-	-	0
7	SF2012-SWE-10	-	-	-	0
8	SF2012-SWE-24	-			0
9	SF2012-SWE-25a	-	-	-	0
10	SF2012-SWE-28	-	-	-	0
11	SF2012-SWE-138	-	-	-	0
12	SF2012-SWE-89	-	-	-	0
13	SF2012-SWE-88	-	-	-	0

Table 1.1.2. Biofungicide products for powdery mildew control in brassica (swede) seedlings cv. Emily – ADAS Boxworth 2012 (Trial 2)

Treat number	SCEPTRE code	Product	Rate of product	Active ingredient	Timing (days)
1 + 2	Untreated	Untreated			-7, 0, +7 and +14
3	Rudis	Rudis	0.4 L/ha	Prothioconazole	-7, 0, +7 and +14
4	SF2012-SWE-105				-7, 0, +7 and +14
5	SF2012-SWE-134				-7, 0, +7 and +14
6	SF2012-SWE-38				-7, 0, +7 and +14
7	SF2012-SWE-06				-7, 0, +7 and +14
8	SF2012-SWE-90				-7, 0, +7 and +14
9	SF2012-SWE-115				-7, 0, +7 and +14
10	SF2012-SWE-43				-7, 0, +7 and +14
11	SF2012-SWE-03				-7, 0, +7 and +14
12	SF2012-SWE-40				-7, 0, +7 and +14
13	SF2012-SWE-136				-7, 0, +7 and +14

Results

Table 1.1.3. Effect of fungicides on powdery mildew (*Erysiphe cruciferarum*) severity (% leaf area affected) at intervals after inoculation – ADAS Boxworth, 2012 (Trial 1)

		Severity (% leaf area)		
Treatment	Product name or code	18 days	21 days	28 days
1 + 2	Untreated	31.64	41.99	57.88
3	Rudis	**0.25**	**4.14**	**6.90**
4	SF2012-SWE-137	**0.49**	**4.67**	**12.03**
5	SF2012-SWE-29	**1.23**	**5.08**	**14.75**
6	SF2012-SWE-46	**2.30**	**9.68**	**24.25**
7	SF2012-SWE-10	**1.51**	**3.75**	**13.48**
8	SF2012-SWE-24	**0.22**	**1.89**	**6.10**
9	SF2012-SWE-25a	**1.45**	**5.10**	**18.10**
10	SF2012-SWE-28	**0.27**	**2.90**	**8.78**
11	SF2012-SWE-138	**1.95**	**6.67**	**18.75**
12	SF2012-SWE-89	**0.63**	**2.78**	**8.28**
13	SF2012-SWE-88	**1.54**	**4.34**	**12.65**
Probability (F value)		<.001	<.001	<.001
LSD vs. treatment (37 d.f.)		16.23	19.95	14.39
LSD vs. untreated (37 d.f.)		14.06	17.28	12.46

* treatments that are significantly better than the untreated are shown in bold

Table 1.1.4. Effect of biofungicides on powdery mildew (*Erysiphe cruciferarum*) severity (% leaf area affected) at intervals after inoculation – ADAS Boxworth, 2012 (Trial 2)

		Severity (% leaf area)		
Treatment	Product name or code	18 days	21 days	28 days
1+2	Untreated	23.46	46.54	69.16
3	<u>Rudis</u>	**0.00**	**0.00**	**0.00**
4	SF2012-SWE-105	**5.03**	**21.63**	68.25
5	SF2012-SWE-134	**3.82**	**16.67**	65.18
6	SF2012-SWE-38	**9.55**	**30.50**	66.08
7	SF2012-SWE-06	**6.58**	**31.92**	65.42
8	SF2012-SWE-90	**2.91**	**14.63**	**34.66**
9	SF2012-SWE-115	**6.70**	**28.67**	65.17
10	SF2012-SWE-43	**12.05**	35.58	70.75
11	SF2012-SWE-03	**11.10**	40.60	69.67
12	SF2012-SWE-40	15.42	51.00	71.55
13	SF2012-SWE-136	**1.98**	**11.25**	**37.75**
Probability (F value)		<.001	<.001	<.001
LSD vs. treatment (61 d.f.)		9.07	15.63	9.23
LSD vs. untreated (61 d.f.)		7.86	13.53	8.00

* treatments that are significantly better than the untreated are shown in bold.

- Disease pressure was moderate to high.
- Slight phytotoxicity was observed at the Day 3 assessment on plots treated with SF2012-SWE-90 and SF2012-SWE-136 in Trial 2 (biologicals). This increased to moderate phytotoxicity at the Day 14 assessment. On plants affected, leaves were slightly yellower than the untreated exhibiting a yellow/green hue.
- In Trial 1 (fungicides) there were significant differences in efficacy for all products. The best performers were the industry standard Rudis and SF2012-SWE-24.
- In Trial 2 (biofungicides) the industry standard Rudis performed consistently better than all of the novel treatments. There were significant differences 21 days post inoculation for all products except SF2012-SWE-40, 2102-SWE-43 and 2012-SWE-03.

Discussion

Disease pressure was moderate and increased to a high level; this allowed a good assessment of disease control. Up to 21 days after treatments were applied all fungicide products significantly reduced incidence of powdery mildew. After 28 days, several products in Trial 1 (fungicides) still significantly reduced powdery mildew incidence and severity. SF2012-SWE-24 gave the best control, while products SF2012-SWE-28, SF2012-SWE-89 and Rudis also significantly reduced incidence by over 80%.

In Trial 2 (biofungicides) products SF2012-SWE-105, SF2012-SWE-134, SF2012-SWE-38, SF2012-SWE-06, SF2012-SWE-90 and SF2012-SWE-115 significantly reduced the disease at 21 days, but only the industry standard Rudis, SF2012-SWE-90 and SF2012-SWE-136 showed significant persistence of activity at 28 days after inoculation.

1.2 Assessment of the efficacy of several fungicides and biofungicides against ring spot on brassica crops

Two replicated experiments were conducted simultaneously in 2012/2013 in unheated polytunnels at ADAS Boxworth to screen fungicides (Trial 1) and biofungicides (Trial 2) for the control of ring spot (*Mycosphaerella brassicicola*) on spring greens plants cv. Caraflex. The results obtained were compared with an untreated control and an industry standard fungicide, Signum.

Fungicides were applied as single sprays on Day 0 and allowed to dry before inoculation the following day by laying ring spot affected leaves on the floor on Day 1. Biofungicides were applied at -7 days before, on the day of inoculation, 7 days after inoculation and 14 days after inoculation. A further set of ring spot affected leaves was laid on the floor on day 22. Treatments applied are listed below:

Table 1.2.1. Fungicide products for ring spot control in brassica (spring greens) seedlings cv. Caraflex – ADAS Boxworth 2012

Treatment number	SCEPTRE code or product	Rate of product	Active ingredient	Timing (days after 1st inoc)
1	Untreated			
2	Signum	1.0 kg/ha	Boscalid + pyraclostrobin	Day 0
3	Amistar	1.0 L/ha	Azoxystrobin	Day 0
4	SF2012-BRA-117			Day 0
5	SF2012-BRA-29			Day 0
6	SF2012-BRA-27			Day 0
7	SF2012-BRA-10			Day 0
8	SF2012-BRA-25a			Day 0
9	SF2012-BRA-24			Day 0

Table 1.2.2. Biological and plant activator products for ring spot control in brassica (spring greens) seedlings cv. Caraflex – ADAS Boxworth 2012

Treat number	SCEPTRE code or product	Rate of product	Active ingredient	Timing (days after 1st inoc)
1	Untreated			
2	Signum	1.0 kg/ha	Boscalid + pyraclostrobin	-7, 0, +7 and +14
3	SF2012-BRA-105			-7, 0, +7 and +14
4	SF2012-BRA-98			-7, 0, +7 and +14
5	SF2012-BRA-49			-7, 0, +7 and +14
6	SF2012-BRA-38			-7, 0, +7 and +14
7	SF2012-BRA-43			-7, 0, +7 and +14
8	SF2012-BRA-40			-7, 0, +7 and +14
9	SF2012-BRA-90			-7, 0, +7 and +14

Results

- Disease levels were low initially, however in late December disease levels increased rapidly.
- Ring spot disease at the later assessment (Table 1.2.4) showed a decline between day 64 and day 71 due to loss of severely diseased leaves though disease was still developing on the younger leaves.

Fungicide trial

- Although the results obtained for the standard treatments were rather less effective than expected this can be considered a valid trial with high disease pressure.
- Phytotoxic effects were identified in one replicate of treatments 2, 3, 7 and 8, with this being more severe in the Day 14 assessment than later assessments. By the Day 71 assessment only one replicate of treatment 8 was exhibiting slight phytotoxic effects.
- For ring spot control, all fungicide treatments significantly reduced disease compared with the untreated (Table 1.2.3). All of the coded products were better than the Signum and Amistar standards. SF2012-BRA-10 performed the best. Light leaf spot severity was significantly higher than the control in all treatments apart from SF2012-BRA-27 on day 64 but not on day 71 assessments.
- Treatments 3, 4 and 5 had no *Alternaria brassicicola*, however all treatments had higher severity of downy mildew than the untreated control (Table 1.2.4).

Table 1.2.3. Effect of fungicides on brassica foliar diseases, Day 64 Assessment - 2012

Treatment	SCEPTRE code or product	Rate of product	Ring spot (% leaf area)	Light leaf spot (% leaf area)
1	Untreated	-	10.43	0.22
2	Signum	1.0 kg/ha	**6.65**	0.34
3	Amistar	1.0 L/ha	**8.01**	0.25
4	SF2012-BRA-117		**2.35**	**0.77**
5	SF2012-BRA-29		**1.38**	0.44
6	SF2012-BRA-27		**2.20**	0.15
7	SF2012-BRA-10		**0.80**	0.44
8	SF2012-BRA-25a		**1.74**	0.29
9	SF2012-BRA-24		**1.14**	0.36
Fpr	-	-	<0.001	0.003
SED	-	-	0.729	0.149
LSD	-	-	1.434	0.293

* treatments that are significantly better than the untreated are shown in bold.

Table 1.2.4. Effect of fungicides on brassica foliar diseases, Day 71 Assessment - 2012

Treatment	SCEPTRE code or product	Rate of product	Ring spot (% leaf area)	Alternaria (% leaf area)	Downy mildew (% leaf area)
1	Untreated	-	8.59	0.044	0.11
2	Signum	1.0 kg/ha	**6.67**	**0.008**	**0.72**
3	Amistar	1.0 L/ha	**7.22**	**0.000**	0.49
4	SF2012-BRA-117		**1.60**	**0.000**	0.62
5	SF2012-BRA-29		**1.06**	**0.000**	**0.72**
6	SF2012-BRA-27		**0.77**	**0.003**	**1.05**
7	SF2012-BRA-10		**0.18**	**0.008**	**1.12**
8	SF2012-BRA-25a		**0.72**	**0.003**	**0.83**
9	SF2012-BRA-24		**0.45**	**0.003**	0.29
Fpr	-	-	<0.001	0.028	0.019
SED	-	-	0.590	0.013	0.304
LSD	-	-	1.161	0.027	0.597

* treatments that are significantly better than the untreated are shown in bold.

Biofungicides

- *Phytotoxicity* – At all assessments it was noted that treatment 9 (SF2012-BRA-90) exerted slight toxicity in all replicates with yellow blotches on leaves.
- Signum performed better than all biological treatments in controlling ring spot (Note: multiple applications gave much better control than the single application in the fungicide experiment).
- SF2012-BRA-90 performed better than the other biocontrols in reducing ring spot.
- Only SF2012-BRA-98 and SF2012-BRA-40 did not give significant control of ring spot.
- SF2012-BRA-90 reduced downy mildew (Table 1.2.5) but effects on light leaf spot were not significant.

Table 1.2.5. Effect of biofungicides on brassica foliar disease, Day 64 - 2012

Treatment	SCEPTRE code or product	Rate of product	Ring spot (% leaf area)	Downy mildew (% leaf area)	Light leaf spot (% leaf area)
1	Untreated	-	10.37	0.33	0.23
2	Signum	1.0 kg/ha	**0.54**	0.04	0.10
3	SF2012-BRA-105		**7.71**	0.01	0.05
4	SF2012-BRA-98		10.93	0.19	0.06
5	SF2012-BRA-49		**7.30**	0.27	0.09
6	SF2012-BRA-38		**6.65**	0.32	0.06
7	SF2012-BRA-43		**6.44**	0.31	0.08
8	SF2012-BRA-40		10.31	0.48	0.21
9	SF2012-BRA-90		**4.21**	**0.05**	0.05
Fpr	-	-	<0.001	0.006	0.07
SED	-	-	0.910	0.137	0.072
LSD	-	-	1.789	0.269	0.141

* treatments that are significantly better than the untreated are shown in bold.

Discussion

Disease levels were low during the first few weeks but severe disease developed in late December. Large numbers of lesions developed on expanded leaves and this caused loss of the oldest heavily infected leaves (and hence decreased disease severity) in early January. The cold weather experienced for the two weeks in late November until mid December is likely have slowed disease progress, with symptoms appearing at least four weeks after infection. The experiments were inoculated by addition of ring spot affected leaves on day 1 and day 22. Ring spot control with Signum was much greater in the biofungicides experiment reflecting more frequent and later applications. This suggests that the ring spot epidemic developed mainly from the second inoculation on day 22. Later phases of infection were also evident by January as young leaves had some small ring spots.

Throughout both trials it was noted that many treatments resulted in higher severities of non target diseases such as downy mildew, alternaria and light leaf spot. However it is thought that this was due to those treatments having excellent ring spot control compared to the untreated and weaker treatments, which made it easier for the non targets to infect.

Lower ring spot severity was found in the final assessment, however this was due to many of the diseased leaves senescing. Nevertheless, small numbers of new lesions were still forming at this late stage which demonstrated the residual activities of some test treatments.

Fungicide

Trials were sprayed on the 30 October 2012, and many of the test treatments were still offering reasonable control at the final assessment on the 10 January. Some of the coded products looked promising (Treatments 4-9), being significantly better than the Signum standard.

Biofungicides

Treatment 9 (SF2012-BRA-90) offered very good control, reducing ring spot severity by 73% compared to the untreated, however this treatment was identified as causing phytotoxic effects to the crop.

Treatments 3 (SF2012-BRA-105), 5 (SF2012-BRA-49), 6 (SF2012-BRA-38) and 7 (SF2012-BRA-43) looked promising, offering 30-44% disease control. Further work with more extended treatment regime and in mixtures is required to develop programmes for commercial use.

1.3 Assessment of the efficacy of several fungicides against rust on leek

One replicated trial was conducted in 2012 in an unheated polytunnel at ADAS Boxworth to screen fungicides for the control of rust of alliums (*Puccinia allii*) on leeks cv. Darwin F1. The results obtained were compared with an untreated control and an industry standard fungicide Amistar (azoxystrobin).

Fungicides were applied as single sprays and allowed to dry before inoculation the same day. Treatments are listed below.

Inoculation was repeated three times on 22 August, 4 September and 18 September 2012.

1.3.1. Fungicides evaluated for control of *Puccinia allii* on leeks 2012

Treatment number	SCEPTRE code	Product	Rate of product	Active ingredient	Timing
1	Untreated	Untreated			
2	Amistar	Amistar	1.0 L/ha	Azoxystrobin	Day 0
3	SF2012-LEE-27				Day 0
4	SF2012-LEE-46				Day 0
5	SF2012-LEE-10				Day 0
6	SF2012-LEE-25a				Day 0
7	SF2012-LEE-24				Day 0
8	SF2012-LEE-118				Day 0
9	SF2012-LEE-31				Day 0
10	SF2012-LEE-127				Day 0

Results

Table 1.3.2. Effect of fungicides on *Puccinia allii* at 49, 55 and 63 days after the 1st inoculation – ADAS Boxworth, 2012

Treatment	Product name or code	Incidence of rust (% plants)		Incidence in Upper Leaf (% plants)	Severity in Upper Leaf (% leaf area)
		49 days	55 days	63 days	63 days
1	Untreated	44	74	72	1.07
2	Amistar	11	**25**	**38**	**0.42**
3	SF2012-LEE-27	28	**45**	**53**	**0.63**
4	SF2012-LEE-46	21	**30**	**51**	**0.43**
5	SF2012-LEE-10	3	**10**	**18**	**0.13**
6	SF2012-LEE-25a	31	**41**	62	0.71
7	SF2012-LEE-24	41	**57**	78	1.64
8	SF2012-LEE-118	20	**43**	**51**	**0.66**
9	SF2012-LEE-31	25	**50**	61	0.85
10	SF2012-LEE-127	35	**60**	70	1.38
Probability (F value)		0.10	**<0.01**	**0.02**	**0.03**
LSD vs. treatment (31` d.f.)		0.15	0.12	0.16	0.42
LSD vs. untreated (31 d.f.)		0.13	0.10	0.14	0.36

* treatments that are significantly better than the untreated are shown in bold.

- There were significant differences in incidence and % severity for many treatments when compared to the untreated with the best performer being SF2012-LEE-10.

Discussion

Disease pressure was low, and although not a stern test of the products this data can be compared to similar practical situations. A better assessment of disease control could have been made if incidence was higher but five promising fungicides were noted and warrant further testing. All fungicides significantly reduced *Puccinia allii* incidence 55 days after the first inoculation, and five fungicides continued to significantly reduce incidence and % severity of disease at 63 days post inoculation. SF2012-LEE-10 gave the best control of rust throughout the trial with SF2012-LEE-27, SF2012-LEE-46, SF2012-LEE-118 and the commercial standard, Amistar also significantly reducing both incidence and severity of the disease.

1.4 Assessment of the efficacy of several fungicide and biofungicide programmes against dark leaf spot in brassica crops

Two trials were carried out in summer 2012 at ADAS Boxworth to screen fungicide and biofungicide programmes for the control of dark leaf spot (*Alternaria brassicicola*) on Chinese cabbage seedlings cv. Bilko. The results obtained were compared with an untreated control and an industry standard fungicide program containing Signum and Rudis.

Fungicides and biofungicides were applied as detailed in the table below. Inoculation was carried out 7 and 14 days after the first biofungicide application. Treatments were applied in the morning and allowed to dry before inoculation later the same day. Treatment details are listed in the second table.

Table 1.4.1. Programmes of fungicides and biofungicides examined for control of dark leaf spot on brassica - 2012

Treatment number	Timing 1 Day -7	Timing 2 Day 0	Timing 3 Day +7	Timing 4 Day +14	Timing 5 Day + 28
1	-	Untreated	-	Untreated	Untreated
2 (standard)	-	Signum	-	Rudis	Signum
3	-	Rudis	-	Nativo 75 WG	Rudis
4	-	Nativo 75 WG	-	Rudis	Nativo 75 WG
5	-	SF2012-BRA-28	-	Signum	SF2012-BRA-28
6	-	SF2012-BRA-24	-	Rudis	SF2012-BRA-24
7	-	SF2012-BRA-25a	-	SF2012-BRA-28	SF2012-BRA-25a
8	Untreated	Untreated	Untreated	Untreated	Untreated
9	SF2012-BRA-06	SF2012-BRA-06	SF2012-BRA-06	SF2012-BRA-06	SF2012-BRA-06
10	SF2012-BRA-49	SF2012-BRA-49	SF2012-BRA-49	SF2012-BRA-49	SF2012-BRA-49**
11	SF2012-BRA-40	SF2012-BRA-40	SF2012-BRA-40	SF2012-BRA-40	SF2012-BRA-40
12	Untreated	Untreated	Signum#	Untreated	Untreated
13	SF2012-BRA-06	SF2012-BRA-06	Signum#	SF2012-BRA-06	SF2012-BRA-06
14	SF2012-BRA-49	SF2012-BRA-49	Signum#	SF2012-BRA-49	SF2012-BRA-49
15	SF2012-BRA-40	SF2012-BRA-40	Signum#	SF2012-BRA-40	SF2012-BRA-40

applied at first sign of disease (not necessarily 7 days).

Plants were inoculated on day 0 and day 7.

Table 1.4.2. Detail of fungicides and biofungicides evaluated for control of dark leaf spot on brassica - 2012

SCEPTRE Code	Product	Rate of product	Active Ingredient	Application date
Signum	Signum	1.0 kg/ha	Boscalid and pyraclostrobin	as detailed in previous table
Rudis	Rudis	0.4 kg/ha	Prothioconazole	as detailed in previous table
Nativo 75 WG	Nativo 75 WG	0.3 kg/ha	Tebuconazole and trifloxystrobin	as detailed in previous table
SF2012-BRA-28				as detailed in previous table
SF2012-BRA-24				as detailed in previous table
SF2012-BRA-25a				as detailed in previous table
SF2012-BRA-06				as detailed in previous table
SF2012-BRA-49				as detailed in previous table
SF2012-BRA-40				as detailed in previous table
SF2012-BRA-06				as detailed in previous table
SF2012-BRA-49				as detailed in previous table
SF2012-BRA-40				as detailed in previous table

Results

Table 1.4.3. Effect of fungicides and biofungicides on dark leaf spot at 7 and 43 days after the first inoculation – ADAS Boxworth, 2012

		Incidence (% plants affected)		Severity (% leaf area)	
		7 days	43 days	7 Days	43 days
Number	Treatment				
1+ 8	Untreated	97	100	0.030	1.850
2	Signum/Rudis	75	**20**	**0.010**	**0.002**
3	Rudis/Nativo 75 WG	**60**	**5**	**0.007**	**0.003**
4	Nativo 75 WG/Rudis	**70**	**5**	**0.007**	**0.0**
5	SF2012-BRA-28/ SF2012-BRA-46	**65**	**5**	**0.010**	**0.002**
6	SF2012-BRA-24/ SF2012-BRA-27	75	**5**	**0.011**	**0.003**
7	SF2012-BRA-25a/ SF2012-BRA-28	**55**	**5**	**0.015**	**0.0**
9	SF2012-BRA-06	90	80	**0.013**	**0.250**
10	SF2012-BRA-49	95	95	**0.018**	**0.440**
11	SF2012-BRA-40	100	100	0.020	**1.070**
12	Untreated + Signum	97	**50**	0.030	**0.040**
13	SF2012-BRA-06 + Signum	85	**10**	**0.012**	**0.003**
14	SF2012-BRA-49 + Signum	85	**30**	**0.015**	**0.023**
15	SF2012-BRA-40 + Signum	95	**60**	0.019	1.22
Probability (F value)		0.011	<.001	0.014	<.001
LSD vs. treatment (44 d.f.)		28.61	26.99	0.0129	0.8396
LSD vs. untreated (44 d.f.)		23.36	23.37	0.0106	0.7272

* treatments that are significantly better than the untreated are shown in bold.

