AHDB Agriculture & Horticulture DEVELOPMENT BOARD

HDC

Grower Summary

CP 77 (HL01109)

Sustainable Crop and Environment Protection – Target Research for Edibles (SCEPTRE)

Annual 2013

Disclaimer

The results and conclusions in this report may be based on an investigation conducted over one year. Therefore, care must be taken with the interpretation of the results.

Use of pesticides

Only officially approved pesticides may be used in the UK. Approvals are normally granted only in relation to individual products and for specified uses. It is an offence to use non-approved products or to use approved products in a manner that does not comply with the statutory conditions of use, except where the crop or situation is the subject of an off-label extension of use.

Before using all pesticides check the approval status and conditions of use.

Read the label before use: use pesticides safely.

Further information

If you would like a copy of the full report, please email the HDC office (hdc@hdc.ahdb.org.uk), quoting your HDC number, alternatively contact the HDC at the address below.

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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.

Project Number:	CP 77 (HL01109)
Project Title:	Sustainable Crop and Environment Protection – Target Research for Edibles (SCEPTRE)
Project Coordinator:	Dr Tim O'Neill, ADAS
Report:	Second Annual Report, Year 2, February 2013
Publication Date:	27 February 2013
Start Date:	1 October 2010
End Date:	30 September 2014
HDC Project Cost (total project cost):	£ 740,500 (£2,034,247.00)

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	
<u>Field vegetables</u>				
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
<u>Soft fruit</u>				
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
<u>Protected edibles</u>				
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
<u>Top fruit</u>				
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.