- Disease pressure was moderate. The number of spots on individual plants ranged from 80 (untreated) to zero or near zero on the best fungicide treatments.

- Among the fungicide treatments, after 3 weeks there were significant differences in % leaf area affected when compared with the untreated plots for programmes alternating the products Signum and Rudis (standard), Rudis and Nativo 75WG, SF2012-BRA-28 and SF2012-BRA-46, SF2012-BRA-24 and SF2012-BRA-47, and SF2012-BRA-25a and SF2012-BRA-28 at 7 days and 43 days post inoculation.
- Alternating Nativo 75WG and Rudis, and SF2012-BRA-25a and SF2012-BRA-28 were the best performing fungicide combinations when applied alternately.
- Among the biofungicide treatments, there were significant differences in % leaf area affected at 43 days post inoculation compared with the untreated programme, where SF2012-BRA-06, SF2012-BRA-49 & SF2012-BRA-40 were applied at seven day intervals at five spray timings.
- SF2012-BRA-06 and SF2012-BRA-49 sprayed as a single spray programme performed best.
- The application of Signum as a single spray at the first sign of disease significantly increased the efficacy of the biological programmes when included at the second spray timing. Programmes containing SF2012-BRA-06 and SF2012-BRA-49 and Signum significantly reduced incidence of dark leaf spot at 7 and 43 days after inoculation.

Discussion

Disease pressure was moderate, and although not a stern test of the products this data can be compared to similar practical situations. Programmes alternating the products Signum and Rudis (standard), Rudis and Nativo 75WG, SF2012-BRA-28 and SF2012-BRA-46, SF2012-BRA-24 and SF2012-BRA-47, and SF2012-BRA-25a and SF2012-BRA-28 gave good control of dark leaf spot at this disease pressure.

The biological programmes also gave significant control of the % leaf area affected of the dark leaf spot at 7 days after inoculation, but did not significantly reduce incidence at this time. The addition of Signum at the second application timing improved the control of incidence and % leaf area affected significantly at both 7 and 43 days post inoculation, when used alongside SF2012-BRA-06 and SF2012-BRA-49.

1.5 and 1.6 Assessment of the efficacy of several insecticides and bio-insecticides against currant-lettuce aphid and caterpillar on lettuce

Eight replicated trials (four for insecticides and four for bio-insecticides) were conducted in 2012 to evaluate the efficacy of insecticides in an IPM programme for the control of currant-lettuce aphid (plants infested artificially) and caterpillars on lettuce. The insecticides applied were compared with untreated controls and a standard treatment Movento (spirotetramat), for aphid control, applied at the recommended rate.

Table 1.5.1. Insecticide and bio-insecticide products examined for control of currant-lettuce aphid and caterpillar on lettuce – Wellesbourne, 2012

Code[1]	Treatments (aphid)	Treatments (Caterpillar)
C1	Untreated	Untreated
C2	Movento	SI2012-LET-140
C3	SI2012-LET-50	Untreated
C4	SI2012-LET-54	SI2012-LET-48 (2 reps) SI2012-LET-140 (2 reps)
C5	SI2012-LET-59	SI2012-LET-48 (2 reps) SI2012-LET-140 (2 reps)
C6	SI2012-LET-60	SI2012-LET-48 (2 reps) SI2012-LET-140 (2 reps)
B1	Untreated	Untreated
B2	SI2012-LET-62	SI2012-LET-94 (2 reps) SI2012-LET-51 (2 reps) SI2012-LET-68 (2 reps)
B3	SI2012-LET-130	SI2012-LET-130 (6 reps)
B4	SI2012-LET-51	SI2012-LET-94 (2 reps) SI2012-LET-51 (2 reps) SI2012-LET-68 (2 reps)
B5	SI2012-LET-92	SI2012-LET-94 (2 reps) SI2012-LET-51 (2 reps) SI2012-LET-68 (2 reps)

[1] C = insecticide and B = bio-insecticide.

Results

No caterpillars were observed and therefore none of the caterpillar treatments were applied. Numbers of aphids were generally extremely low and their distribution was very uneven. Analysis showed that there were no statistically significant treatment effects. Mean numbers of aphids per plot are summarised (Table 1.5.2).

Table 1.5.2. Effect of insecticides and bio-insecticides on currant-lettuce aphid on lettuce – Wellesbourne, 2012

Insecticide treatments	Mean number of aphids per plot		
	Trial 1	Trial 3	Trial 4
Untreated	2.5	4.5	1
SI2012-LET-75	3	0.8	2
SI2012-LET-50	1	27.3	2
SI2012-LET-54	4	11.5	1.5
SI2012-LET-59	0.8	27	1
SI2012-LET-60	2.5	13.5	0.8
Probability	0.42	0.10	0.78

Bio-insecticide treatments	Mean number of aphids per plot	
	Trial 3	Trial 4
Untreated	70.7	8.5
SI2012-LET-62	70.5	14.5
SI2012-LET-130	80.0	11.8
SI2012-LET-51	156.3	13.2
SI2012-LET-92	132.2	7.7
Probability	0.48	0.16

Discussion

The very wet weather had adverse effects on colonisation of the trials by pest insects. Numbers of aphids were generally low and colonies of *N. ribisnigri* did not develop consistently across trials, so the results are difficult to interpret. The trials were not colonised by caterpillars.

1.7 Assessment of the efficacy of several insecticides and bio-insecticides against onion thrips on leek

Two replicated trials (one for insecticides and one for bio-insecticides) were conducted in 2012 to evaluate the efficacy of insecticides for the control of onion thrips on leek. The results obtained were compared with untreated controls and the trial protocol was validated by inclusion of a standard treatment, Tracer (spinosad), applied at the recommended rate. Four applications of all treatments were made at fortnightly and weekly intervals for insecticides and bio-insecticides respectively.

Table 1.7.1. Detail of treatments examined for control of onion thrips on leek – Wellesbourne, 2012

Treatment	SCEPTRE code	Product	UK rate of product	Dosage rate a.s.	Application timing
C1	Untreated	Untreated	-	-	-
C2	Tracer	Tracer	200 ml/ha	96 g/ha	A1 - 4
C3	SI2012-LEE-48				A1 - 4
C4	SI2012-LEE-50				A1 - 4
C5	SI2012-LEE-54				A1 - 4
B1	Untreated				-
B2	SI2012-LEE-62				B1 - 4
B3	SI2012-LEE-130				B1 - 4
B4	SI2012-LEE-62				B1 - 4
B5	SI2012-LEE-130				B1 - 4

[1] C = insecticide and B = bio-insecticide.

The biological treatments were each applied at two water volumes (200 and 1000 l/ha).

Application timings:

A – 10 Aug, 24 Aug, 7 Sept and 21 Sept

B – 10 Aug, 21 Aug, 28 Aug and 31 Aug

Results

Thrips damage was very slight and no valid data were obtained. However, there was moderate damage by leek moth (*Acrolepiosis assectella*) and plots were assessed for this damage and the data were analysed. There were significant efficacy effects using Tracer, SI2012-LEE-48, SI2012-LEE-50, SI2012-LEE-62 (both application volumes) and SI2012-LEE-130 (both application volumes) on leek moth control.

Table 1.7.2. Effect of insecticides and bio-insecticides on leek moth

Insecticide treatments	Mean damage score
Untreated	0.98
Tracer	**0.37**
SI2012-LEE-48	0.58
SI2012-LEE-50	**0.33**
SI2012-LEE-54	0.87
Probability	0.002
LSD (15 df)	0.315

Bioinsecticide treatment	Application volume	Mean damage score
Untreated		1.52
SI2012-LEE-62	200 l/ha	**1.14**
SI2012-LEE-130	200 l/ha	**1.09**
SI2012-LEE-62	1000 l/ha	**0.97**
SI2012-LEE-130	1000 l/ha	**1.02**
Probability		0.005
LSD (15 df)		0.278

* treatments that are significantly better than the untreated are shown in bold.

Discussion

Poor weather prevented establishment of a thrips infestation on the crop. Leek moth is an uncommon pest of conventional leek crops in the UK, presumably because it is usually controlled effectively by the insecticides applied to control thrips. In this instance, leek moth damage was sufficient to distinguish between treatments.

1.8a Assessment of the efficacy of several bio-insecticides against cabbage root fly on cauliflower

One replicated trial was conducted in 2012 to evaluate the efficacy of bio-insecticides for the control of cabbage root fly on cauliflower. The results obtained were compared with untreated controls and the trial protocol was validated by inclusion of the standard treatment 'Tracer' (spinosad) applied at the recommended rate. One application of each treatment was made. Treatment 7a was included after plants in treatment 7 were killed by the treatment. The plants were infested artificially (20 cabbage root fly eggs per plant).

Table 1.8.1. Detail of bio-insecticide treatments examined for control of cabbage root fly – Wellesbourne, 2012

	Treatment	Product	UK rate of product	Dosage rate a.s.	Application timing
1	Untreated		-	-	-
2	Tracer	Tracer	12 ml/1000 plants	5.76g/1000 plants	A2
3	Tracer	Tracer	12 ml/1000 plants	5.76g/1000 plants	A1
4	SI2012-CAU-65			-	A3
5	SI2012-CAU-65			-	A1
6	SI2012-CAU-130			-	A3
7	SI2012-CAU-130			-	A1
7a	SI2012-CAU-130			-	A3
8	SI2012-CAU-93			-	A2
9	SI2012-CAU-93			-	A3
10	SI2012-CAU-57			-	A3
11	SI2012-CAU-57			-	A1

Application timings:

A1 – At sowing

A2 – Pre-transplant

A3 – 8 days post-transplant (after egg inoculation)

Results

The trial is ongoing and full results will follow upon completion. Initial observations suggest that Tracer is as effective when applied at sowing as it is when applied pre-transplanting. SI2012-CAU-130 provided good levels of control when applied after egg inoculation as either a granular (Treatment 6) or liquid (Treatment 7a) formulation, but when incorporated into the compost at sowing (granular formulation) it was extremely phytotoxic, killing all plants.

Discussion

Only one of the bio-insecticides tested appears to offer any significant control of cabbage root fly larvae regardless of application timing. Although persistence could be a factor all of the treatments tested, amongst other application timings, were applied immediately after a single inoculation of eggs. Assuming all of the treatments are potential cabbage root fly killers it is clear that application timing or technique needs to be refined.

1.8b Assessment of the efficacy of insecticides and bio-insecticide programmes against brassica pests

Two replicated trials (one for insecticides and one for bio-insecticides) were conducted in 2012 to evaluate the efficacy of insecticides in an IPM programme for the control of cabbage root fly, caterpillars and aphids on Brussels sprout. The results obtained were compared with untreated controls and the trial protocol was validated by inclusion of the standard treatments (Tracer for cabbage root fly, Steward for caterpillars and Movento for aphids) applied at recommended rates.

The aim was to treat each plot for cabbage root fly, aphids and caterpillars. A summary of the treatments is below.

Table 1.8.2. Insecticide and bio-insecticide programmes examined for control of pests on Brussels sprout – Wellesbourne, 2012

	Target pest/product		
Code[1]	Cabbage root fly	Aphids	Caterpillars
C1	None	None	None
C2	<u>Tracer</u>	<u>Movento</u>	<u>Steward</u>
C3	<u>Tracer</u>	<u>Movento</u>	None
C4	<u>Tracer</u>	SI2012-BRU-54	SI2012-BRU-48 (2 reps) SI2012-BRU-143 (2 reps)
C5	<u>Tracer</u>	SI2012-BRU-60	SI2012-BRU-48 (2 reps) SI2012-BRU-143 (2 reps)
C6	SI2012-BRU-55	SI2012-BRU-59	SI2012-BRU-48 (2 reps) SI2012-BRU-143 (2 reps)
C7	SI2012-BRU-50	None	None
B1	SI2012-BRU-155	None	None
B2	SI2012-BRU-155	SI2012-BRU-01	SI2012-BRU-64 (2 reps) SI2012-BRU-68 (2 reps) SI2012-BRU-93 (2 reps)
B3	SI2012-BRU-155	SI2012-BRU-92	SI2012-BRU-64 (2 reps) SI2012-BRU-68 (2 reps) SI2012-BRU-93 (2 reps)
B4	SI2012-BRU-155	SI2012-BRU-62	SI2012-BRU-64 (2 reps) SI2012-BRU-68 (2 reps) SI2012-BRU-93 (2 reps)
B5	SI2012-BRU-155	SI2012-BRU-130	SI2012-BRU-130

[1] C = conventional insecticides and B = biological insecticides

Table 1.8.3. Detail of insecticides and bio-insecticides applied for control of insect pests on Brussels sprout

Treatment	SCEPTRE code	Product	UK rate of product	Dosage rate a.s.	Application timing
C1/B1	Untreated		-	-	-
C2,3,4,5	Tracer	Tracer	12 ml/1000 plants	5.76 g/1000 plants	A2
C6	SI2012-BRU-55	-	-	-	A1
C7	SI2012-BRU-50	-	-	-	A2
B1-5	SI2012-BRU-155	-	-	-	A2
C2,3	Movento	Movento	500 ml/ha	75 g/ha	A3
C4	SI2012-BRU-54	-	-	-	A3
C5	SI2012-BRU-60	-	-	-	A3
C6	SI2012-BRU-59	-	-	-	A3
B2	SI2012-BRU-01	-	-	-	A3, A4
B3	SI2012-BRU-92	-	-	-	A3, A4
B4	SI2012-BRU-62	-	-	-	A3, A4
B5	SI2012-BRU-130	-	-	-	A3, A4
C2	Steward	Steward	No caterpillars observed, no spray applied		
C4,5,6	SI2012-BRU-48	-	No caterpillars observed, no spray applied		
C4,5,6	SI2012-BRU-143	-	No caterpillars observed, no spray applied		
B2,3,4	SI2012-BRU-64	-	No caterpillars observed, no spray applied		
B2,3,4	SI2012-BRU-68	-	No caterpillars observed, no spray applied		
B2,3,4	SI2012-BRU-93	-	No caterpillars observed, no spray applied		

Application timing:

A1 – 20 March (Sowing)

A2 – 14 May (pre-transplanting)

A3 – 24 October

A4 – 31 October

Results

Table 1.8.4. Effect of Tracer and two coded insecticides on cabbage root fly on cauliflower – Wellesbourne, 2012

Treatment	Root weight (g)	Root damage score (0 - 5)	Stem damage (0 - 5)
Untreated	1.93	2.17	2.58
Tracer	3.42	**0**	**0.63**
SI2012-BRU-55	2.89	**0.09**	**1.60**
SI2012-BRU-50	2.85	**0**	**0.42**
Probability	0.12	<0.001	<0.001
LSD (2-sided, 12 df)	1.227	0.396	0.528

* treatments that are significantly better than the untreated are shown in bold.

Table 1.8.5. Effect of coded conventional insecticides on cabbage aphid and cabbage whitefly on Brussels sprout – Wellesbourne, 2012

Treatment	Aphid score	Whitefly score
Untreated	0.13	2.66
Movento	0.00	**1.80**
Movento	0.00	**1.39**
SI2012-BRU-54	0.02	**1.47**
SI2012-BRU-60	0.05	**1.14**
SI2012-BRU-59	0.06	**1.78**
SI2012-BRU-50	0.00	2.31
Probability	NS	<0.001
LSD (2-sided, 21 df)		0.608

* treatments that are significantly better than the untreated are shown in bold.

Table 1.8.6. Effect of coded bio-insecticides on cabbage aphid and cabbage whitefly on Brussels sprout – Wellesbourne, 2012

Treatment	Aphid score	Whitefly score
Untreated	0.17	2.10
SI2012-BRU-01	0.11	1.96
SI2012-BRU-92	0.10	2.32
SI2012-BRU-62	0.15	1.88
SI2012-BRU-130	0.14	1.64
Probability (25 df)	NS	NS

The level of pest infestation was high for cabbage root fly. Very wet weather during the summer and early autumn reduced infestation by foliar pests (aphids and caterpillars). Treatments to control aphids were applied very late in the season when numbers increased slightly; no treatments were applied to control caterpillars.

There were significant efficacy effects for treatments Tracer, SI2012-BRU-55 and SI2012-BRU-50 on cabbage root fly control (root damage score) and also for the spray treatments Movento, SI2012-BRU-54, SI2012-BRU-60, and SI2012-BRU-59 for whitefly control. Although no significant differences can be established (due to high numbers of zero values), aphid numbers appear to have been reduced by all of the insecticides. No aphids were observed on any plants treated with Movento or SI-2012-BRU-50. No significant treatment effects were observed on either foliar pest following treatment with the bio-insecticides.

Discussion

All treatments applied for cabbage root fly control reduced root damage considerably and in some cases also reduced stem damage (Tracer, S12012-BRU-50). Despite low numbers of pests and testing weather conditions there is at least some evidence of aphid and whitefly control with the insecticides tested. This could be particularly interesting if the results are repeated for whitefly control as Movento is the only effective treatment currently available.

1.9 Assessment of the selectivity and efficacy of two herbicides in 14 vegetable crops

In a field screening trial in 2012 herbicides SH2012-FVS-76 and SH2012-FVS-123 were applied post-weed-emergence at a range of dose rates in 14 crops: drilled bulb onion, leek, carrot, parsnip, coriander, peas, dwarf French beans, broad beans, mizuna, swede, spinach; transplanted celery, cauliflower and lettuce. Crop safety and weed species controlled in comparison with untreated plots were evaluated. 'Volunteer' potatoes were planted to see whether they might be suppressed by the herbicides.

Herbicide treatments

Both herbicides have residual and foliar activity and were applied post-emergence of the drilled and after transplanting crops, at early post-weed-emergence stage. Herbicides were applied at 2x 'Normal', Normal, ½ Normal dose rates in all crops, except onion and leek where dose rates were Normal, ½ Normal, ¼ Normal. The "Normal" dose rate for SH2012-FVS-76 suggested for this trial was 2.0 L/ha. The "Normal" dose rate suggested for SH2012-FVS-123 post-emergence was a low dose of 1.5 L/ha.

Table 1.9.1. Detail of herbicides examined and their approval status (Dec 2012)

SCEPTRE code	Company	active substance, formulation	EU status	'N' dose rate product	Registered
SH2012-FVS-76	Confidential	Confidential	Pending	2.0 L/ha	**No EU authorisation**
SH2012-FVS-123	Confidential	Confidential formulation of A/B	A and B on approved list of active substances	1.5 L/ha	**UK authorisations pre-emergence**

Low doses of standard pre-emergence herbicides were applied overall on 13 April to carrot, parsnip, onion and leek plots so that these slow-emerging crops, that are uncompetitive at early stages, were not smothered by weeds: Wing-P (1.25) L/ha was applied to onion, leek; Stomp Aqua + Afalon (480 g/L formulation) (1.45 + 1.04) L/ha to carrot and parsnip.

There were two replications. Rainfall was much higher than the long-term average throughout the trial. No irrigation was needed to increase herbicide effects.

Crops were assessed on several occasions for herbicide damage (crop scores, phytotoxicity symptoms, delayed maturity). Herbicide efficacy was also assessed (weed species present on herbicide treated plots compared with numbers of each weed species present on untreated control plots, overall weed control scores).

Table 1.9.2. Detail of crops treated and dates of herbicide application – Lincs, 2012

Sowing dates and herbicide application post-weed emergence dates 2012

Crop (Variety)	Sowing/transplant date	Crop growth stage	Herbicides applied
'Volunteer' potatoes	12 April	1-2 shoots	28 May
Onion (Hystar)	12 April	1 Leaf	28 May
Leek ((Striker)	12 April	1 Leaf	28 May
Carrot (Nairobi)	12 April	2 True Leaves	28 May
Parsnip (Palace)	12 April	1 True Leaf	28 May
Celery transplant (Tango)	16 May	established	2 June
Cauliflower transplant (Marbella)	16 May	established	2 June
Lettuce transplant (Challenge)	16 May	established	2 June
Coriander (Filtro)	16 May	1True Leaf	10 June
Pea (Cabree)	28 May (re-drilled)	2 node	20 June
Dwarf French Bean (Parker)	16 May	simple Leaf	10 June
Swede (Tweed)	7 June (re-drilled)	2 True Leaves	1 July
Mizuna (Early)	7 June (re-drilled)	Poor emergence	1 July
Spinach baby-leaf (Renegade)	16 May	2 expanded True Leaves	10 June
Broad beans (Manita)	16 May	3 node	10 June

(TL – true leaf; L – leaf)

Results

<u>Crop safety</u>

Phytotoxicity symptoms from SH2012-FVS-76 applied post-weed-emergence were leaf necrosis (scorch), followed by severe stunting of sensitive crops.

SH2012-FVS-76 at 2.0 L/ha applied post-weed-emergence was safe to drilled carrot (2 TL), parsnip (1 TL), coriander (1 TL) and transplanted celery; at 1.0 L/ha it was also safe to leek and bulb onion at one leaf stage. No damage effects were seen on carrot or parsnip roots that would reduce quality.

The most sensitive crop was swede, which was killed by SH2012-FVS-76 2.0 L/ha within 7 days, and baby-leaf spinach was also very sensitive. SH2012-FVS-76 at 2.0 L/ha was not safe to: conventional-leaved vining pea, which suffered scorch to 50% of the leaf area 10 days after application followed by severe stunting and plant death or broad bean, 20% leaf blackening and severe stunting. There was less damage to dwarf French beans where leaf margins were scorched but new growth was unaffected and there was some recovery.

Cauliflower transplants were scorched and severely stunted; lettuces were chlorotic, stunted and maturity was delayed.

Component A of SH2012-FVS-123 has mainly foliar activity and phytotoxicity symptoms were yellowing followed by gradual stunting. SH2012-FVS-123 at the low dose of 0.75 L/ha appeared safe to vining peas (2 node stage) and broad beans (3 node stage), causing only slight stunting and delayed flowering at 1.5 L/ha. Although the lowest dose of 0.375 L/ha was safe to bulb onion and leek, the weed control was inadequate. Surprisingly, SH2012-FVS-123 appeared safe to lettuce transplants at 0.75 L/ha.

SH2012-FVS-123 even at low dose rates was very damaging to swede and spinach (initial wilting) and coriander, causing yellowing, followed by stunting and total plant death. Parsnip was also very sensitive showing similar effects, carrots were slightly less sensitive. SH2012-FVS-123 at 3.0 and 1.5 L/ha killed transplanted cauliflower, celery appeared less sensitive. Dwarf French beans were stunted and maturity was delayed.

Very few mizuna emerged, and the plants that did emerge were killed by both SH2012-FVS-76 and SH2012-FVS-123 at all dose rates.

For crop safety there should be no, or negligible/transient damage at a recommended dose rate and no, or acceptable, effects at the ‘overlap’ double dose.

Table 1.9.3. Crop safety: Herbicides applied post-emergence of drilled crops and post-transplanting: √ safe; x not safe, N “normal”

Herbicide ‘Normal’ dose/ha	Onion	Leek	Carrot	Parsnip	Coriander	Celery transplants	Cauliflower transplants	Lettuce transplants	Dwarf Bean	Vining Pea	Swede	Mizuna	Spinach	Broad beans
SH2012-FVS-76 2.0 L	√ ½ N	√ ½ N	√	√	√	√	x	x	x	x	x	x	x	x
SH2012-FVS-123 1.5 L	√ ¼ N	√ ¼ N	x	x	x	x	x	√ ½N	x	√ ½N	x	x	x	√ ½N

Weed control

Weed populations on untreated areas were over 700/m^2 on the earliest drilled plots. In the later drilled/transplanted crops weed populations on untreated areas were lower (47/m^2 to 270/ m^2). On the latest re-drilled peas and swedes, where cultivations had produced a finer seedbed there were more weeds. There were 18 species, including mayweeds, small nettle, knotgrass all at very high populations, and groundsel, redshank, fool's parsley, red dead-nettle, shepherd's purse, fat-hen and chickweed. There were various breeding lines of mustard on the trial area.

SH2012-FVS-76 and SH2012-FVS-123 performed best where applied to small weeds at early growth stages.

SH2012-FVS-76 at 4.0 L/ha controlled all weed species on the trial area. SH2012-FVS-76 at 2.0 L/ha gave excellent control of a high population of mayweeds, small nettle, fat-hen, annual meadow-grass and shepherd's purse. Efficacy on knotgrass, speedwells and fool's parsley was poor, and control of groundsel variable.

SH2012-FVS-123 at 3.0 L/ha applied post-weed-emergence controlled all weed species with the exception of mayweeds. SH2012-FVS-123 gave excellent control of knotgrass, redshank and pale persicaria even at the low dose rate of 0.75 L/ha, due to the foliar activity of component A.

SH2012-FVS-123 at 1.5 L/ha was also effective on shepherd's purse, groundsel, fool's parsley, mustard, fat-hen, chickweed and red dead-nettle. Weaknesses were on mayweeds and small nettle.

Table 1.9.4. Weed control: √ weed species controlled; x poor control or not controlled at the dose rate; √x variable; ## low population; $ limited data

Herbicide post-weed-emergence dose rate L/ha	Mayweeds #	Knotgrass	Groundsel	Fool's parsley	Redshank	Pale persicaria	Mustard	Small nettle	Shepherd's purse	Ivy-leaved speedwell	Field speedwell	Fat-hen	Chickweed	Common poppy $	Red dead-nettle	Field pennycress ##	Annual meadow-grass$
FVS-76 4.0L	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
FVS-76 2.0L	√	x	√x	x	√	√	√x	√	√	x	x	√	√	√	√s	√	√
FVS-76 1.0L	√s	x	x	x	x	x	√x	√	√	x	x	√	√	x	x	√	√
FVS-76 0.5L	x	x	x	x	x		x		√								
SH2012-FVS-123 3.0L	x	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
SH2012-FVS-123 1.5L	x	√	√	√	√	√	√	x	√	√	√	√	√	√	√	√	√
SH2012-FVS-123 0.75L	x	√	x	√	√	√	√	x	√	√	√	√	√	x	√s	√	x
SH2012-FVS-123 0.375L	x	√	x	x	√		X		√								

mainly pineapple weed, some scentless mayweed; s controlled small weeds.

<u>“Volunteer” potatoes</u>

Herbicides were applied when there were 1-2 shoots per potato plant. Post-emergence SH2012-FVS-76 at 4.0 L/ha caused scorch to leaf margins (20% of the leaf area); at 2.0 L/ha 5% scorch and 1.0 L/ha dose had negligible effect. The potatoes recovered and there was no long-term suppression and herbicides did not reduce flowering or berry formation.

Potatoes were severely stunted by post-emergence SH2012-FVS-123 at 3.0, 1.5 and 0.75 L/ha and there appeared to be no further growth following application. There were no flowers or berries and the few small tubers produced were malformed.

Discussion

SH2012-FVS-76 was tested pre-weed-emergence in a previous HDC screen as HDC H1 in FV 256c in 2010. SH2012-FVS-123 was also tested pre-weed-emergence in 2005 but at higher dose rates. In this trial 2012, both were tested post-emergence of drilled crops and post-transplanting. SH2012-FVS-76 has mainly soil residual activity but some contact action. Component A of SH2012-FVS-123 has mainly foliar activity.

In 2012 the high rainfall in the days following application of the herbicides increased the soil residual effect and enhanced efficacy on weeds and control was probably better than could be expected in a ‘normal’ season. High rainfall also increased the risk of herbicide damage to the crops from root uptake and was a stringent test of crop safety.

In a season with high rainfall SH2012-FVS-76 and SH2012-FVS-123, appear to be safe to some vegetable crops on a light, silt loam soil, at the timing and dose rates shown in the table above. Damage will be increased where crops are grown on a sand soil.

Nettles are a nuisance in hand-harvested lettuce, cauliflower and celery. Fool’s parsley and groundsel are contaminants in machine harvested crops (parsley, baby-leaf spinach and mizuna). Several flushes of groundsel have become a problem in some crops following the loss of propachlor. Mayweeds are frequently found in commercial carrot crops. Volunteer potatoes are often a problem in vegetable crops and potato berries are a toxic contaminant in vining pea produce.

- SH2012-FVS-76 at 2.0 L/ha applied post-weed-emergence had potential for drilled carrot, parsnip, coriander and transplanted celery and at 1.0 L/ha for leek and bulb onion. It was also safe to these crops pre-weed-emergence in 2010 trials (HDC project FV 256c) and could be a replacement for linuron in parsnip and carrot. A post-weed-emergence herbicide would be useful for celery grown on organic soils where there are very few herbicide options.

- SH2012-FVS-76 (HDC H1) pre-emergence was promising in peas (and spinach) in 2010, but the post-emergence application in 2012 was not safe in peas, spinach or broad beans, causing severe scorch and stunting.
- SH2012-FVS-76 post-weed-emergence at 2.0 L/ha gave excellent control of some important weed species: mayweeds, small nettle, fat-hen, annual meadow-grass and shepherd's purse and was effective on small groundsel. Efficacy on knotgrass was poor, but post-weed-emergence it performed better on redshank and red dead-nettle than a pre-emergence application tested in previous trials. SH2012-FVS-76 performed best where applied to small weeds at early growth stages. A programme would be needed to control Polygonums and groundsel.
- SH2012-FVS-76 is not authorised yet in the EU (August 2012) however, there is potential for on-label approvals or Extension of Authorisation for Minor Use (EAMU) for some vegetables.
- SH2012-FVS-123 at low dose 0.75 L/ha post-emergence appeared safe to vining peas and broad beans; volunteer potatoes were severely stunted and no flowers or berries were formed. There may be an opportunity for potato berry control in peas post-emergence but further work on dose rates and timing will be needed. The potatoes in this trial were hand planted – in a commercial situation emergence is over a longer period. Residues data at this timing would be required for an EAMU.
- SH2012-FVS-123 at 0.75 L/ha also appeared safe to iceberg lettuce and a foliar-acting herbicide would be useful on organic soils where redshank is a problem. SH2012-FVS-123 applied post-weed-emergence gave excellent control of knotgrass and redshank even at low dose rates due to the foliar activity of component A. SH2012-FVS-123 at 1.5 L/ha was also effective on shepherd's purse and groundsel. Weaknesses were on mayweeds and small nettle. However there is no metabolism data to support use in lettuce.

1.10 Assessment of the efficacy of bandsprayed herbicides against annual weeds in onion and cauliflower

<u>Bulb onion trials</u>

Two replicated trials were conducted in Nottinghamshire and Cambridgeshire to evaluate the efficacy and crop safety of a range of bandsprayed residual herbicides for the control of broad leaved annual weeds in bulb onions. The results obtained were compared with untreated controls and the trial protocol was validated by inclusion of the standard treatment

Stomp Aqua (pendimethalin) applied at commercial rates. One application of each treatment was made. Treatments applied are listed below:

Table 1.10.1. Bandsprayed herbicide treatments applied to onion pre-emergence – Notts & Cambs, 2012

	Over the row			Between rows		
	Product	Rate of product	Dose rate (kg as/ha)	Product	Rate of product	Dose rate (kg as/ha)
1	Untreated	-	-	Untreated	-	-
2	Stomp Aqua	0.63 L/ha	0.29	Stomp Aqua	0.82 L/ha	0.37
3	Stomp Aqua	1.27 L/ha	0.58	Stomp Aqua	1.63 L/ha	0.74
4	Stomp Aqua + Better DF	0.63 L/ha 0.22 kg/ha	0.29 0.14	Stomp Aqua + Better DF	0.82 L/ha 0.28 kg/ha	0.37 0.18
5	Dual Gold	0.31 L/ha	0.29	Dual Gold	0.39 L/ha	0.38
6	Dual Gold	0.61 L/ha	0.59	Dual Gold	0.79 L/ha	0.76
7	Wing-P	0.87 L/ha	0.22+0.19	Wing-P	1.13 L/ha	0.28+0.24
8	Wing-P	1.75 L/ha	0.44+0.37	Wing-P	2.25 L/ha	0.56+0.48
9	Stomp Aqua	0.63 L/ha	0.29	Stomp Aqua + Better DF	1.63 L/ha 0.79kg/ha	0.74 0.51
10	Stomp Aqua	0.63 L/ha	0.29	Stomp Aqua + Defy	1.63L/ha 2.25 L/ha	0.74 1.8
11	Stomp Aqua	0.63 L/ha	0.29	Stomp Aqua + Dual Gold	1.63 L/ha 0.79 L/ha	0.74 0.76
12	Stomp Aqua	0.63 L/ha	0.29	Wing-P + Better DF	2.25 L/ha 0.79 kg/ha	0.56+0.48 0.51
13	Stomp Aqua	0.63 L/ha	0.29	Wing-P + Defy	2.25 L/ha 2.25 L/ha	0.56+0.48 1.80
14	Stomp Aqua	0.63L/ha	0.29	Wing-P + Dual Gold	2.25 L/ha 0.79 L/ha	0.56+0.48 0.76
15	Stomp Aqua	0.63 L/ha	0.29	Wing-P + Dual Gold + Defy	2.25 L/ha 0.79 L/ha 2.25 L/ha	0.56+0.48 0.76 1.80

Cauliflower trials

Two replicated trials were conducted in Lincolnshire to evaluate the efficacy and crop safety of a range of bandsprayed residual herbicides for the control of broad leaved annual weeds in cauliflower. The results obtained were compared with untreated controls and the trial protocol was validated by inclusion of the standard treatment Rapsan + Gamit 36CS (metazachlor + clomazone) applied at commercial rates. One application of each treatment was made. Treatments applied are listed below:

Table 1.10.2. Bandsprayed herbicide treatments applied to cauliflower post-planting – Lincs, 2012

	Over the row			Between rows		
	Product	Rate of product	Dose rate (kg as/ha)	Product	Rate of product	Dose rate (kg as/ha)
1	Untreated	-	-	Untreated	-	-
2	Rapsan + Gamit 36CS	0.25 L/ha 0.04 L/ha	0.12 0.01	Rapsan + Gamit 36CS	1.25 L/ha 0.21 L/ha	0.63 0.09
3	Stomp Aqua	0.48 L/ha	0.22	Stomp Aqua	2.42 L/ha	1.10
4	Dual Gold	0.23 L/ha	0.22	Dual Gold	1.17 L/ha	1.12
5	SH2012-CAU-74	-	-	SH2012-CAU-74	-	-
6	Kerb Flo	0.51 L/ha	0.2	Kerb Flo	2.59 L/ha	1.04
7	Rapsan + Gamit 36CS + SH2012-CAU-74 + Kerb Flo	0.25 L/ha 0.04 L/ha - 0.51 L/ha	0.12 0.01 - 0.2	Rapsan + Gamit 36CS + SH2012-CAU-74 + Kerb Flo	1.25 L/ha 0.21 L/ha - 2.59 L/ha	0.63 0.08 - 1.04
8	Rapsan	0.25 L/ha	0.13	SH2012-CAU-74 + Gamit 36CS	- 0.21 L/ha	- 0.07
9	Rapsan	0.25 L/ha	0.13	SH2012-CAU-74 + Dual Gold	- 1.17 L/ha	- 1.12
10	Rapsan	0.25 L/ha	0.13	SH2012-CAU-74 + Kerb Flo	- 2.59 L/ha	- 1.04
11	Rapsan	0.25 L/ha	0.13	Stomp Aqua + Gamit 36 CS	2.42 L/ha 0.21 L/ha	1.10 0.07
12	Rapsan	0.25 L/ha	0.13	Stomp Aqua + Dual Gold	2.42 L/ha 1.17 L/ha	1.10 1.12
13	Rapsan	0.25 L/ha	0.13	Stomp Aqua + Kerb Flo	2.42 L/ha 2.59 L/ha	1.10 1.04
14	Rapsan	0.25 L/ha	0.13	SH2012-CAU-74 + Gamit 36CS + Kerb Flo	- 0.21 L/ha 2.59 L/ha	- 0.07 1.04

Results

Table 1.10.3. Summary of results for bulb onions – Cambs, 2012

Trt No.	Treatment	Treatment Rate		Assessment - 16th May 2012		
		Rate/treated area	Unit	Plant population/m^2	% Plot weed cover	
1	Untreated			43	59	a
2	Stomp Aqua	1.45	l/ha	42	45	abc
3	Stomp Aqua	2.9	l/ha	39	40	bc
4	Stomp Aqua	1.45	l/ha	43	61	a
	Better DF	0.5	kg/ha			
5	Dual Gold	0.7	l/ha	41	60	a
6	Dual Gold	1.4	l/ha	42	49	ab
7	Wing-P	2	l/ha	43	31	cd
8	Wing-P	4	l/ha	44	11	e
9	Stomp Aqua	1.45	l/ha	46	33	bcd
	Stomp Aqua	2.9	l/ha			
	Better DF	1.4	kg/ha			
10	Stomp Aqua	1.45	l/ha	46	35	bc
	Stomp Aqua	2.9	l/ha			
	Defy	4	l/ha			
11	Stomp Aqua	1.45	l/ha	45	19	de
	Stomp Aqua	2.9	l/ha			
	Dual Gold	1.4	l/ha			
12	Stomp Aqua	1.45	l/ha	46	10	e
	Wing-P	4	l/ha			
	Better DF	1.4	kg/ha			
13	Stomp Aqua	1.45	l/ha	46	4	e
	Wing-P	4	l/ha			
	Defy	4	l/ha			
14	Stomp Aqua	1.45	l/ha	46	9	e
	Wing-P	4	l/ha			
	Dual Gold	1.4	l/ha			
15	Stomp Aqua	1.4	l/ha	45	2	e
	Wing-P	4	l/ha			
	Dual Gold	1.4	l/ha			
	Defy	4	l/ha			
LSD (P=.05)				5.637	14.871	
Standard Deviation				3.945	10.406	
CV				9.02	33.37	
F Probability				0.2778	0.0001	

For T9-T15, Stomp Aqua was applied over the row, the other products between the rows.

Means followed by same letter do not significantly differ (P=.05, Duncan's New MRT)

Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL.

- The amount of annual broad leaved weed was high at both sites.
- Phytotoxicity symptoms and crop vigour differences were observed.
- All of the bandsprayed treatments had significantly less weed cover than the commercial standard at both bulb onion sites.
- No significant differences were found with regard to plant population between bandsprayed and over the top treatments at Farcet Farms, however there was a trend for bandsprayed herbicides to be safer. At Thoresby Home Farm plant populations were significantly lower than the commercial standard in five out of the seven bandsprayed treatments.

Table 1.10.4. Summary of results for Cauliflower (site: PC Tinsley, Holbeach Hurn, Holbeach, Lincolnshire) - 2012

Trt No.	Treatment			Assessment - 27th July 2012			
	Product	Rate/treated area	Unit	% Weed cover		Crop Vigour (1-10) 1= very poor 10= excellent	
1	Untreated Check			93.5	a	0	E
2	Rapsan	1.5	l/ha	0.5	d	9.5	A
	Gamit 36 CS	0.25	l/ha				
3	Stomp Aqua	2.9	l/ha	11.3	b	6.8	D
4	Dual Gold	1.4	l/ha	2.5	cd	8.8	B
5	SH2012-CAU-74	4	l/ha	0	d	10	A
6	Kerb Flo	3.1	l/ha	11.8	b	6.5	D
7	Rapsan	1.5	l/ha	0	d	10	A
	Gamit 36 CS	0.25	l/ha				
	SH2012-CAU-74	4	l/ha				
	Kerb Flo	3.1	l/ha				
8	Rapsan	1.5	l/ha	0	d	10	A
	SH2012-CAU-74	4	l/ha				
	Gamit 36 CS	0.25	l/ha				
9	Rapsan	1.5	l/ha	0	d	10	A
	SH2012-CAU-74	4	l/ha				
	Dual Gold	1.4	l/ha				
10	Rapsan	1.5	l/ha	<0.1	d	10.0	A
	SH2012-CAU-74	4	l/ha				
	Kerb Flo	3.1	l/ha				
11	Rapsan	1.5	l/ha	0	d	10	A
	Stomp Aqua	2.9	l/ha				
	Gamit 36 CS	0.25	l/ha				
12	Rapsan	1.5	l/ha	<0.1	d	10.0	A
	Stomp Aqua	2.9	l/ha				
	Dual Gold	1.4	l/ha				
13	Rapsan	1.5	l/ha	4	c	8.3	C
	Stomp Aqua	2.9	l/ha				
	Kerb Flo	3.1	l/ha				
14	Rapsan	1.5	l/ha	0	d	10	A
	SH2012-CAU-74	4	l/ha				
	Gamit 36 CS	0.25	l/ha				
	Kerb Flo	3.1	l/ha				
LSD (P=.05)				2.913		0.435	
Standard Deviation				2.038		0.304	
CV				23.09		3.56	
F Probability				0.0001		0.0001	

For T7-T14, Rapsan was applied over the row, the other products between the rows.

Means followed by same letter do not significantly differ (P=.05, Duncan's New MRT)

Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL.

- Phytotoxicity symptoms and crop vigour differences were observed.
- All of the bandsprayed treatments were at least as good as the control, whilst applying only 17% of the metazachlor applied in the standard commercial treatment.
- No phytotoxic effects were noted in any of the bandsprayed treatments, however significant reductions in crop vigour were noted in two of the whole plot treatments: 4 L/ha SH2012-CAU-74 and most severely in the combined Rapsan, Gamit 36CS, SH2012-CAU-74 and Kerb Flo treatment at both sites.

Discussion

Bulb onions

The use of targeted relatively high doses of residual herbicides as a band application between planting rows in combination with lower dose rates over the row (10 cm band) has great potential for improving both weed control and crop safety in bulb onions.

In bulb onions weed control was significantly better in the bandsprayed plots than the commercial control and by selecting less water soluble herbicides such as Stomp Aqua and Defy, particularly on lighter soils, crop phytotoxicity can be minimised.

Cauliflower

Restrictions in the use of metazachlor limit its use to 1000 g ai/ha over a three year period. On tight brassica rotations this limits use of this very effective and crop safe residual herbicide to 1 application every 3 years, if used at the commercial rate of 1.5 L/ha. By targeting use just over the crop row (10 cm band) dose rates as low as 0.25 L/ha can be applied, in conjunction with more phytotoxic residual herbicides between the crop rows. Weed control in the bandsprayed plots was at least as good as the commercial standard and no phytotoxicity or loss of vigour was seen. Significant loss of plant vigour was, however, seen in two of the whole plot treatments: SH2012-CAU-74 and Rapsan + Gamit 36CS + SH2012-CAU-74 + Kerb Flo. These two treatments applied between the rows up to 5cm from the plant caused no loss of vigour.

1.11 Assessment of the efficacy of a germinated enhancer against annual weeds

This experiment evaluated the efficacy of a weed seed germination enhancer to stimulate the germination of a range of annual weeds and volunteer crop species to improve the ‘stale seedbed' technique for weed control. The product 'Smoke Master' was applied as a spray to trays of soil sown with seeds of various weeds, and seedling emergence was monitored.

Results

The number of plants per tray was counted on 9 March 2012. A summary of the results are shown in Figure 1.11.1 below. Germination was varied and for fat hen, shepherd's purse and sowthistle it was particularly low. Germination of the oilseed rape was very rapid; however there appeared to be no effect of the smokey water treatment on the germination rate of the oilseed rape compared to the untreated control. The weed species that showed the most response to the smokey water treatment was chickweed, which noticeably germinated quicker in the treated trays and germination levels were higher overall. There was no treatment effect in this particular experiment for charlock, fat hen, groundsel, shepherd's purse, mayweed, sowthistle or annual meadow-grass.

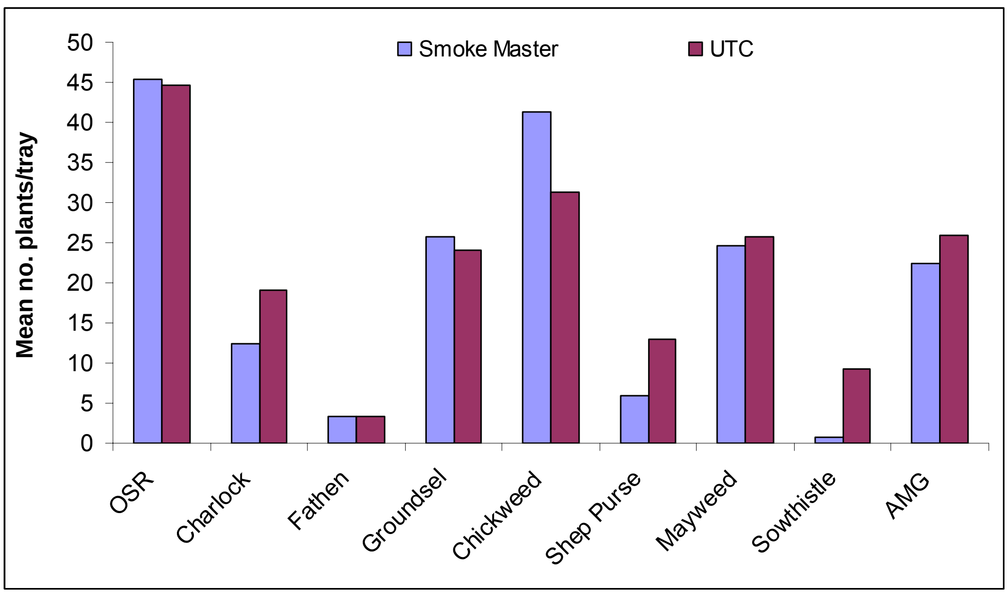


Figure 1.11.1. The mean number of plants per tray eight weeks post application (OSR- oilseed rape, AMG- annual meadow-grass).

Discussion

The results from this experiment show that Smoke Master stimulated germination for chickweed but none of the other weeds or crop species tested. However this is just one glasshouse pot trial and it should be repeated, ideally outside in field conditions. There was only one dose rate trialled so further investigation of dose rate would be advised.

1.12 Assessment of the efficacy of several bioherbicides and one herbicide against some annual and perennial weeds and strawberry runners

This experiment evaluated the efficacy of a range of bioherbicide products and one novel herbicide for control of annual and perennial weed species that are commonly found in horticultural crops, and for control of strawberry runners. A conventional herbicide was included as a standard.

Results

Annual weeds

Bioherbicide SH2012-FVF-116 gave very promising levels of control (Figure 1.12.1) for fat hen, groundsel and, to a lesser extent, redshank. For both groundsel and redshank the assessment 3 weeks after treatment, as opposed to 6 weeks after treatment, has been used as there was natural senescence even in the untreated controls. For shepherd's purse the results show low levels of control from the bioherbicides, however there was protracted and late emergence for this species.

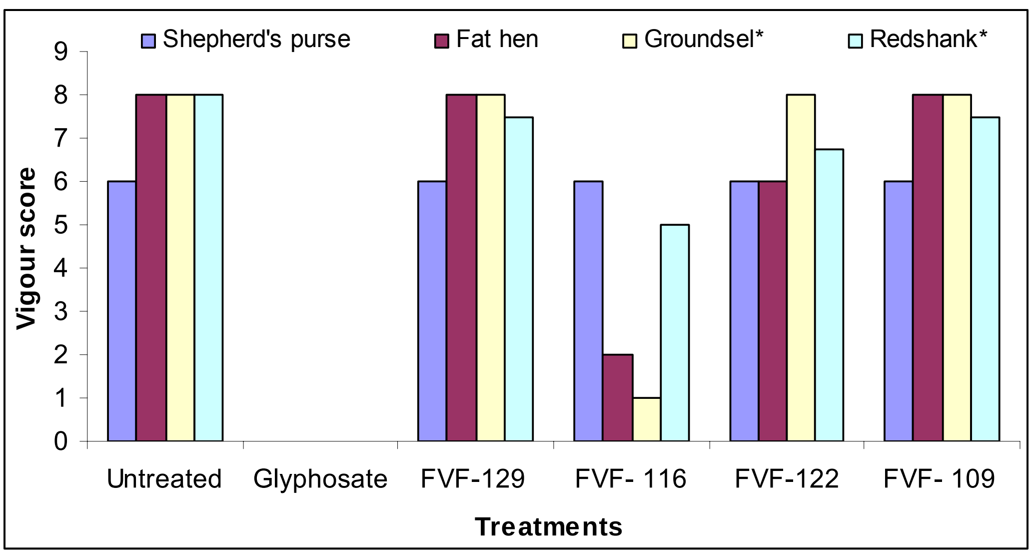


Figure 1.12.1. Vigour score (where 9 = healthy and 0 = dead) for bioherbicide treatments 6 weeks after treatment (WAT) against Shepherd's purse, fat hen, groundsel and redshank (* 3WAT assessment presented).

There was little to no control from the bioherbicides of annual meadow-grass and volunteer potatoes with only glyphosate providing adequate levels of control. Small nettle and knotgrass had very poor germination and were not included in the testing. Results for mayweed and sowthistle are difficult to interpret as germination was very protracted and emergence occurred after the treatments.

Perennial weeds and strawberry runners

Glyphosate gave complete control of dock, thistle and high levels of control to common nettle. The novel herbicide, SH2012-FVF-124, achieved high levels of control from one application and excellent control from a repeated application. The only bioherbicide that controlled dock was SH2012-FVF-116 when applied as a repeated application.

Table 1.12.1. Mean vigour score (0-9 scale, 0=complete kill, 9=healthy) of dock, thistle and nettle six weeks after a single or repeated application of the bioherbicides.

	Dock		Thistle		Nettle	
	Single application	Repeated application	Single application	Repeated application	Single application	Repeated application
Untreated	8	9	7.9	9	8	9
Glyphosate	0	0.5	0	0	1	2
SH2012-FVF-124	3.5	0.5	1.8	1.5	0	0
SH2012-FVF-129	8	9	7.8	8.5	7.5	7.5
SH2012-FVF-116	7.8	1	7.5	3	7.5	4.5
SH2012-FVF-109	7.8	9	7.5	9	7.3	8.5

Discussion

The only bioherbicide that showed a satisfactory level of control for the annual weeds was SH2012-FVF-116. This was particularly effective on fat hen and groundsel. All bioherbicides gave initial scorching symptoms to the annual weeds; however signs of recovery were visible with a few days of application. Even for SH2012-FVF-116 a repeated dose would be required for a complete kill of weeds. There was no control of the annual meadow-grass and volunteer potatoes, despite an initial heavy scorching on the potatoes. Bioherbicides are known to not be as effective on grass weeds, but it was considered useful to include one grass species to test this theory.

As the germination of the annual weeds was over such a protracted period of time it was difficult to target a perfect spray timing. There were therefore seeds still germinating after the spray application which made assessment difficult as weeds had not been tagged. However in a field situation weeds would also be germinating over a period of time and only weeds of a certain growth stage would be controlled, requiring a repeat application. The results for mayweed and sowthistle in particular are not conclusive due to protracted germination, even the standard of glyphosate did not control sowthistle which was unexpected. These weeds in particular would require further screening.

It must be noted that perennial weeds in pots are very different to perennial weeds in the field. The rooting systems in pots are a lot less developed than in the field and therefore pot-grown perennial weeds are an easier target. However the pot trials are an extremely useful starting point for these species to be tested against novel and new products. All efforts were made to ensure the rooting systems were as established as they could be by cutting back the perennial weeds as many times as possible before treating them.

Glyphosate gave extremely high levels of control of docks and thistles, however for common nettle clear signs of re-growth were visible six weeks after treatment. None of the bioherbicides were able to control the perennial weeds or strawberry runners at one application timing only. With a repeated application bioherbicide SH2012-FVF-116 showed very promising levels of control. Novel herbicide SH2012-FVF-124 was extremely good at controlling common nettle, even at a single application. Both thistle and dock were also controlled by SH2012-FVF-124. The strawberry runners showed a quick recovery from SH2012-FVF-124 at a single application and would require at least one repeated application to be effective.

1.13 Field vegetables: Demonstrations of electrical weed control

The novel tractor mounted electrical weeder was demonstrated at Elsoms in June 2012. A shrouded electrode was run between rows of cauliflower to demonstrate the potential for inter-row weed control. Good control of weeds with a high water content was achieved (groundsel, redshank, volunteer potatoes) although more fibrous weeds such as knotgrass were not so well controlled by one pass. This illustrated a need for adjustment according to weed species. Later inspections revealed that any cauliflower plants which had one leaf damaged at the time of the trial later also died.

Trials did highlight limitations with current electrodes. In dense weed situations the voltage will go down the first hit weed with adjacent weeds receiving possibly a non-lethal dose. Further development will look at breaking up the bar and applying a consistent voltage to individual sections

2. Soft fruit

2.1. Assessment of the efficacy of several fungicides against two cane disease of raspberry

One replicated laboratory test was conducted in 2012 to evaluate the efficacy of seven fungicides in plate tests for the control of spur blight (*Didymella applanata*) and cane spot (*Elsinoe veneta*). Growth of the fungi on agar plates amended with the test products was compared with growth on unamended nutrient agar.

Isolates of *Didymella applanata* (spur blight) CBS20763 and *Elsinoe veneta* (cane spot) CBS16429 were obtained from Centraal bureau voor Schimmelcultures, The Netherlands. The fungi were grown on potato dextrose agar. A plug of the test fungus was placed in the centre of a PDA plate amended with the test chemical at concentrations of 0, 2, 20, 200, 2000 ppm. The diameter of the fungal colony was measured after 14 days. Plates were replicated three times.

Table 2.1.1. Fungicides evaluated for control of *Didymella applantata* and *Elsinoe veneta* - 2012

SCEPTRE code or product	Active ingredient(s)	Manufacturer	Content of a.i. nominal	Formulation Type
Untreated	-	-	-	-
Amistar – EAMU approval	azoxystrobin	Syngenta	23.1%	SC
Folicur – EAMU approval	tebuconazole	Bayer	25.9%	Oil emulsion
Signum – EAMU approval	pyraclostrobin + boscalid	BASF	33.4%	WG
Switch – Label approval	cyprodinil + fludioxonil	Syngenta	62.5%	WG
SF2012-RAS-77				
SF2012-RAS-32				
SF2012-RAS-08				

Table 2.1.2. Stock solution preparation for fungicide with 250 g/l active ingredient (Amistar (azoxystrobin), Folicur (tebuconazole)

Amount (250 g/l ai) product per 100 ml	Concentration of fungicide ai in stock solution ppm	Volume of stock solution (ml) to be added to 200 ml PDA	Final concentration of fungicide (ai) in agar (ppm)
0.4 ml	1000 (A)	0.4 ml	2
		4.0 ml	20
40.0 ml	100,000 (B)	0.4 ml	200
		4.0 ml	2000

Results

The results of colony growth of *D. applanata* on amended agar are shown in Table 2.1.3. The fungus grew on PDA amended with fungicide for all the fungicides at a concentration of 2 ppm. At higher concentrations growth was inhibited by all fungicides except Amistar and SF2012-RAS-08

Cultures of *Elsinoe ventata* (cane spot) were very slow growing (1 cm per month on PDA). This work is on-going and will be reported in full in the Year 3 report.

Table 2.1.3. Mean colony diameter (mm) of *Didymella applanata* (spur blight) on PDA amended with various concentrations (ppm) of fungicides tested in December 2012

Fungicide concentration ppm	Amistar	Folicur	Signum	Switch	SF2012-RAS-77	SF2012-RAS-32	SF2012-RAS-08
0	66.3	66.3	66.3	66.3	66.3	66.3	66.3
2	53.8	27.3	31.3	11.0	42.8	50.8	68.0
20	43.7	0	0	0	0	0	11.8
200	46.3	0	0	0	0	0	11.7
2000	45.3	0	0	0	0	0	12.0

Discussion

Signum, Switch, Folicur, SF2012-RAS-77 and SF2012-RAS-32 all reduced mycelial growth of *D. applanata* in culture and look promising to take forward to trials on raspberry. Further laboratory tests will be conducted on other fungicides. The growth of *Elsinoe veneta* was very slow in culture. The use of an alternative growth media for this fungus will be investigated.

2.2 Assessment of the efficacy of several fungicides and biofungicides against crown rot of strawberry

One replicated trial was conducted in 2012 to evaluate the efficacy of three fungicides and four biofungicides for the control of crown rot in strawberry. The results obtained were compared with untreated controls and the trial protocol was validated by inclusion of the standard treatment Paraat (dimethomorph) applied at recommended rates.

Five applications of each treatment were made. Treatments applied are listed below:

Table 2.2.1. Fungicides and biofungicides evaluated for control of strawberry crown rot – East Malling Research, 2012

Treatment	SCEPTRE code or product	UK rate of product	Dosage rate a.s. per litre	Application timing
1	Untreated	-	-	-
2	Untreated	-	-	-
Fungicides				
3	Paraat	1 g/L	0.375 g	26/7
4	SF2012-STR-44			26/7
5	SF2012-STR-24			26/7
6	SF2012-STR-23			26/7
Biofungicides				
7	SF2012-STR-98			26/7, 6/8, 20/8
8	SF2012-STR-105			26/7, 6/8, 20/8
9	SF2012-STR-40			26/7, 6/8, 20/8
10	SF2012-STR-121			26/7, 6/8, 20/8

Results

Table 2.2.2. Mean % plants with crown rot symptoms and mean % dead plants (angular transformed) recorded on strawberry cv. Elsanta following various treatments at East Malling Research in 2012. Figures in parenthesis are back-transformed means

Treatment	Product	Mean % crown rot plants	Mean % dead plants
1	Untreated (combined)	45.1 (50.1)	14.4 (9.0)
Fungicides			
3	Paraat	**38.1** (38.1)	**6.1** (2.6)
4	SF2012-STR-44	41.7 (44.2)	9.4 (4.9)
5	SF2012-STR-24	**38.2** (38.2)	10.5 (5.8)
6	SF2012-STR-23	38.8 (39.3)	10.2 (5.7)
Biofungicides			
7	SF2012-STR-98	**35.1** (33.1)	14.8 (7.9)
8	SF2012-STR-105	44.7 (49.5)	20.3 (13.2)
9	SF2012-STR-40	**31.0** (26.4)	**2.1** (0.9)
10	SF2012-STR-121	42.0 (44.8)	8.8 (4.1)
F Prob		0.007	0.006
SED (54 df)		3.463	2.624
LSD (p=0.05)		6.943	5.260

* treatments that are significantly better than the untreated are shown in bold.

- The amount of crown rot was low - moderate
- No problems were encountered during mixing or application of all of the product formulations under test except for SF2012-STR-105 which was difficult to mix.
- Based on plants with crown rot symptoms there were significant efficacy effects for Paraat, SF2012-STR-24, SF2012-STR-98 and SF2012-STR-40. Based on % dead plants there were significant efficacy effects for Paraat and SF2012-STR-40.

Discussion

Assessments in November based on plants with crown rot symptoms and dead plants have shown that the lowest incidence of symptoms and dead plants was recorded in plots treated with SF2012-STR-40 (biocontrol agent) or Paraat. SF2012-STR-24 and SF2012-STR-98 also looked promising. A final assessment of the crown rot will be done in April 2013 when the plants resume growth.

2.3 Assessment of the efficacy of several fungicides and biofungicides against soft rots of strawberry fruit

One replicated trial was conducted in 2012 to evaluate the efficacy of five fungicides and five biofungicides for control of soft rots caused by *Mucor* and *Rhizopus* in strawberry. The results obtained were compared with untreated controls and the trial protocol was validated by inclusion of the standard treatment Signum (pyraclostrobin + boscalid) applied at recommended rates.

Five applications of each treatment were made. Treatments applied are listed below:

Table 2.3.1. Fungicides and biofungicides evaluated for control of strawberry soft rot – East Malling Research, 2012

Treatment	SCEPTRE code	UK rate of product	Dosage rate a.i. per litre	Application timing
1	Untreated	-	-	-
2	Untreated	-	-	-
Fungicides				
3	Signum	1.8 kg	0.60 kg	1/8, 9/8, 16/8, 23/8, 29/8
4	Switch	1.0 kg	0.625 kg	1/8, 9/8, 16/8, 23/8, 29/8
5	SF2012-STR-77			1/8, 9/8, 16/8, 23/8, 29/8
6	SF2012-STR-25a			1/8, 9/8, 16/8, 23/8, 29/8
7	SF2012-STR-39			1/8, 9/8, 16/8, 23/8, 29/8
Biofungicides				
8	SF2012-STR-146			1/8, 9/8, 16/8, 23/8, 29/8
9	SF2012-STR-105			1/8, 9/8, 16/8, 23/8, 29/8
10	SF2012-STR-99			1/8, 9/8, 16/8, 23/8, 29/8
11	SF2012-STR-40			1/8, 9/8, 16/8, 23/8, 29/8
12	SF2012-STR-06			1/8, 9/8, 16/8, 23/8, 29/8

Results

Table 2.3.2. Effect of various fungicides and biofungicides applied as five sprays from first green fruit on *Mucor/Rhizopus* rot incidence (in post-harvest tests following incubation at ambient temperature for 7 days), plot yield and fruit number in 2012. Data presented for *Mucor* are angular transformed with back transformed means in parenthesis

Treatment	Product	% *Mucor / Rhizopus* fruit rot overall mean for 7 harvests	Total yield Overall mean (kg)	Total fruit number Overall mean
1	Untreated	57.1 (68.8)	8.05	531.3
2	Untreated	53.1 (63.2)	7.46	441.5
Fungicides				
3	Signum	31.5 (27.8)	7.25	435.8
4	Switch	32.5 (29.3)	7.31	420.8
5	SF2012-STR-77	28.7 (23.4)	7.69	455.5
6	SF2012-STR-25a	46.1 (52.1)	6.94	418.0
7	SF2012-STR-39	53.4 (63.6)	7.35	454.0
Biofungicides				
8	SF2012-STR-146	54.4 (65.7)	7.64	517.3
9	SF2012-STR-105	54.9 (66.3)	7.01	420.5
10	SF2012-STR-99	51.4 (60.6)	7.48	527.8
11	SF2012-STR-40	55.1 (66.6)	6.73	442.0
12	SF2012-STR-06	53.1 (63.4)	6.94	445.3
F Prob		<0.001	0.685	0.425
SED (33)		3.732	0.615	57.729
LSD (p=0.05)		7.592	1.252	117.453

- The amount of Mucor / Rhizopus was moderate to high. 66% of isolates were identified as Mucor and 34% as Rhizopus
- No problems were encountered during mixing or application of the product formulations under test except for SF2012-STR-105) which was difficult to mix.
- There were significant efficacy effects for treatments Signum, Switch and SF2012-STR-77 compared to the untreated control.
- It was observed that sprays of Signum were associated with increased levels of Botrytis.

Discussion

Weather conditions were favourable for infection and development of *Mucor* and *Rhizopus* soft rots on strawberry in August and September. The disease was present at low incidence at harvest but developed rapidly to high levels in untreated plots in the post-harvest tests. None of the treatments gave complete control of the soft rot. Signum, Switch and SF2012-STR-77 consistently gave the lowest incidence of soft rots in the post-harvest tests. SF2012-STR-25a showed some reduction in soft rots at some harvests. None of the biofungicides had any effect on the soft rot. It was hoped that these would have given some control of *Mucor / Rhizopus* so that they could have been used in conjunction with the fungicides during the fruiting and harvesting period. Under favourable conditions *Mucor* and *Rhizopus* can colonise and rot fruit very rapidly (within a day). It is likely that the BCAs evaluated are too slow growing to be able to compete with these soft rot fungi. In 2013 programmes of the effective fungicides identified will be evaluated in conjunction with management of rots and ripe fruit at harvest and environmental control.

2.4 Assessment of the efficacy of several insecticides and bio-insecticides against large raspberry aphid on raspberry

One replicated trial was conducted in controlled glasshouse conditions to evaluate the efficacy of three insecticides and three bio-insecticides for the control of large raspberry aphid, *Amphorophora idaei,* in protected raspberry. The results obtained were compared with untreated controls (water) and the trial protocol was validated by inclusion of the standard treatment Calypso (thiacloprid), applied at recommended rates. Four applications of each treatment were made at 7 day intervals. Treatments applied are listed below:

Table 2.4.1. Insecticides and bio-insecticides evaluated for control of large raspberry aphid – James Hutton Institute, 2012

Treatment	SCEPTRE code	Product	UK rate of product	Dosage rate a.s.	Application timing
1 (A)	Untreated (water)		-	-	4 x weekly
Insecticides					
2 (B)	Calypso	Calypso	250 ml/ha	0.05% v/v	4 x weekly
3 (C)	SI2012-RAS-60				4 x weekly
4 (D)	SI2012-RAS-50				4 x weekly
5 (E)	SI2012-RAS-54				4 x weekly
Bio-insecticides					
6 (F)	SI2012-RAS-130				4 x weekly
7 (G)	SI2012-RAS-51				4 x weekly
8 (H)	SI2012-RAS-62				4 x weekly

Results

Summary statistics (treatment means for total numbers of aphids/plant, plotted weekly) are shown in the graph below.

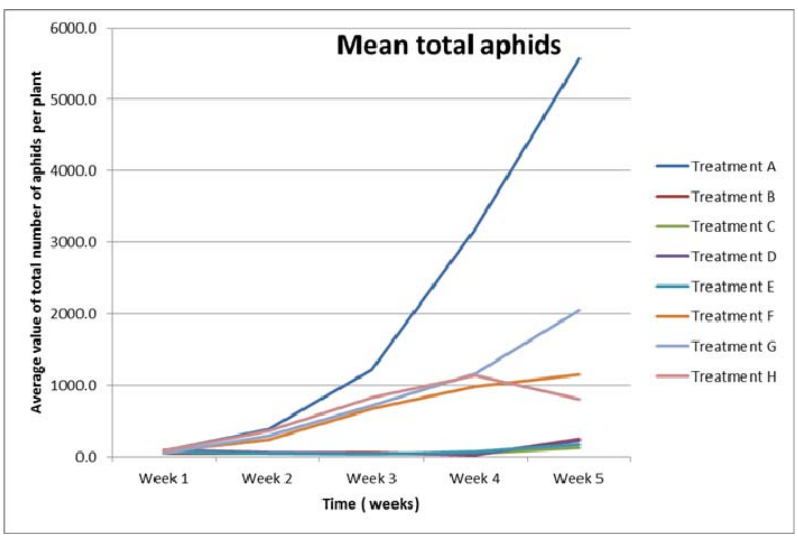


Figure 2.4.1. Effect of insecticides (B-E) and bio-insecticides (F-H) on large raspberry aphid compared with water (A).

- The amount of large raspberry aphid was high due to optimal glasshouse conditions.
- There were significant efficacy effects for conventional insecticide treatments B-E and less but effective control of large raspberry aphid by biopesticide treatments F-H

respectively. Biopesticide G was less effective after 4 weeks, whereas efficacy of other treatments persisted for at least a week after the last treatment application.

Discussion

All three conventional insecticides were effective, giving similar control to the industry standard, Calypso. Two biopesticides, SI2012-RAS-130 and SI2012-RAS-62 were less effective than conventionals but looked promising if they are compatible with biocontrol agents (e.g. parasitoids).

2.5 Assessment of the efficacy of several insecticides against European tarnished plant bug on strawberry

One replicated trial was conducted in 2012 to evaluate the efficacy of insecticides for the control of European tarnished plant bug (*Lygus rugulipennis*) in strawberry. The results obtained were compared with untreated controls and the trial protocol was validated by inclusion of the standard treatment Calypso applied at recommended rates.

Two applications of each treatment were made. Treatments applied are listed below:

Table 2.5.1. Products evaluated for control of European tarnished plant bug – EMR, 2012

Treatment	SCEPTRE code or product	Active ingredient	UK rate of product	Dosage rate a.s.	Application timing (days)
1	Untreated	-	-	-	-
2	Calypso	Thiacloprid	250 ml/ha	1.2 ml/l/ha	0, 14
3	Chess WG	Pymetrozine	400 g/ha	0.2 g/l/ha	0, 14
4	Spruzit	Pyrethrin	24.0 l/ha	0.075 g/l/ha	0, 14
5	SI2012-STR-149				0, 14
6	SI2012-STR-54				0, 14
7	SI2012-STR-60				0, 14
8	SI2012-STR-50				0, 14

Results

Table 2.5.2. Mean total numbers of *Lygus rugulipennis* (all life stages) at intervals after the first spray application of treatments on 27 July (DAA1) and after the second spray application on 10 August (DAA2) (DAA = Days after application)

Product	30 Jul 3DAA1	1 Aug 5DAA1	9 Aug 13DAA1	17 Aug 7DAA2	23 August 13DAA2	**Mean**
			Mean number per cage (n)			
Untreated	12.00	13.00	14.00	18.20	9.00	**13.24**
Calypso	3.58	8.18	9.38	5.18	3.38	**5.94**
Chess WG	6.60	10.60	8.40	10.60	4.40	**8.12**
Spruzit	4.34	3.54	6.34	3.74	7.14	**5.02**
SI2012-STR-149	3.49	5.89	4.89	3.29	1.89	**3.89**
SI2012-STR-54	4.66	8.86	7.26	9.66	7.26	**7.54**
SI2012-STR-60	3.12	4.32	5.92	8.52	6.52	**5.68**
SI2012-STR-50	8.41	8.81	16.01	22.01	8.21	**12.69**
Mean	**5.78**	**7.90**	**9.03**	**10.15**	**5.97**	**7.76**
			$Log_{10}(n+1)$			
Untreated	1.102	1.113	1.128	1.263	0.939	**1.109**
Calypso	0.615	0.815	0.905	0.659	0.512	**0.701**
Chess WG	0.864	1.054	0.938	1.031	0.720	**0.921**
Spruzit	0.682	0.590	0.702	0.557	0.755	**0.657**
SI2012-STR-149	0.576	0.791	0.723	0.481	0.403	**0.595**
SI2012-STR-54	0.726	0.956	0.897	0.983	0.903	**0.893**
SI2012-STR-60	0.576	0.660	0.819	0.907	0.805	**0.754**
SI2012-STR-50	0.890	0.889	1.169	1.312	0.951	**1.042**
Mean	**0.754**	**0.859**	**0.910**	**0.899**	**0.748**	**0.834**

ANOVA TABLE‡	Covariate	Product	Time	Product.Time	Product. Time†
Fprob	0.541	0.025	<0.001	0.013	0.013
SED		0.1485	0.0436	0.1838	0.1237
df		27	99	61	99
LSD (P=0.05)		0.3048	0.0904	0.3836	0.2563

‡ Repeated measures ANOVA, covariance adjusted for pre-treatment total count of all life stages on 25 July (2 days before the first spray applications on 27 July), done on $Log_{10}(n+1)$ transformed data

† When comparing means with the same level of Product

- The numbers of the pest in the cages was high compared to levels commonly seen in the field.
- Phytotoxic symptoms were observed for one treatment or treatment related crop vigour, but no other differences were observed at any of the assessment timings. Note that this product was used at the maximum dose recommended on the label for protected crops, a much higher rate than that used in commercial practice according to the parent company.
- There were significant reductions in the pests for treatments Calypso, Spruzit, SI2012-STR-149 and SI2012-STR-60 (mean numbers 0.657, 0.701, 0.595 and 0.805, respectively).
- Supplementary feeding *Lygus* bugs with dead blowfly larvae, bee collected pollen and an alyssum plant improved the reproduction and survival of the Lygus in the trial compared to 2011.

Discussion

The incidence of the pest was higher than would be expected under field conditions. Calypso, Spruzit, SI2012-STR-149 and SI2012-STR-60 all gave significant levels of control against whole populations (adults and nymphs) (P=0.05, df 99, LSD 0.2563). Spruzit and SI2012-STR-60 give significant levels of control of nymphs (P=0.05, df 99, LSD 0.3065). Spruzit has shown significant phytotoxic symptoms on this strawberry variety (P=0.05, df 38, LSD 1.6375). Note that Spruzit was used at the maximum dose recommended on the label for protected crops, a much higher rate than that used in commercial practice.

2.6 Assessment of the efficacy of four residual herbicides against annual weeds in strawberry

One replicated trial was conducted in March to July 2012 to evaluate the efficacy and crop safety of four residual herbicides for the control of annual weeds in strawberry when applied overall to a main season matted row crop of cv. Symphony. The results obtained were compared with an untreated control. One application of each treatment was made on 2nd March 2012.

Table 2.6.1. Herbicide products examined for control of annual weeds in strawberry – Cambs, 2012

Treatment	Product	Rate of product	Application timing
1	Untreated control	-	-
2	SH2012-STR-74	4.0 L/ha	2 March 2012
3	SH2012-STR-119	0.25 L/ha	2 March 2012
4	SH2012-STR-05	2.0 L/ha	2 March 2012
5	SH2012-STR-76	4.0 L/ha	2 March 2012

Results

Table 2.6.2. Effect of four residual herbicides on populations of annual weeds and fruit yield in strawberry – Cambs, 2012

	Phytotoxicity score 0 = nil 9 = severe 20 June 2012	Weeds/m^2 2 May 2012	Weeds/m^2 20 June 2012	Average yield/plant (g)
1. Untreated control	0.00	7.30	17.40	581
2. SH2012-STR-74	0.00	3.20	6.00	**477**
3. SH2012-STR-119	**3.63**	0.50	10.00	**448**
4. SH2012-STR-05	0.00	0.70	9.20	513
5. SH2012-STR-76	0.00	0.50	7.20	**462**
F. pr	<0.001	NS	NS	0.031
d.f.	12	12	12	12
LSD	0.330	9.800	13.600	83.6

Discussion

- Significant levels of drift and damage to adjacent plots was observed with SH2012-STR-119.
- Phytotoxic symptoms were observed for SH2012-STR-119 at all four assessments. Milder phytotoxic symptoms were observed for SH2012-STR-05 and SH2012-STR-76 at the third assessment date on 2 May 2012 but these were transient and plants recovered by the time harvest began.
- Yield was recorded over a three week period from 29 June to 16 July 2012 and was significantly reduced in plants treated with SH2012-STR-74, SH2012-STR-119 and SH2012-STR-76. Yield was most severely reduced in plots treated with SH2012-STR-119. There were increased levels of rots, misshapen fruit and fruit with leathery

damaged skin, possibly a result of weather damage as the canopy appeared reduced by the phytotoxic affects of this herbicide

- Weed populations were low and consisted predominantly of groundsel (*Senecio vulgaris*). Weed control did not show statistical significance between treatments however all treatments tended to reduce levels of annual weeds compared to the untreated control.

2.7 Assessment of the efficacy of herbicides on perennial weeds commonly found in bush and cane fruit

Three replicated trials were conducted May-August 2012 to investigate the efficacy and crop safety of a range of herbicide products (predominately sulfonylureas), on perennial weed species commonly found in bush and cane fruit. The selected weed species for investigation were creeping thistle (*Cirsium arvense*) and common nettle (*Urtica dioica*).

Three trials were conducted:

1. Investigating the efficacy of the herbicides in controlling nettles and phytotoxic effects on blackcurrant bushes. Treatments were applied on 15 March using a directed spray.
2. Investigating the efficacy of the herbicides in controlling thistles and phytotoxic effects on blackcurrant bushes. Treatments were applied 29 March using a hooded spray.
3. Investigating phytotoxic effects of herbicides on raspberries. Treatments were applied 15 March using a directed spray.

One application of each treatment was made to each of the three trials.

Table 2.7.1. Herbicide products evaluated for control of weeds in blackcurrant and raspberry - 2012

Treatment	Herbicide product	SCEPTRE code	Rate of product
1	Untreated control	-	-
2	-	SH2012-CAF-72	
3	-	SH2012-CAF-102	
4	-	SH2012-CAF-109	
5	-	SH2012-CAF-135	
6	Roundup	Roundup	4 L/ha
7	Shark	Shark	330 ml/ha

Roundup is the standard herbicide treatment used in bush fruit. This provides a useful baseline for efficacy and phytotoxicity.

Results

A 0-9 scale was used to assess herbicide efficacy against the target weed (nettles in trial 1 and thistles in trial 2) and severity of phytotoxic symptoms observed on crop. In weed assessments, 9 represents no effect on weeds and 1 represents death of weeds. In phytotoxic assessments, 9 represents no phytotoxic symptoms and 1 represents very severe phytotoxic symptoms leading to crop death.

Table 2.7.2. Efficacy against nettles and blackcurrant phytotoxicity – 2012 (Trial 1)

Herbicide product	SCEPTRE code	Application date	Nettle efficacy 27 June 2012 (15 WAT)	Phytotoxicity 27 June 2012 (15 WAT)
Untreated control	-		9.00	9.0
-	SH2012-CAF-72	15 March	**0.50**	9.0
-	SH2012-CAF-102	15 March	**2.25**	**7.0**
-	SH2012-CAF-109	15 March	**1.75**	**7.8**
-	SH2012-CAF-135	15 March	**3.50**	9.0
Roundup	Roundup	15 March	**6.50**	9.0
Shark	Shark	15 March	**4.00**	9.0
F.pr (df 18)			0.012	0.004
LSD			4.438	1.111

* treatments that are significantly different from the untreated are shown in bold.

All six herbicides were effective against nettles; SH2012-CAF-72 was particularly effective.

Across all plots, phytotoxic symptoms were mild and only SH2012-CAF-102 caused significant phytotoxic damage to the blackcurrant plants visible 15 weeks after treatment (WAT).

Table 2.7.3. Efficacy against thistles and blackcurrant phytotoxicity – 2012 (Trial 2)

Herbicide product	SCEPTRE code	Application date	Thistle efficacy 27 June 2012 (13 WAT)	Blackcurrant phytotoxicity 27 June 2012 (13 WAT)
Untreated control	-		9.00	9.00
-	SH2012-CAF-72	29 March	**0.75**	9.00
-	SH2012-CAF-102	29 March	**0.50**	**4.75**
-	SH2012-CAF-109	29 March	**6.00**	9.00
-	SH2012-CAF-135	29 March	**5.00**	9.00
Roundup	Roundup	29 March	**8.00**	9.00
Shark	Shark	29 March	8.75	9.00
F.pr (df 18)			<0.001	<0.001
LSD			0.2807	2.849

* treatments that are significantly different from the untreated are shown in bold.

All herbicides, with the exception of Shark had some efficacy against thistles.

Thirteen weeks after application, phytotoxic symptoms were observed only on plots treated with SH2012-CAF-102.

Table 2.7.4. Raspberry phytotoxicity – 2012 (Trial 3)

Herbicide product	SCEPTRE code	Application date	Phytotoxicity 20 April (5 WAT)	Phytotoxicity 17 May (9 WAT)	Phytotoxicity 30 August (24 WAT)
Untreated	-	-	9.00	9.00	9.00
-	SH2012-CAF-72	15 March	9.00	8.33	8.67
-	SH2012-CAF-102	15 March	**6.33**	**5.67**	**5.00**
-	SH2012-CAF-109	15 March	**7.67**	**7.67**	9.00
-	SH2012-CAF-135	15 March	8.33	**7.67**	9.00
Roundup	Roundup	15 March	**7.33**	**7.67**	9.00
Shark	Shark	15 March	8.33	8.33	9.00
F.pr (df 18)			0.001	0.004	<0.001
LSD			1.051	1.307	0.388

* treatments that are significantly different from the untreated are shown in bold.

Mild phytotoxic symptoms were observed in plots treated with SH2012-CAF-102, SH2012-CAF-109 and Roundup at the five-week assessment and again at the nine week assessment. After nine weeks raspberries treated with SH2012-CAF-135 also showed symptoms attributable to phytotoxicity. After four months, all plants had recovered apart from those treated with SH2012-CAF-102 where symptoms had become more severe and presented as yellowing and leaf curling high up in the floricane canopy.

Discussion

- All six herbicides tested were effective against nettles and thistles compared to the untreated control with the exception of Shark which did not significantly affect thistles. SH2012-CAF-72 was particularly effective against both weeds.
- Significant phytotoxic symptoms were observed on blackcurrants and raspberries treated with SH2012-CAF-102. This effect was more distinct at later stages of the trials, after thirteen weeks in blackcurrant and after four months in raspberry.

2.8 Assessment of the efficacy of several bioherbicides and one herbicide against some annual and perennial weeds and strawberry runners

See section 1.12.

2.9 Assessment of the efficacy of electrical weed control against perennial weeds

One trial was conducted in spring 2012 to evaluate the efficacy of electrical weed control using a tractor-mounted, shielded, high power electrode applied to the perennial weed creeping thistle (*Cirsium arvense*) between rows of blackcurrants. Between each treated row of blackcurrants, a single pass of the electrical weeder was made using one of five treatments.

Results

Regardless of treatment, thistles which were tall enough to receive physical contact with the electrode were killed by the electrical weeder. Those which were too small at the time of treatment were unaffected. There were a large number of thistles which emerged after treatment which were also unaffected.

Table 2.9.1. Detail of electrical treatments applied to creeping thistle and their effect on thistle stem number and plant vigour – Norfolk, 2012

Row no.	Tractor speed (km/h)	Electrode arrangement	Mean no. thistles	Mean vigour score*
11	2.4 (medium)	Single	2.2	1.0
12	1.6 (slow)	Single	4.5	2.8
13	3.9 (fast)	Single	3.5	4.8
14	3.9 (fast)	Double	4.3	1.8
15	2.4 (medium)	Double	2.5	3.6
16	-	-	4.0	9.0

*Mean vigour score is the average vigour of all thistles within a 0.1m^2 quadrat. Vigour is scored on a 0-9 scale, 0=dead, 9=healthy.

Discussion

Where the electrode made contact with the thistles they were well controlled. Thistles which did not directly contact the electrode were not controlled. One of the current constraints of the electrical weeder is the speed at which treatment can take place. The results shown here indicate that the length of contact with the electrode is less crucial than the contact itself and therefore it may be possible to further increase the speed of treatment, assuming an electrode could be built to ensure even weed contact. Two electrode arrangements were tested, however the possibilities are many. Keeping in mind that contact is the key to control, further work to develop the most appropriate electrode arrangement is required.

This work did not assess the level of control achieved on the thistle rhizomes; further work is required.

During the experiment a small patch of common nettles (*Urtica dioica*) was also treated. Again, contact with the electrode was more important for control than the length of time in contact. The treated patch of nettles had re-grown 3 weeks after treatment; a better understanding of the level of control below the soil surface is required.

3. Protected edibles

3.1 Assessment of the efficacy of several fungicides and biofungicides against powdery mildew in cucumber

One replicated trial was conducted in 2012 to evaluate the efficacy of six fungicides and seven biofungicides for the control of powdery mildew (*Sphaerotheca fuliginea* syn. *Podosphaera xanthii*) in cucumbers. The results obtained were compared with untreated controls and the trial was validated by inclusion of the standard treatment (Systhane/Systhane/Nimrod in sequence) applied at recommended rates.

Eight applications of biological products and four of conventional products were made. Biological and conventional treatments were spatially separated within the glasshouse in order to minimize any negative effects from conventional products on biological products. The results for biofungicides and fungicides were examined separately. Treatments applied are listed below.

Table 3.1.1. Biofungicide and fungicide treatments evaluated for control of powdery mildew on cucumber - 2012

Trt No.	Treatment	Rate	Rate Unit	Application Dates
1	Uninoculated (Biofungicides)			
2	Inoculated (Biofungicides)			
3	Systhane 20EW	0.375	L/ha	1/6/2012 15/6/2012 11/7/2012
	Nimrod	200	mL/100 L	29/6/2012
Biofungicides				
4	SF2012-CUC-38			
5	SF2012-CUC-134			28/5/2012 1/6/2012 7/6/2012 15/6/2012 21/6/2012 27/6/2012 4/7/2012 10/7/2012
6	SF2012-CUC-115			
7	SF2012-CUC-06			
8	SF2012-CUC-105			
9	SF2012-CUC-90			
10	SF2012-CUC-154			
	SF2012-CUC-154			
Fungicides				
11	SF2012-CUC-08			
12	SF2012-CUC-77			
13	SF2012-CUC-10			1/6/2012 15/6/2012 29/6/2012 11/7/2012
14	SF2012-CUC-14			
15	SF2012-CUC-88			
16	SF2012-CUC-25a			
17	Uninoculated (Fungicides)			
18	Inoculated (Fungicides)			

Treatments 1 and 2 were in the biofungicide section of the glasshouse, treatments 17 and 18 were in the fungicides section. Biofungicides were applied eight times, fungicides four times.

Results

Table 3.1.2. Effect of biofungicides on cucumber powdery mildew – STC, 2012

Pest Name		Powdery mildew		Powdery mildew		Powdery mildew		Powdery mildew		Powdery mildew	
Crop Name		Cucumber		Cucumber		Cucumber		Cucumber		Cucumber	
Part Rated		INOCULATED LEAF		LOWER LEAF		MIDDLE LEAF		UPPER LEAF		PLANT	
Rating Date		14/6/2012		27/6/2012		27/6/2012		27/6/2012		26/7/2012	
Rating Type		PERCENT		PERCENT		PERCEN		COUCOL		PERCEN	
Rating Unit		%		%		%		NUMBER		%	
Sample Size, Unit		1 LEAF		1 LEAF		1 LEAF		1 LEAF		1 LEAF	
Transformation		Arcsine Sq. Root %		Arcsine Sq. Root %		Arcsine Sq. Root %				Arcsine Sq. Root %	
Trt No.	Description										
1	Untreated uninoculated	16.8	a	34.9		13.5	a	18.4		76.8	ab
2	Untreated inoculated	20.8	a	24.8		16.3	a	10.8		82.2	a
4	SF2012-CUC-38	16.2	a	19.0		9.9	ab	12.3		83.2	a
5	SF2012-CUC-134	19.9	a	30.0		9.6	ab	11.2		65.8	b
7	SF2012-CUC-06	19.7	a	33.6		11.9	ab	27.0		82.5	a
8	SF2012-CUC-105	5.2	b	6.3		3.8	b	11.4		81.4	a
9	SF2012-CUC-90	5.6	b	1.9		7.0	ab	1.9		73.5	ab
10	SF2012-CUC-154	7.4	b	15.7		8.4	ab	6.5		78.4	ab
Probability		<0.001		0.124		0.009		0.265		0.027	
LSD (P=.05)		4.8948		26.0771		6.0577		18.8610		10.4474	
Standard Deviation		3.7790		18.2279		4.6768		14.5614		8.0658	
CV		27.05		87.71		46.54		117.37		10.34	

Means followed by same letter do not significantly differ (P=.05, Student-Newman-Keuls).

Data presented is transformed from raw percentage data (arcsine square root percent transformation).

Table 3.1.3. Effect of fungicides on cucumber powdery mildew – STC, 2012

Pest Name	Powdery mildew	Powdery mildew	Powdery mildew	Powdery mildew	Powdery mildew	Powdery mildew
Crop Name	Cucumber	Cucumber	Cucumber	Cucumber	Cucumber	Cucumber
Part Rated	INOCULATED LEAF	LOWER LEAF	LOWER LEAF	MIDDLE LEAF	UPPER LEAF	PLANT
Rating Date	14/6/2012	27/6/2012	23/7/2012	23/7/2012	23/7/2012	26/7/2012
Rating Type	PERCENT	PERCENT	PERCENT	PERCENT	PERCENT	PERCENT
Rating Unit	%	%	%	%	%	%
Sample Size, Unit	1 LEAF	1 LEAF	1 LEAF	1 LEAF	1 LEAF	1 PLANT
Transformation	Arcsine Sq.Root %	Arcsine Sq.Root %	Arcsine Sq.Root %	Arcsine Sq.Root %	Arcsine Sq.Root %	Arcsine Sq.Root %
Trt No. Description						
3 Systhane/Nimrod	9.9 a	6.5 ab	1.2	6.5 ab	10.2 b	9.7 ab
6 SF2012-CUC-115	9.0 a	9.2 ab	17.8	23.8 a	30.7 a	30.5 a
11 SF2012-CUC-08	0.0 b	0.0 b	0.1	0.4 b	0.2 b	2.0 b
12 SF2012-CUC-77	0.0 b	0.0 b	0.3	0.0 b	0.0 b	0.0 b
13 SF2012-CUC-10	0.2 b	1.9 b	0.0	1.4 b	2.6 b	12.2 ab
14 SF2012-CUC-14	0.3 b	2.4 b	0.6	1.6 b	2.0 b	3.9 b
15 SF2012-CUC-88	0.0 b	0.0 b	0.7	1.7 b	4.5 b	2.6 b
16 SF2012-CUC-25a	0.0 b	0.3 b	0.0	0.0 b	0.0 b	0.0 b
17 Untreated Uninoculated	9.9 a	10.9 ab	14.2	15.0 ab	12.4 b	18.7 ab
18 Untreated inoculated	9.4 a	13.9 a	6.1	9.8 ab	18.1 ab	10.6 ab
Probability	<0.001	0.004	0.010	0.019	0.002	0.007
LSD (P=.05)	2.4761	7.5402	11.0871	14.1496	14.5685	15.6865
Standard Deviation	1.9372	5.6962	8.5849	11.0700	11.2805	12.2724
CV	50.0	126.62	209.65	183.72	139.95	136.1

Means followed by same letter do not significantly differ (P=.05, Student-Newman-Keuls).

Data presented is transformed from raw percentage data (arcsine square root percent transformation).

The amount of disease was high in the biological products section of the glasshouse and moderate in the conventional products section of the glasshouse. This was considered to be due to the greater efficacy of the applied conventional products relative to the biological products.

Problems were encountered during mixing of one of the product formulations under test. SF2012-CUC-105 caused a nozzle blockage at the first spray timing, but no further problems were encountered as water rates increased with crop growth. No problems were encountered with any of the other treatments.

Phytotoxicity symptoms were observed with a number of the conventional pesticide treatments after the first spray application (made on 01 June 2012). The standard treatment (Systhane 20EW), SF2012-CUC-14, SF2012-CUC-25a, SF2012-CUC-77, and SF2012-CUC-88 caused slight-moderate phytotoxicity symptoms on the young plants. Subsequent application rates were reduced for some of these treatments.

The results obtained for the standard treatment were as expected therefore this can be considered a valid trial. The standard treatment for powdery mildew in cucumbers was not expected to, and did not provide complete control.

There were significant efficacy effects early in the trial for biological treatments SF2012-CUC-90, SF2012-CUC-105 and SF2012-CUC-154.

There were significant reductions in powdery mildew early in the trial for conventional fungicide treatments SF2012-CUC-08, SF2012-CUC-10, SF2012-CUC-14, SF2012-CUC-25a, SF2012-CUC-77 and SF2012-CUC-88. At the end of the trial, significant efficacy effects were largely lost, due to high levels of variance. However, no disease at all was seen in plots treated with SF2012-CUC-25a and SF2012-CUC-77, compared to low to moderate levels of disease in other plots. This provided a clear demonstration of good efficacy against powdery mildew in this study.

Discussion

None of the biological products tested provided complete control of powdery mildew in cucumbers. However, SF2012-CUC-105 significantly reduced levels of the disease for 1 month following inoculation; SF2012-CUC-90 and SF2012-CUC-105 significantly reduced disease levels for 2 weeks following inoculation and appeared to reduce levels (albeit not significantly) for up to one month; and SF2012-CUC-134 had significantly lower levels of disease at the final assessment date (although still at an unacceptable level for commercial practice). These biological products may provide a useful addition to fungicide programmes where a reduction in conventional product use is desirable.

Some of the conventional treatments (SF2012-CUC-25a and SF2012-CUC-77) kept the crop clean throughout the trial, in contrast to both the standard and untreated plots. SF2012-CUC-08, SF2012-CUC-14 and SF2012-CUC-88 all appeared to reduce levels of powdery mildew at the end of the trial to, on average, less than 1% of leaf area affected, compared with 7-15% in untreated plots. Unfortunately, due to high levels of variance (mostly within untreated plots) these results are not statistically significant.

3.2 Assessment of the efficacy of several fungicides and biofungicides against grey mould in tomato

One replicated trial was conducted in 2012 to evaluate the efficacy of six biofungicides and eight fungicides for the control of grey mould (*Botrytis cinerea*) in tomatoes. The results obtained were compared with untreated controls and the trial was validated by inclusion of the standard treatment (Rovral WG, Switch and Signum in sequential programme) applied at recommended rates.

Fourteen applications of biofungicides and seven of fungicides were made. Biofungicide and conventional fungicide treatments were spatially separated within the glasshouse in order to minimize any effects from fungicides on biofungicide treatments. Results for biofungicides and fungicides were examined separately. Treatments are listed below:

Table 3.2.1. Biofungicide and fungicide treatments evaluated for control of grey mould on tomato - 2012

Trt No.	Treatment	Rate	Rate unit	Application Dates
1	Uninoculated (Biofungicides)			
2	Inoculated (Biofungicides)			
3	<u>Rovral</u>	67	g/100 L	22/8/2012 3/10/2012
	<u>Switch</u>	1.0	kg/ha	5/9/2012 17/10/2012 30/10/2012
	<u>Signum</u>	0.9	kg/ha	19/9/2012 14/11/2012
<u>Biofungicides</u>				
4	SF2012-TOM-105			15/8/2012 22/8/2012 30/8/2012 5/9/2012 11/9/2012 18/9/2012 26/9/2012 2/10/2012 10/10/2012 15/10/2012 22/10/2012 29/10/2012 5/11/2012 12/11/2012
5	SF2012-TOM-35			
6	SF2012-TOM-98			
7	SF2012-TOM-38			
8	SF2012-TOM-40			
9	SF2012-TOM-15			
<u>Fungicides</u>				
10	Signum			22/8/2012 5/9/2012 19/9/2012 3/10/2012 17/10/2012 30/10/2012 14/11/2012
11	SF2012-TOM-14			
12	SF2012-TOM-25a			
13	SF2012-TOM-31			
14	SF2012-TOM-08			
15	SF2012-TOM-77			
16	SF2012-TOM-156			
17	SF2012-TOM-118			
18	Inoculated (Fungicides)			

Treatments 1 and 2 were in the biofungicide section of the glasshouse; treatment 18 was in the fungicide section. Biofungicides were applied 14 times, fungicides seven times.

Results

Table 3.2.2. Effect of biofungicides on tomato grey mould – STC, 2012

		Botrytis disease index (0-100)		
Part Rated		PLOT	PLOT	PLOT
Rating Date		8/11/2012	19/11/2012	6/12/2012
Trt No.	Description			
1	Untreated control - uninoculated	12.5	17.6	19.0
2	Untreated control - inoculated	14.1	16.9	19.1
4	SF2012-TOM-105	10.3	14.3	16.6
5	SF2012-TOM-35	10.5	15.5	16.6
6	SF2012-TOM-98	15.5	18.1	19.7
7	SF2012-TOM-38	12.4	15.5	16.1
8	SF2012-TOM-40	13.6	18.8	17.4
9	SF2012-TOM-15	13.0	17.3	16.8
Probability		0.535	0.857	0.839
LSD (P=.05)		5.3797	6.5399	5.7381
Standard Deviation		4.1534	5.0491	4.4300
CV		32.64	30.17	25.09

Table 3.2.3. Effect of fungicides on tomato grey mould – STC, 2012

		Botrytis disease Index (0-100)					
Part Rated		PLOT C		PLOT C		PLOT C	
Rating Date		8/11/2012		19/11/2012		6/12/2012	
Trt No.	Description						
3	Standard	9.4	a-d	15.5	a	15.4	a
10	<u>Signum</u>	7.7	b-e	9.7	bc	12.6	ab
11	SF2012-TOM-14	9.0	a-e	12.3	abc	13.2	ab
12	SF2012-TOM-25a	**7.6**	cde	10.4	bc	12.2	ab
13	SF2012-TOM-31	8.9	a-e	11.3	abc	11.4	ab
14	SF2012-TOM-08	**6.1**	de	**8.7**	c	**9.4**	b
15	SF2012-TOM-77	11.4	a	14.2	ab	15.5	a
16	SF2012-TOM-156	10.0	abc	12.3	abc	12.8	ab
17	SF2012-TOM-118	**5.9**	e	**7.8**	c	**8.2**	b
18	Untreated control-inoculated	11.1	ab	13.8	ab	15.1	a
Probability		0.02		0.06		0.07	
LSD (P=.05)		3.4499		4.9980		4.9945	
Standard Deviation		2.6991		3.9102		3.9074	
CV		30.99		33.71		31.07	

Means followed by the same letter do not significantly differ (P=.01, LSD). Figures in bold are significantly different from the untreated.

- Biological products were applied weekly, commencing 9 days before inoculation with the pathogen. Conventional products were applied every 14 days, commencing 2 days before inoculation.
- The amount of *Botrytis* infection present was initially low, eventually becoming moderate towards the end of the trial.
- Grey mould was encouraged to establish via a number of methods: sporulating agar plate cultures of *Botrytis cinerea* (a culture pathogenic on tomato as proved in laboratory tests) and infected fruits were placed amongst plots; damaged leaflets were sprayed with a *Botrytis* spore suspension; guard plants were inoculated with agar culture plugs applied to cut leaf stumps; and the crop was regularly sprayed with a *Botrytis* spore suspension.
- Crop husbandry was intentionally poor throughout the trial period in order to stress the crop and encourage disease development.

- The standard treatment (Signum) did not provide any significant level control of *B. cinerea*. This might be due to potential fungicide tolerance or insensitivity in the pathogen population used to inoculate the trial.
- Significant differences were seen between fungicide treatments (SF2012-TOM-25a, SF2012-TOM-08 and SF2012-TOM-118) and untreated plots, but no differences were found between biofungicide treatments and untreated plots.

Discussion

Despite repeated efforts to inoculate the crop with *Botrytis*, and establish grey mould infection on leaves, stems and fruit, symptoms were slow to develop in the crop. Infection did finally develop throughout the crop, mostly beginning as lesions at leaf margins as opposed to lesions beginning at various wound points. Disease pressure seemed to be even throughout the glasshouse.

The standard treatment did not provide any significant level of control of *B. cinerea*. This was perhaps due to potential fungicide tolerance or insensitivity in the *B. cinerea* isolates that were used to inoculate the trial.

Biological products could be expected to provide control against infection for 7-10 days post-application. The final assessment of disease was made 24 days after the final application of biological products at which point we would no longer expect plants to be protected from infection. However, no biological treatments provided control of disease at *any* assessment date when compared to the untreated control plots.

No conventional treatments provided complete or near complete control of disease. However, three conventional products were significantly more effective than the untreated control at the first assessment date (treatments SF2012-TOM-08, SF2012-TOM-25a and SF2012-TOM-118). Treatments SF2012-TOM-08 and SF2012-TOM-118 continued to be significantly effective throughout all three assessment timings.

3.3 Assessment of the efficacy of some insecticides and bio-insecticides against spider mite on tomato

Two replicated trials (Trials 1 and 2) were conducted in 2012 to evaluate the efficacy of conventional chemical and biological treatments against spider mites in glasshouse trials at STC.

<u>Trial 1</u>

The efficacy of two chemical and four biological products against spider mites were compared to a water control. Spider mites were established artificially throughout the crop.

Treatments were first applied at low pest levels as preferred by some of the biological products. Numbers of spider mites in the untreated control increased throughout the trial.

Numbers of eggs and nymphs were recorded in situ on a randomly selected leaf per plant, six plants per plot. At the final assessment, single leaves from each plant were collected and examined under a microscope to record adults, nymphs and eggs.

Table 3.3.1. Details of treatments applied for control of spider mite – STC, 2012 (Trial 1)

Trt No.	Treatment name	Description	Application dates
1	Control		15/5/12, 22/5/12, 29/5/12
2	Oberon	Chemical	15/5/12, 22/5/12,29/5/12
3	SI2012-TOM-62	Biological	15/5/12, 22/5/12, 29/5/12
4	SI2012-TOM-01	Biological	15/5/12, 22/5/12, 29/5/12
5	SI2012-TOM- 92	Biological	15/5/12, 22/5/12, 29/5/12
6	SI2012-TOM-131	Chemical	15/5/12, 22/5/12, 29/5/12

Results and discussion

Figures 3.3.1, 3.3.2 & 3.3.3 show the mean numbers of spider mite adults, nymphs and eggs recorded at the final assessment of the trial. Treatment 2 (Oberon) is a standard product and produced expected levels of control of the pest.

All treatments reduced numbers of spider mite development stages compared to the control plots (Figures 3.3.1, 3.3.2 & 3.3.3).

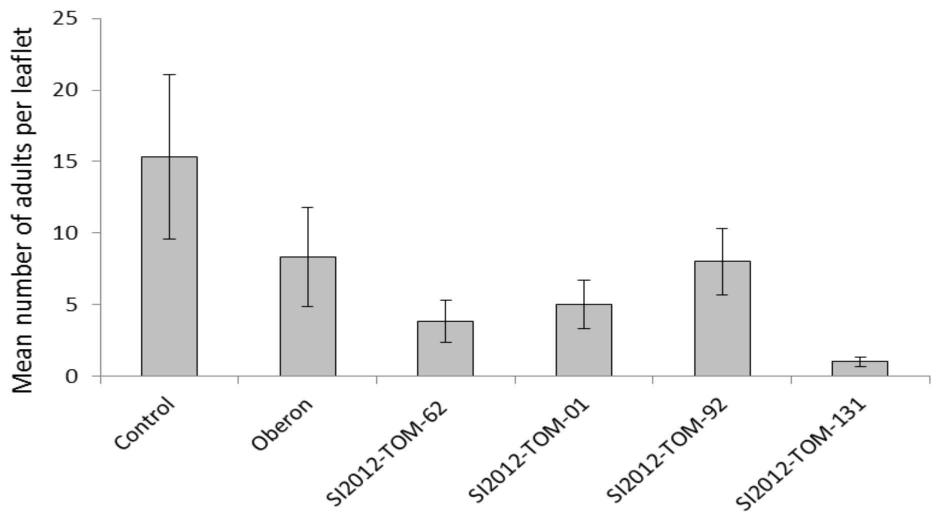


Figure 3.3.1. The mean numbers of adult spider mite per leaflet 7 days after the last of three applications of treatments

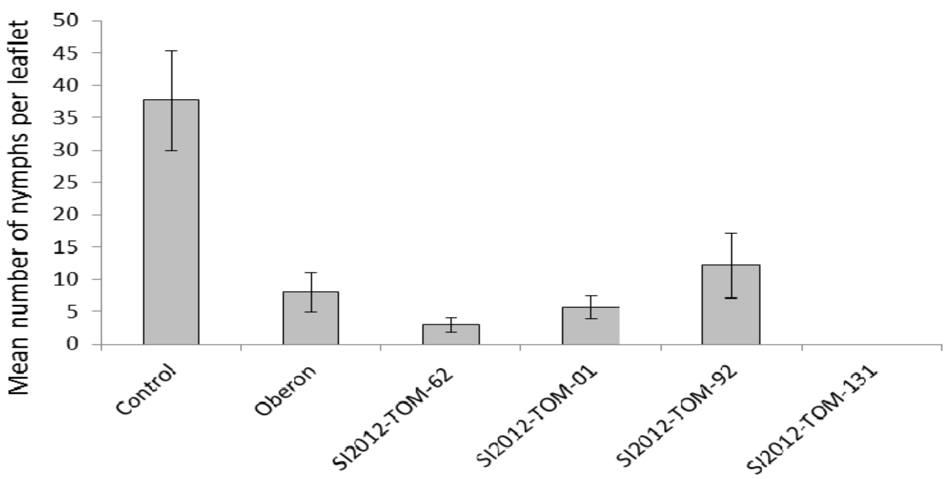


Figure 3.3.2. The mean numbers of spider mite nymphs per leaflet *7* days after the last of three applications of treatments

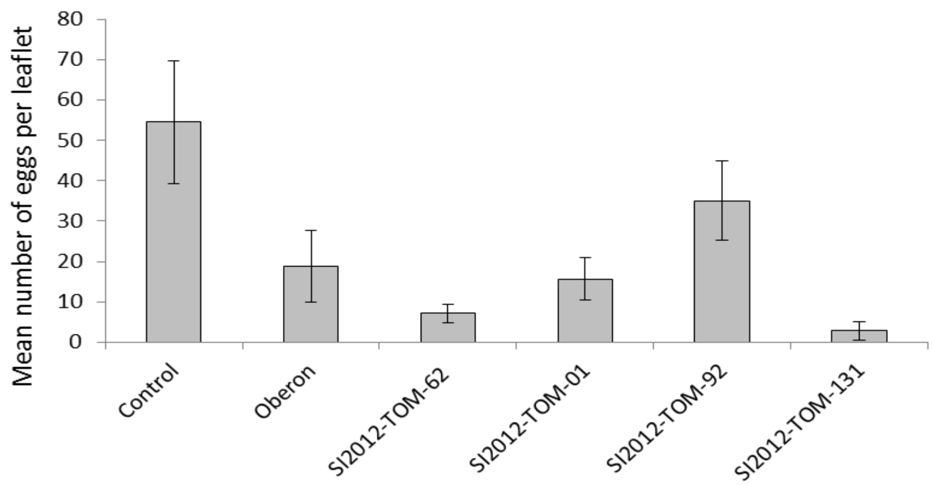


Figure 3.3.3. The mean numbers of spider mite eggs per leaflet *7* days after the last of three applications of treatments

Analysis of the transformed data (square root (n+5)) (Table 3.3.2), shows that all treatments, with the exception of treatment 5 for mean egg numbers, significantly reduced the numbers of nymphs and eggs in comparison to the control (p<0.05).

Table 3.3.2. The mean numbers of surviving adult spider mite after three applications of treatments at seven day intervals

Treatment	Name	Mean adults		Mean nymphs		Mean eggs	
1	Control	15.3	a	37.7	a	54.5	a
2	Borneo	8.3	ab	8.9	bc	18.8	bc
3	SI2012-TOM-62	3.8	bc	3.0	cd	7.2	c
4	SI2012-TOM-01	5.0	bc	5.7	bc	15.7	bc
5	SI2012-TOM-92	8.0	ab	12.2	b	35.0	ab
6	SI2012-TOM-131	1.0	c	0.0	d	2.8	c
	F(probability)	0.0049		0.0001		0.0007	

Means followed by the same letter do not differ significantly (LSD: P<0.05). LSD was performed on transformed data.

Treatment 6 (SI2012-TOM-131) produced the lowest numbers of adults and nymphs and was significantly lower than the standard (Oberon), but this was not significantly different from the biological treatment 3 (SI2012-TOM-62).

Table 3.3.2 shows that biological treatments (3, 4 and 5) were comparable to conventional chemical products, and this maybe because the products were applied when spider mite populations were relatively low in number.

Trial 2

A replicated trial was conducted in 2012 to evaluate the efficacy of six treatments, including two chemical and four biological products compared to a water control. A standard treatment, Borneo (etoxazole) was included.

Table 3.3.3. Detail of treatments applied for control of spider mite – STC, 2012 (Trial 2)

Trt no.	Treatment name	Description	Rate	Application
1	Water	-	-	13/9/12, 20/9/12
2	Borneo	Chemical	35 ml/100 l	13/9/12
3	SI2012-TOM-91	Biological	-	13/9/12, 20/9/12
4	SI2012-TOM-62	Biological	-	13/9/12, 20/9/12
5	SI20I2-TOM-51	Biological	-	13/9/12, 20/9/12
6	SI2012-TOM-131	Chemical	-	13/9/12, 20/9/12
7	SI2012-TOM-92	Biological	-	13/9/12, 20/9/12

Spider mites were introduced in July and established throughout the crop. Treatments were first applied at low pest levels (around10 adults/plant) as preferred by some of the biological products. Numbers of spider mites in the untreated control increased throughout the trial. The standard (Borneo) produced significantly lower numbers of spider mite nymphs and eggs than the control.

Nymphs and eggs were recorded *in situ* on a randomly selected leaf per plant, six plants per plot. At the final assessment leaves were collected and examined under a microscope to record adults, nymphs and eggs.

Due to the numbers of spider mites in the treated plots being very low after a second application, there were no further treatment applications.

The results in Figures 3.3.4, 3.3.5 & 3.3.6, show that all treatments reduced spider mite development stages to lower values than that recorded in the control plots.

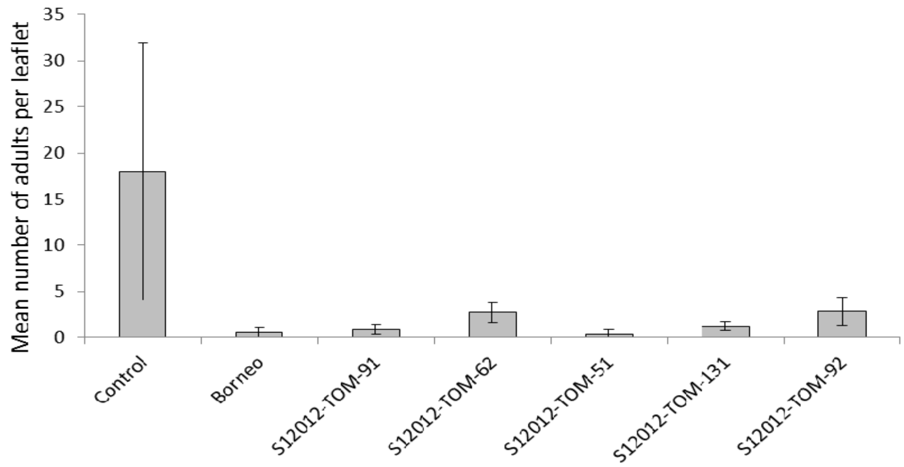


Figure 3.3.4. Mean numbers of adult spider mites per leaflet after two applications of treatments

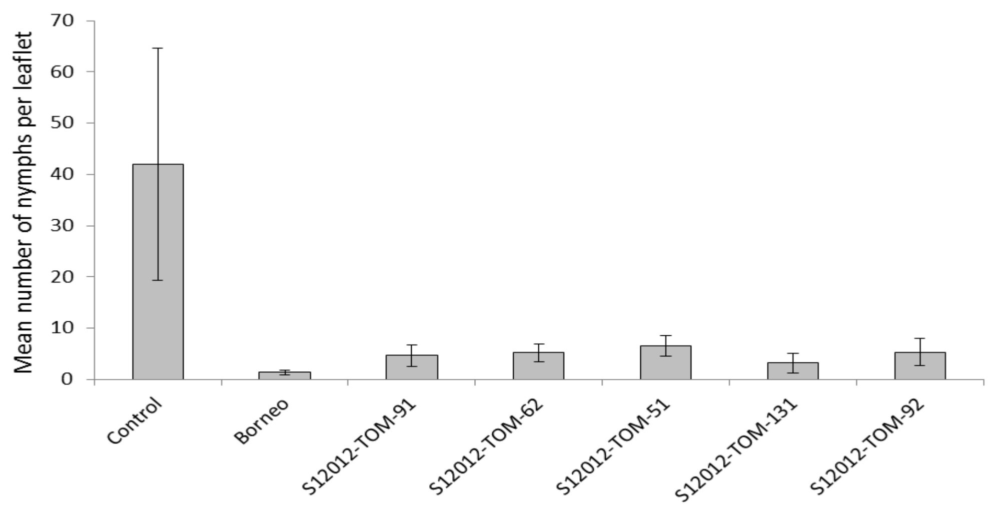


Figure 3.3.5. Mean numbers of spider mite nymphs per leaflet after two applications of treatments

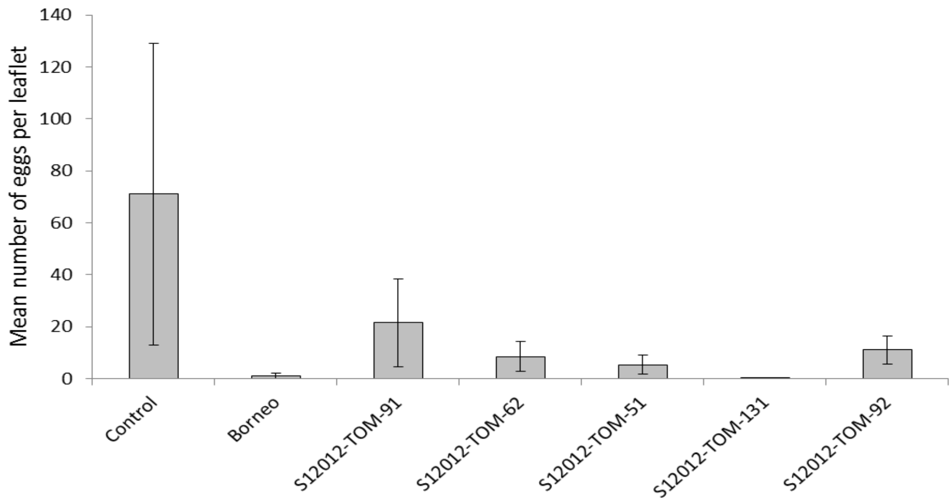


Figure 3.3.6. Mean numbers of spider mite eggs per leaflet after two applications of treatments

Analysis of the transformed data (Log (n+1)), shows that all treatments significantly reduced the numbers of spider mite nymphs in comparison to the control (Table 3.3.4).

Table 3.3.4. Mean numbers of spider mite adults, nymphs and eggs on tomato plants after two applications of treatments in a glasshouse trial

Treatment	Name	Mean no. adults	Mean no. nymphs		Mean no. eggs	
1	Control	18.0	42.0	a	71.0	a
2	Standard [Borneo	0.5	1.3	c	1.0	bc
3	S12012-TOM-91	0.8	4.7	bc	21.5	a
4	S12012-TOM-62	2.7	5.2	bc	8.5	abc
5	S12012-TOM-51	0.3	6.5	b	5.3	abc
6	S12012-TOM-131	1.2	3.2	bc	0.2	c
7	S12012-TOM-92	2.8	5.3	bc	11	a
	F(probability)	0.0570	0.0057		0.0320	

Means followed by a common letter do not significantly differ (LSD: $P<0.05$) LSD was performed on transformed data.

Although the numbers of adults were highest in the control plots, the values were not significantly different ($p>0.05$) from the treatments, higher levels of variability in the adult populations were recorded in the control plots (see Figure 3.3.4).

The biological treatments produced similar levels of control as the conventional chemical products, but this may have been because those treatments were applied whilst spider mite populations remained low in number thereby demonstrating that biological perhaps are most efficacious when applied frequently at low pest densities.

3.4 Assessment of the efficacy of some insecticides and bio-insecticides against glasshouse whitefly on tomato

A replicated trial was conducted in 2012 to evaluate the efficacy of six treatments, including three chemical and three biological products compared to a water control and a standard treatment Chess (pymetrozine)

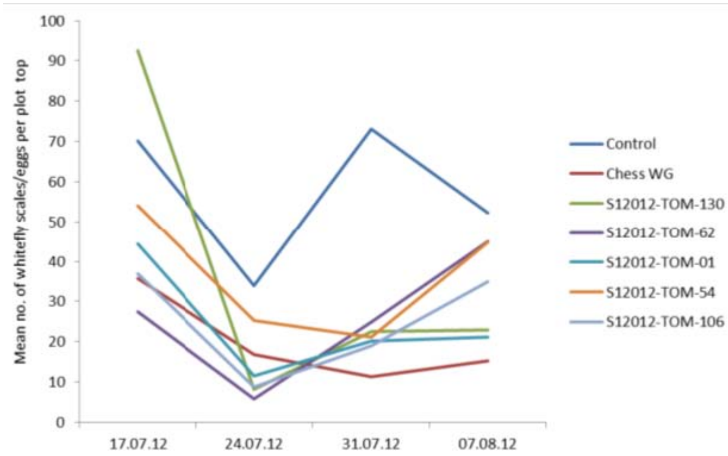
Whitefly adults were recorded for each plant, six plants per plot. Numbers of eggs/scales were recorded in the 'middle' third of each plant. Eggs and scales were also recorded from the 'top' third of each plant. Treatments were first applied when pest populations had established throughout the crop, but were still at relatively low levels as required by some of the biological products.

Table 3.4.1. Detail of treatments applied for control of whitefly – STC, 2012

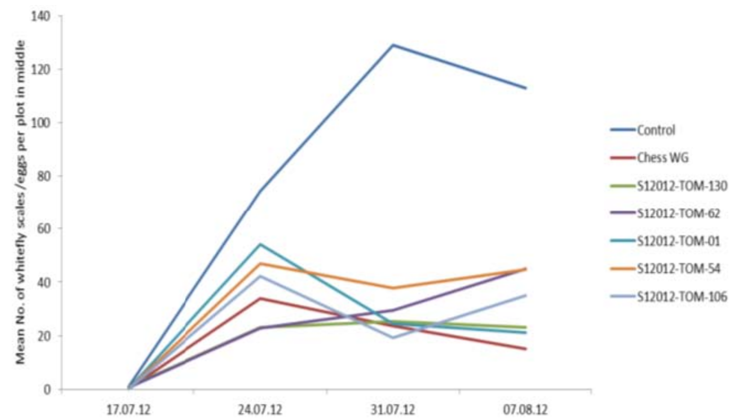
Trt no.	Treatment name	Description	Rate	Applications
1	Control			18/7/12, 25/7/12, 1/8/12
2	Chess	Standard	20 g/l	18/7/12, 25/7/12, 1/8/12
3	SI2012-TOM-130	Biological	-	18/7/12, 25/7/12, 1/8/12
4	SI2012-TOM-62	Biological	-	18/7/12, 25/7/12, 1/8/12
5	SI2012-TOM-01	Biological	-	18/7/12, 23/7/12, 27/7/12, 1/8/12
6	SI2012-TOM-54	Chemical	-	18/7/12, 25/7/12, 1/8/12
7	SI2012-TOM-106	chemical	-	18/7/12, 25/7/12, 1/8/12

Results and discussion

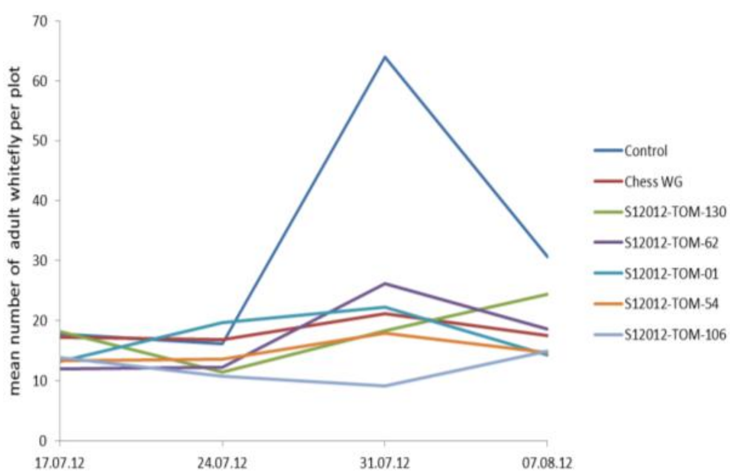
Numbers of whitefly in the control plots increased throughout. Treatment 2 is a standard product and gave expected levels of control.



a.



b.



c.

Figure 3.4.1. The mean numbers of scales/eggs top (a), middle (b) and whitefly adults (c) on tomato plant after three applications of treatments at seven day intervals (treatment SI2012-TOM-01 was applied four times at 4 to 5 day intervals - see Table 3.4.1.).

The data obtained from all treatments were square root transformed for analysis (square root- n+5); however in the pre-treatment assessment for whitefly eggs/scales recorded at the top of the plants there was statistical significance in the numbers recorded between the treatments. As a result, pre/post treatment assessments for data from the top of the plant were analysed using the Henderson-Tilton formula to take account of different starting levels. Analysis and figures below are from the penultimate assessment (31 July), as adult populations were in decline in the control plots at the final assessment (probably as a result of synchronised generations).

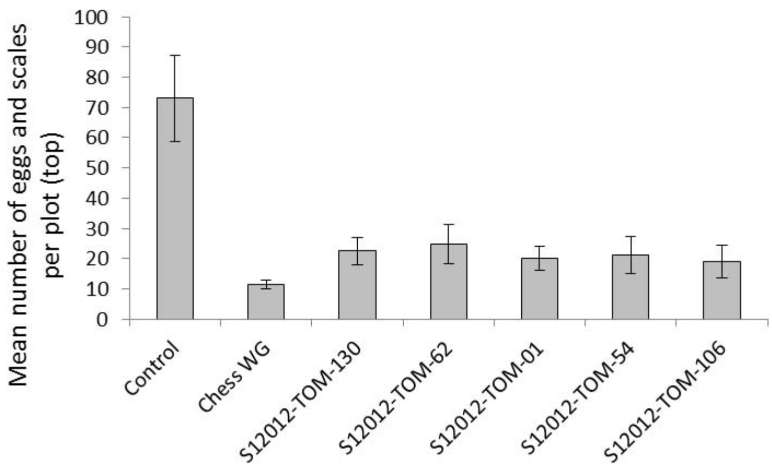


Figure 3.4.2. The mean numbers of whitefly eggs and scales in the top of tomato plants after two applications of treatments at seven days intervals

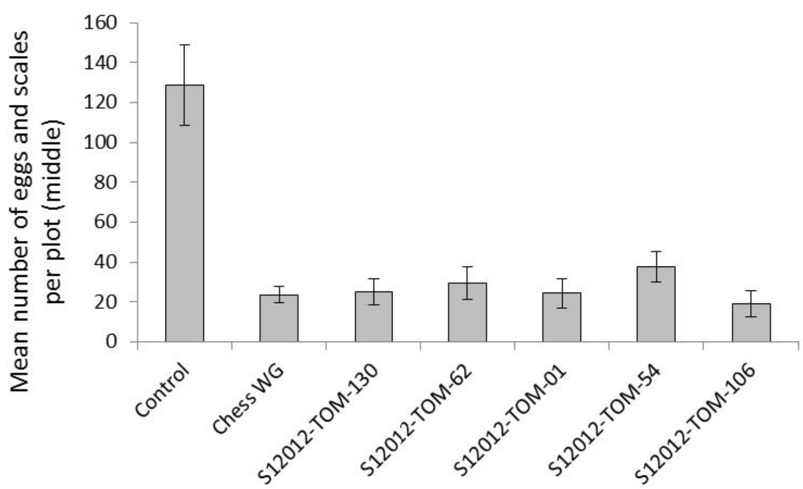


Figure 3.4.3. The mean numbers of whitefly eggs and scales in the middle of tomato plants after two applications of treatments at seven days intervals

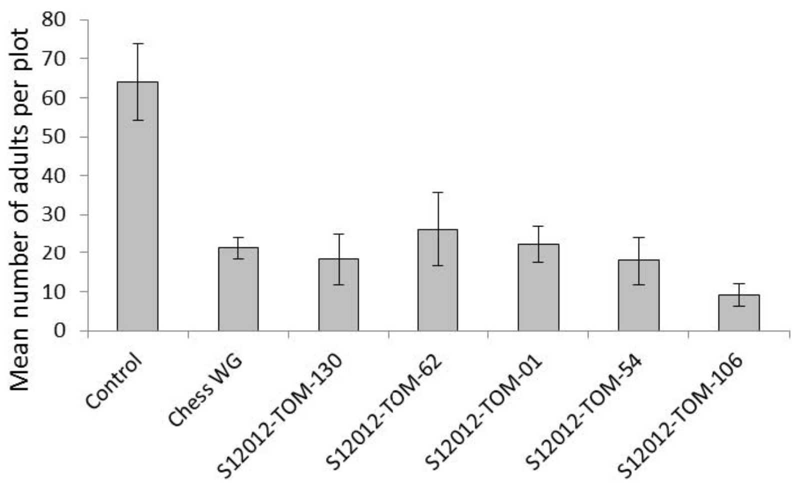


Figure 3.4.4. The mean numbers of adult per plot after two applications of treatments at seven days intervals

Figures 3.4.2, 3.4.3 and 3.4.4 show that at the penultimate assessment (after two applications of treatments) all treatments reduced the numbers of whiteflies in comparison to the control plots. Analysis of these results (Table 3.4.2) at the penultimate assessment show that numbers of whitefly eggs/scales in the middle of the plants, and the numbers of adults, were significantly reduced by all treatments compared to the control plots ($p<0.05$). Numbers of eggs/scales in the top of the plant did not differ at this assessment.

However at the final assessment (after three applications), the standard (Chess) and SI2012-TOM-130, had significantly reduced the numbers of eggs/scales in the top of the plants in comparison to the control plots ($p<0.05$). The numbers eggs/scales in the middle of the plants were also lower for treatments compared to the control. Adult whitefly declined in the control plots at the final assessment (probably as a result of synchronised populations), as a result there was no significant difference ($p>0.05$) between adults in the control and treated plots.

Table 3.4.2. Mean numbers of whitefly development stages at the penultimate assessment (31 July) after application three applications of treatments (treatment 5 had five applications)

Treatment	Name	Mean eggs & scales (middle)		Mean eggs & scales (top)	Mean adults	
1	Control	128.8	a	73.0	64.0	a
2	Chess WG	23.7	bc	11.3	21.2	bc
3	SI2012-TOM-130	25.2	bc	22.5	18.3	bc
4	SI2012-TOM-62	29.5	bc	24.8	26.2	b
5	SI2012-TOM-01	24.3	bc	20.2	22.3	bc
6	SI2012-TOM-54	37.8	b	21.2	18.0	bc
7	SI2012-TOM-106	19.3	c	19.0	9.2	c
F probability		0.001		0.1124	0.001	

Means followed by a common letter do not differ significantly.

3.5 Assessment of the efficacy of several bio-fungicides against Western flower thrips

A replicated trial was conducted in 2012 to evaluate the efficacy of six treatments, including one chemical standard (Pyrethrum 5EW) and five biological products compared to a water control.

Table 3.5.1. Details of treatments applied for control of WFT – STC, 2012

Trt No.	Treatment name	Description	Rate	Applications
1	Control			1/8/12, 8/8/12, 15/8/12
2	Pyrethrum 5EC	Standard	4 ml/l	1/8/12, 8/8/12, 15/8/12
3	SI2012-PEP-01	Biological		1/8/12, 8/8/12, 15/8/12
4	SI2012-PEP-62	Biological		1/8/12, 8/8/12, 15/8/12
5	SI2012-PEP-91	Biological		1/8/12, 8/8/12, 15/8/12
6	SI2012-PEP-60	Biological		1/8/12, 8/8/12, 15/8/12
7	SI2012-PEP-51	Biological		1/8/12, 8/8/12, 15/8/12

The numbers of WFT adults and nymphs were sampled *in situ* from one flower per plant, six plants per plot. Treatments were first applied when numbers of the pest were relatively low, as required by some of the biological products. Treatment 2 (Pyrethrum 5EC) is a standard product and produced expected levels of control.

Results and discussion

Figures 3.5.1 and 3.5.2 show that at the final assessment the numbers of WFT nymphs and adults were lower for all treatments when compared to the numbers recorded in the control plots.

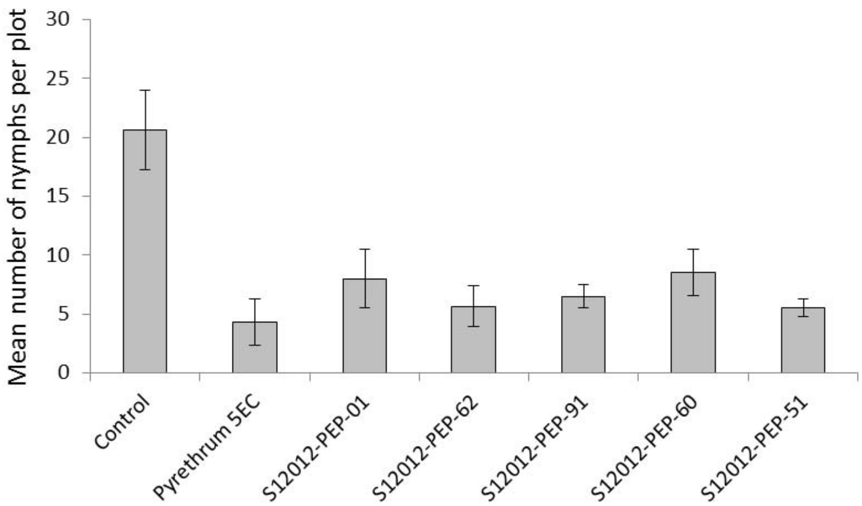


Figure 3.5.1. Mean numbers of WFT nymphs on 21 August after three applications of treatments at seven day intervals in a glasshouse trial.

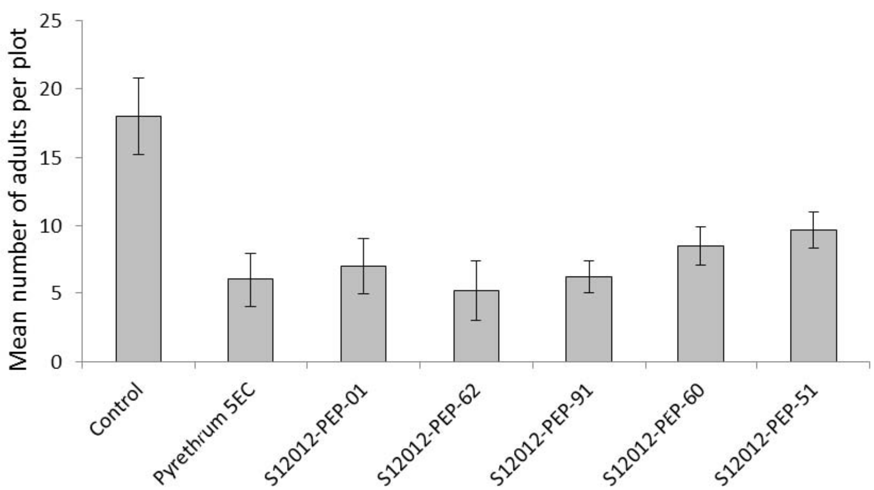


Figure 3.5.2. Mean numbers of WFT adults on 21 August after three applications of treatments at seven day intervals in a glasshouse trial.

Analysis of the transformed data (square root n+5), shows that the numbers of adult and nymphs recorded from flowers in each plot, were significantly lower for the treated plots compared to the control (except for treatment 7 adults, but this was very close to significant). There was no difference between the biological and the standard products.

Table 3.5.2. Mean numbers of adult and nymphs *Frankliniella occidentalis* after three applications of treatments at seven day intervals

Treatment	Name	Mean no. of nymphs		Mean no of adults	
1	Control	20.7	a	18.0	a
2	Pyrethrum 5EC	4.3	b	6.0	b
3	S12012-PEP-01	8.0	b	7.0	b
4	S12012-PEP-62	5.7	b	5.2	b
5	S12012-PEP-91	6.5	b	6.2	b
6	S12012-PEP-60	8.5	b	8.5	b
7	S12012-PEP-51	5.5	b	9.7	ab
F probability		0.0009		0.0139	

Means followed by same letter do not significantly differ (P=.05, LSD), LSD was done on transformed data.

The results show that the use of the biological products at low pest densities produce comparable levels of control to the chemical standard Pyrethrum 5EC and the other conventional insecticide products tested. Therefore the method for using these biological products within IPM programmes has to be determined; are biological products better implemented at the beginning of IPM programmes or can they be used effectively as 'knockdown' treatments when pest levels are too high to be managed by biocontrol agents alone?

4. Top fruit

4.1 Assessment of the efficacy of several fungicides and biofungicides against powdery mildew on apple

Replicated trials were conducted in 2012 to evaluate the efficacy of fungicides (Trial 1) and biofungicides (Trial 2).

Trial 1

The efficacy of eight fungicides was examined for the control of powdery mildew in apple. The results obtained were compared with untreated controls and the trial protocol was validated by inclusion of the standard treatment Systhane 20EW (myclobutanil) applied at recommended rates.

Five applications of each treatment were made. Treatments applied are listed below:

Table 4.1.1. Fungicides evaluated for control of apple powdery mildew - 2012

Treatment	Product	UK rate of product/ha	Dosage rate a.s./ha	Application timing
1	Untreated	-	-	-
2	Systhane 20EW	330 ml	66 g/ha	28/5, 19/6, 25/6, 9/7, 23/7
3	SF2012-APL-32			28/5, 19/6, 25/6, 9/7, 23/7
4	SF2012-APL-128			28/5, 19/6, 25/6, 9/7, 23/7
5	SF2012-APL-17			28/5, 19/6, 25/6, 9/7, 23/7
6	SF2012-APL-25a			28/5, 19/6, 25/6, 9/7, 23/7
7	SF2012-APL-87			28/5, 19/6, 25/6, 9/7, 23/7
8	SF2012-APL-159			28/5, 19/6, 25/6, 9/7, 23/7
9	SF2012-APL-89			28/5, 19/6, 25/6, 9/7, 23/7
10	SF2012-APL-158			28/5, 19/6, 25/6, 9/7, 23/7

Results

Table 4.1.2. Mean % mildewed leaves (mean of 5 assessments), mean russet score on fruit and mean % fruit drop recorded on apple cv. Cox following five sprays of various fungicides applied to apple trees post-blossom at East Malling Research in 2012

Treatment	Product	Overall mean % mildewed leaves	Mean russet score*	Mean % fruit drop
1	Untreated	88.3	138.0	48.5 (56.1)
2	Systhane 20EW	**67.7**	118.0	34.6 (32.2)
3	SF2012-APL-32	**41.5**	121.2	43.6 (47.6)
4	SF2012-APL-128	**54.1**	136.8	41.5 (43.9)
5	SF2012-APL-17	**63.4**	125.0	38.2 (38.3)
6	SF2012-APL-25a	**48.0**	113.3	41.4 (43.7)
7	SF2012-APL-87	**55.8**	117.8	38.7 (39.2)
8	SF2012-APL-159	**44.7**	125.2	42.9 (46.4)
9	SF2012-APL-89	**56.4**	124.2	**24.0** (16.6)
10	SF2012-APL-158	**61.1**	130.5	57.7 (71.4)
F Prob		<0.001	0.690	0.019
SED (27 df)		3.326	13.56	7.41
LSD (p=0.05)		6.824	27.86	15.21

*Russet score 0-4 where 0= no russet 4= rough russet with cracking.

* treatments that are significantly better than the untreated are shown in bold.

- The amount of powdery mildew was moderate – high.
- No phytotoxic symptoms or treatment related crop vigour differences were observed at any of the assessment timings. There were no effects of treatments on fruit russet, fruit colour or fruit size. However, the % fruit drop was significantly lower on plots treated with SF2012-APL-89.
- There were significant efficacy effects for all treatments compared to the untreated control at all assessment dates. The least mildew was recorded on plots treated with SF2012-APL-32, SF2012-APL-159 and SF2012-APL-25a.

Discussion

Weather conditions during the trial were conducive to the development of powdery mildew on apple, with higher than expected rainfall which encouraged shoot growth and provided the humid conditions necessary for infection and development. The high rainfall in 2012 meant that some treatment timings were delayed but this did not affect the outcome of the trial. The incidence of the powdery mildew was higher than normal. First treatments were applied soon after blossom at the start of the extension growth and the secondary mildew epidemic. Because of the high incidence of primary mildew on blossoms and shoots powdery mildew was already established on the extension growth. Secondary mildew in untreated plots rapidly increased such that for most of the assessments 100% of the leaves were infected. Only limited control of mildew was achieved by the standard product Systhane 20EW. This is mostly likely due to the presence of mildew with reduced sensitivity to Systhane 20EW (and hence other DMI fungicides) in the orchard. This may also have affected the performance of some of the test fungicides in the trial. All treatments significantly reduced the incidence of powdery mildew compared to the untreated control at all assessment dates. The least mildew was recorded on plots treated with SF2012-APL-32, SF2012-APL-159 and SF2012-APL-25a. There was no effect of treatments on fruit quality, although significantly fewer fruit dropped off trees treated with SF2012-APL-89. Further work is needed to look at efficacy of treatments used in programmes over longer periods of time. This approach will be investigated in 2013 trials.

<u>Trial 2</u>

The efficacy of seven biofungicides was evaluated. The results obtained were compared with untreated controls and the trial protocol was validated by inclusion of the standard treatment Systhane 20EW (myclobutanil) applied at recommended rates. Five applications of each treatment were made. Treatments applied are listed below:

Table 4.1.3. Biofungicides evaluated for control of apple powdery mildew – EMR, 2012

Treatment	Product	UK rate of product	Dosage rate a.s.	Application timing
1	Untreated	-	-	-
2	Systhane 20EW	330 ml	66 g/ha	13/6, 20/6, 26/6, 4/7, 12/7
3	SF2012-APL-105	-		13/6, 20/6, 26/6, 4/7, 12/7
4	SF2012-APL-162	-	-	13/6, 20/6, 26/6, 4/7, 12/7
5	SF2012-APL-160	-	-	13/6, 20/6, 26/6, 4/7, 12/7
6	SF2012-APL-158	-	-	13/6, 20/6, 26/6, 4/7, 12/7
7	SF2012-APL-06	-	-	13/6, 20/6, 26/6, 4/7, 12/7
8	SF2012-APL-38	-	-	13/6, 20/6, 26/6, 4/7, 12/7
9	SF2012-APL-157	-	-	13/6, 20/6, 26/6, 4/7, 12/7
10	SF2012-APL-90	-	-	13/6, 20/6, 26/6, 4/7, 12/7
11	SF2012-APL-115	-	-	13/6, 20/6, 26/6, 4/7, 12/7

Results

Table 4.1.4. Mean % mildewed leaves (angular transformed) recorded on apple cv. MM106 rootstock following five sprays of various biofungicides at East Malling Research in 2012. Figures in parenthesis are back-transformed means (Trial 2)

Treatment	Product	Mean % mildewed leaves		
		18 June	2 July	6 August
1	Untreated	61.2 (76.8)	58.9 (73.4)	69.3 (87.5)
2	Systhane 20EW	40.2 (41.6)	**21.0** (12.8)	**24.4** (17.1)
3	SF2012-APL-105	53.8 (65.2)	**41.8** (44.4)	**42.2** (45.2)
4	SF2012-APL-162	50.7 (59.9)	**31.1** (26.7)	**35.4** (33.5)
5	SF2012-APL-160	47.4 (54.1)	**20.0** (11.6)	**25.7** (18.8)
6	SF2012-APL-158	54.3 (65.9)	**24.0** (16.5)	**32.2** (28.4)
7	SF2012-APL-06	51.8 (61.8)	**42.8** (46.1)	**50.6** (59.7)
8	SF2012-APL-38	45.3 (50.6)	**45.5** (50.8)	**42.3** (54.0)
9	SF2012-APL-157	47.8 (54.9)	**41.9** (44.6)	**47.4** (54.2)
10	SF2012-APL-90	42.2 (45.2)	**35.8** (34.2)	**40.8** (42.7)
11	SF2012-APL-115	51.9 (61.9)	**38.5** (38.7)	**48.9** (56.8)
F Prob		0.107	<0.001	<0.001
SED (55 df)		5.19	5.66	4.85
LSD (p=0.05)		10.43	11.37	9.74

*Russet score 0-4 where 0= no russet 4= rough russet with cracking. Treatments that are significantly better than the untreated are shown in bold.

- The amount of powdery mildew was moderate – high.
- No problems were encountered during mixing or application of all of the product formulations under test except for treatment 3 (SF2012-APL-105) which was difficult to mix and stuck to the filter of the sprayer.
- Necrotic spotting on leaves was noted after the first spray application following treatment with SF2012-APL-157, SF2012-APL-115 and SF2012-APL-158. Most of the spotting was on trees treated with SF2012-APL-158. No further leaf damage was noted following later sprays. No treatment related crop vigour differences were observed at any of the assessment timings.
- There were significant efficacy effects for all treatments compared to the untreated control at the second and third assessment. The least mildew was recorded on plots treated with the standard Systhane 20EW or SF2012-APL-162, SF2012-APL-160, SF2012-APL-158. There appeared to be no benefit from applying SF2012-APL-160 in mixture with SF2012-APL-162 (SF2012-APL-158).

Discussion

Weather conditions during the trial were conducive to the development of powdery mildew on apple, with higher than expected rainfall which encouraged shoot growth and provided the humid conditions necessary for infection and development. The incidence of the powdery mildew was higher than normal. All products reduced the incidence of powdery mildew compared to the untreated control. However, none of the treatments gave complete control of mildew. The least mildew was recorded on plots treated with the standard Systhane 20EW or SF2012-APL-162, SF2012-APL-160, SF2012-APL-158. There appeared to be no benefit from applying SF2012-APL-160 in mixture with SF2012-APL-162 (SF2012-APL-158). The biofungicides based on microorganisms were the least effective in reducing mildew. With a perennial crop like apple where the powdery mildew overwinters in the buds it is doubtful whether the partial control provided by these products applied alone would be sufficient to make their use worthwhile unless there were other constraints on the use of conventional fungicides. Further work needs to be done to establish their efficacy when used in combination with conventional fungicides or other biofungicides. This approach will be investigated in 2013 trials.

4.2 Assessment of the efficacy of several biofungicides against Botrytis storage rot of pear

One replicated trial was conducted in 2011/2012 to evaluate the efficacy of biofungicides for the control of *Botrytis* fruit rot in cold-stored pears cv. Conference. The results obtained were compared with untreated controls and the trial protocol was validated by inclusion of the standard treatment Rovral WG (iprodione) applied at the recommended rates.

One application of each treatment was made in September 2011 applied as a dip treatment to crates of pears inoculated with *Botrytis cinerea*. After dipping the crates were allowed to drain and then placed in cold store at -1^{o}C to 0^{o}C until February 2012. Treatments applied are listed below. Pears treated with SF2011-1299, SF2011-1221, and SF2011-1298 were either placed straight in the cold store after treatment or left at ambient temperature for 24 hours prior to cold storage.

Table 4.2.1. Detail of treatments applied for control of Botrytis rot in cold-stored pears – EMR, 2011

Treatment	Product	Rate of product/L	Dosage rate a.s.	Application timing
1	Untreated - inoculated	-	-	7/9
2	Untreated - uninoculated	-	-	7/9
3	Rovral WG	1.3 g	0.975 g	7/9
4	SF2011-1238	-	-	7/9
5	SF2011-1299 (24 hrs)	-	-	7/9
6	SF2011-1299	-	-	7/9
7	SF2011-1221 (24 hrs)	-	-	7/9
8	SF2011-1221	-	-	7/9
9	SF2011-1298 (24 hrs)	-	-	7/9
10	SF2011-1298	-	-	7/9

Results

Table 4.2.2. Incidence of pears rotted with Botrytis (angular transformed) following treatment with various biocontrol products and storage at 0ºC until 14 February 2012. Figures in brackets are back-transformed data.

Treatment number	Product	% Botrytis rot
1	Untreated - inoculated	52.5 (62.9)
2	Untreated - uninoculated	7.1 (1.5)
3	Rovral WG	**18.7** (10.3)
4	SF2011-1238	**32.3** (28.6)
5	SF2011-1299 (24 hours)	**43.8** (47.9)
6	SF2011-1299	**42.8** (46.1)
7	SF2011-1221 (24 hours)	49.8 (58.4)
8	SF2011-1221	46.7 (53.0)
9	SF2011-1298 (24 hours)	**44.5** (49.2)
10	SF2011-1298	**38.9** (39.4)
F Prob		<0.001
SED (30df)		3.729
LSD (p=0.05)		7.617

* treatments that are significantly better than the untreated are shown in bold.

- The amount of Botrytis rot was moderate/high.
- There were significant efficacy effects for treatments 3, 4, 5, 6, 9 and 10.
- There was no significant difference in botrytis rot spread for treatments SF2011-1299, SF2011-1221, and SF2011-1298 between immediate storage or 24 hour delayed storage

Discussion

All the biofungicides tested significantly reduced the Botrytis spread in cold-stored pears apart from treatments 7 and 8. None were as effective as the standard Rovral WG fungicide. Treatment 4 was the most effective of the biofungicides and is worth pursuing as a possible treatment for control of Botrytis fruit rot in cold-stored pears. Further work should be done to examine efficacy at higher rates. There was no significant difference in Botrytis rot spread for treatments SF2011-1299, SF2011-1221, and SF2011-1298 between immediate storage or 24 hour delayed storage to allow biocontrol development.

Technology transfer (1 October 2011 – 30 September 2012)

Articles

Anon (2012). Sceptre project delivers first new crop protection approval. *HDC News* **185**, p 3.

Atwood J (2012). New directions for soft fruit crop protection. *HDC News* **182**, 27-29.

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Berrie A (2012). SCEPTRE targets tree fruit diseases. *HDC News* **186**, 23.

Brough W (2012). Common targets, common solutions. *HDC News* **184**, 20-21.

Collier R & Jukes A (2012). Control contenders under trial. *HDC News* **183**, 18-19.

Gladders P & Collier R (2012). New hopes for better control. *HDC News* **181**, 13-15.

Knott C (2011). Potential new herbicides for vegetables. *HDC News* **179**, 13-15.

McPherson M, Croft P, Wright K & Tilley L (2012). First screen reveals hopefuls for glasshouse crop protection. *HDC News* **185**, 12-13.

O'Neill T M (2011). Sceptre: new crop protection measures for soft fruit. EMRA Members Day Booklet.

Raffle S (2012). Controls for the next generation. *HDC Soft Fruit Review 2012*, p. 5.

Raffle S (2012). New generation of active ingredients for tree fruit. *HDC Tree Fruit Review 2012*, p. 8.

Presentations

Berrie A (2012). Sustainable management of Mucor and Rhizopus in strawberry. HDC Soft Fruit Consultants Day, East Malling Research, 6 March 2012.

Berrie A (2012). Integrated pest and disease management in top fruit. Getting to the heart of horticulture – opportunities for the West Midlands, Pershore, 12 January 2012.

Green K G (2012). Vegetable diseases. Bayer Vegetable Conference, Peterborough, 24 January 2012.

McPherson G M (2012). Sceptre: an update on pest and disease control in protected crops. Tomato Conference, Coventry, 27 September 2012.

O'Neill T M (2011). Sceptre: new crop protection measures for soft fruit. HDC/EMRA Members Day, East Malling, 23 November 2011.

O'Neill T M (2012). Update on Sceptre - field vegetables. ADAS-Syngenta Vegetable Conference, Peterborough, 8 February 2012.

O'Neill T M (2012). New crop protection measures for edible crops. AgriFood Panel, Campden BRI, Chipping Campden, 23 May 2012.

Powell V (2012). Crop protection update. HDC/BGA Brassica Technical Seminar, Lancashire, 5 July 2012.

Powell V (2012). Crop protection update for speciality crops. International Blackcurrant conference, 16 July 2012.

Powell V & Neve B (2011). An introduction to Sceptre. AAB Biopesticides Conference, Grantham, 29 November 2011.

Demonstrations

Vegetable disease and weed control. ADAS Boxworth Open day, 30 May 2012 (Lynn Tatnell, Jessica Sparkes, Angela Huckle, Tim O'Neill).

Cucumber powdery mildew. Cucumber Growers Association, STC, 5 July 2012 (Kirsty Wright, Martin McPherson, Tim O'Neill).

Vegetable weed control open day. Elsoms Seeds Trial Ground, Spalding, 5 July 2012 (Cathy Knott, Andy Richardson).

Brassica powdery mildew. ADAS Boxworth trial viewing, 24 August 2012 (Angela Huckle, Tim O'Neill).

Warwick Crop Centre Open Afternoon, 19 September 2012 (Rosemary Collier, Andy Jukes).

Website

http://www.hdc.ahdb.org.uk/sceptre

Appendix 1 Crop protection targets (revised February 2013)

Summary of completed (Years 1 and 2) and planned work on disease targets

Year	Item	Disease type	FV	PE	SF	TF
1	1	Powdery mildew	-	Cucumber	-	Apple
	2	Downy mildew	Brassica	-	-	-
	3	Leaf/cane spots	Brassica (Alternaria)	-		-
	4	Botrytis	-	Tomato	-	Pear
	5	Fusarium wilts	Lit Review	-	-	-
	6	Pythium/ Phytophthora	-	-	-	-
	7	Other	-	-	Mucor/Rhizopus	-
2	1	Powdery mildew	Brassica	Cucumber	-	Apple
	2	Rust	Leek	-	-	-
	3	Leaf/cane spots	Brassica (Ring spot)	-	Raspberry cane	-
	4	Botrytis	-	Tomato	-	Pear
	5	Downy mildew	-	-	-	-
	6	Pythium/ Phytophthora	-	-	Strawberry crown rot	-
	7	Other	-	-	Mucor/Rhizopus	-
	8	IPM work	Brassica	-	-	-
3	1	Powdery mildew	Brassica	-	-	Apple
	2	Rust	Leek	-		
	3	Downy mildew	Onion	-	-	-
	4	Leaf/cane spots	Brassica (Ring spot)	-	Raspberry cane	-
	5	Botrytis	-	Tomato	-	Pear

	6	Pythium/ Phytophthora	-	Cucumber	Strawberry crown rot	-
	7	Other	-	Cucumber Phomopsis	Mucor/Rhizopus	-
4	1	Powdery mildew	Brassica		Strawberry	Apple
	2	Downy mildew	Brassica	-	-	-
	3	Leaf/cane spots	Brassica/ other	-	Raspberry cane	-
	4	Botrytis	Lettuce	-	-	Pear
	5	Pythium/ Phytophthora	-	Cucumber	Strawberry crown rot	-
	6	Other	-	Phomopsis	Mucor/Rhizopus	-

Summary of planned work on pest targets

Year	Item	Pest type	FV	PE	SF
1	1	Aphid	B/L/C	-	Raspberry
	2	Cabbage root fly	Brassica	-	-
	3	Moth/butterfly caterpillar	Brassica	-	-
	4	Spider mite	-	Tomato	-
	5	Thrips	Allium	Pepper	-
	6	Capsid	-	-	Strawberry
	7	Whitefly	Brassica	Tomato	
2	1	Aphid	Lettuce	-	Raspberry
	2	Cabbage root fly	Brassica	-	-
	3	Moth/butterfly caterpillar	Lettuce		-
	4	Spider mites	-	Tomato	-
	5	Thrips	Allium	Pepper	-
	6	Capsid	-		Strawberry
	7	Whitefly	-	Tomato	
	8	IPM	Brassica	-	-
3	1	Aphid	Lettuce	-	Raspberry (IPM)
	2	Cabbage root fly	Brassica (part of 7; IPM)	-	-
	3	Moth/butterfly caterpillar	Lettuce	-	-
	4	Spider mites	-	-	-
	5	Thrips	Allium	-	-
	6	Capsid	-	-	Strawberry
	6	Whitefly	-	-	-

	7	IPM	Brassica	Tomato/ pepper	-
4	1	Aphid	B or L or C	-	Strawberry
	2	Cabbage root fly	-	-	-
	3	Moth/butterfly caterpillar	Carrot/Lettuce	-	-
	4	Spider mites	-	-	-
	5	Thrips	Allium	-	-
	6	Whitefly	-	-	
	7	IPM	Lettuce/Carrot/ Brassica	Tomato/ pepper	Raspberry

L - lettuce; C - carrot; B - Brassica.

Summary of planned work on weeds targets

Year	Item	Work area	FV	SF
1	1	Residue studies	Several crops	-
	2	Annual broad leaf weeds	Many crops	Strawberry
	3	Perennial weeds	-	Bush & cane fruit
	4	Alleyways/runners	-	-
	5	Band spraying	-	-
	6	Non-herbicide methods	-	Test rig for electric weed control
2	1	Residue studies	-	-
	2	Annual broad leaf weeds	Many crops	Strawberry
	3	Perennial weeds	-	Bush & cane fruit
	4	Alleyways/runners	-	Strawberry
	5	Band spraying	Vegetables	-
	6	Non-herbicide methods	Several	Electric weed control
3	1	Residue studies	-	-
	2	Annual broad leaf weeds	Many crops	-
	3	Perennial weeds	-	Bush & cane fruit
	4	Alleyways/runners	-	-
	5	Band spraying	Vegetables	-
	6	Non-herbicide methods	Several	-
4	1	Residue studies	-	-
	2	Annual broad leaf weeds	Many crops	-
	3	Perennial weeds	-	Bush & cane fruit
	4	Alleyways/runners	-	Strawberry
	5	Band spraying	Vegetables	-
	6	Non-herbicide methods	Several	Electric weed control