Grower Summary

CP 077

SCEPTRE

Final 2014

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 this 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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GROWER SUMMARY

Headline

- Potential new pesticide and/or biopesticide products have been identified to fill many of the crop protection gaps on edible crops arising from changing legislation.

Background

Numerous widely used conventional chemical 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 substances to remain on Annex I (a positive list of active substances permitted in the EC) following review of substances that had been approved under the Pesticide Registration Directive (91/414/EEC);
- some active substances were not supported by crop protection companies for economic reasons and were withdrawn from the pesticides review;
- implementation of Regulation (EC) (1107/2009) that requires assessment of inherent hazard as well as risk;
- assessment of pesticides to determine if they are endocrine disruptors;
- implementation of the Water Framework Directive (WFD), a measure that particularly impacts on herbicides and molluscicides;
- adoption of the Sustainable Use Directive (SUD), which became compulsory on 1 January 2014, whereby crop protection chemicals must be used only to supplement alternative (non-chemical) methods of control.
- establishment of a list of active substances within certain properties as candidates for substitution (the current draft list contains 77 candidates), as required under Regulation (EC) No. 1107/2009.

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 priority 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 usually expensive and requiring detailed biological and residue studies for each specific crop (in some instances extrapolation from one crop to another similar crop is permitted). Microbial pesticides and botanical pesticides (biopesticides) also face large registration costs.

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

- new chemical actives;
- a rapidly increasing number of biopesticides in the registration pipeline (except for bioherbicides);
- potential to reduce number of conventional pesticide applications in a programme through targeted use of biopesticides;
- 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 aimed to identify effective plant 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 conventional pesticides and biopesticides now coming to the market and some new technologies, including non-plant protection product methods of pest control, were evaluated.

A broad Consortium was 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 comprised three teams (diseases, pests and weeds) working across the major organizations currently delivering applied crop protection research in the UK.

Summary

In Year 4, 48 conventional plant protection products based on chemical pesticides, 17 based on microorganisms, 8 based on botanical extracts and 1 other were screened against disease, pest and weed problems identified as high priority targets on edible crops. Thirty-four experiments were completed on 30 pests (Tables 1-3).

The numbers and types of products tested in each experiment are shown (Table 2) and the broad results are listed (Table 3). Novel products with good potential to fill crop protection gaps have been identified in all crop sectors (Tables 4-6). A summary of each experiment is given.

Table 1. Overview of experiments completed in 2014

Sector and Pest	Crop				
Field vegetables	Brassica	Lettuce	Leek	Onion	Field veg*
Downy mildew				✓	
Powdery mildew	✓				
Ring spot	✓				
Rust			✓		
Aphid	✓	✓			
Caterpillar	✓	✓	✓		
Cabbage root fly	✓				
Thrips			✓		
Annual weeds			✓	✓	✓
Soft fruit	Strawberry	Raspberry	Bush/Cane		
Cane diseases		✓			
Crown rot	✓				
Powdery mildew	✓				
Aphid		✓			
Capsid (Lygus)	✓				
Runners	✓				
Annual weeds	✓				
Perennial weeds			✓		
Protected edibles	Cucumber	Tomato	Pepper		
Phomopsis	✓				
Pythium	✓				
WFT			✓		
Aphid			✓		
Top fruit	Apple	Pear			
Powdery mildew	✓				
Botrytis		✓			

* broad beans, carrots, cauliflowers, celeriac, celery, coriander, courgette, drilled bulb onion, dwarf French bean, flat leaf parsley, leek, lettuce, mizuna, parsnip, rocket, spinach, swede.

Table 2. Overview of experiments in 2014 showing numbers and types of products tested individually

Trial	Crop	Target	Novel products tested					
			micro-org	Botanical	Salt/other	Total bio	Chemical	TOTAL products
1.1	Brassica	Powdery mildew	0	0	0	0	5	5
1.2	Brassica	Ring spot	1	1	0	2	2	4
1.3	Leek	Rust	0	1	0	1	5	6
1.4	Spring onion	Downy mildew	0	0	0	0	5	5
1.5	Leek	Onion thrips/Moth	1	2	0	6	6	10
1.6	Lettuce	Aphid	1	2	0	3	3	6
1.6	Lettuce	Caterpillar	NT	NT	NT	NT	NT	NT
1.7a	Brassica (sprouts)	Aphids, caterpillar	0	5	0	5	6	11
1.7b	Brassica (sprouts)	CRF	2	1	0	3	4	7
1.8	Courgette	Annual weeds	0	0	0	0	5	5
1.9	Umbellifers	Annual weeds	0	0	0	0	3	3
1.10	Field Vegetables	Annual weeds	0	0	0	0	1	1
1.11	Alliums	Annual weeds	0	0	0	0	3	3
1.12a	Cauliflower	Electric weed control	N/A	N/A	N/A	N/A	N/A	N/A
1.12b	Leek	Electric weed control	N/A	N/A	N/A	N/A	N/A	N/A
2.1	Raspberry	Cane diseases[b]	4	1	0	5	6	11
2.2	Strawberry	Crown rot	2	0	0	0	3	5
2.3	Strawberry	Powdery mildew (C)	-	-	-	-	10	10
2.4	Strawberry	Powdery mildew (B)	6	4	-	-	-	10
2.5	Raspberry	Aphid	0	2	0	0	2	4
2.6	Strawberry	Capsid (Lygus)	0	0	0	0	2	2
2.7	Strawberry	Herbicide crop safety	0	0	0	0	1	1
2.8	Strawberry	Runner control	0	1	0	1	1	2
2.9	Blackcurrant	Electric weed control	N/A	N/A	N/A	N/A	N/A	N/A
3.1a	Cucumber	Phomopsis	7	1	0	8	12	20
3.1b	Cucumber	Phomopsis	2	0	0	2	8	10
3.2	Cucumber	Pythium	2	0	0	2	7	9
3.3	Pepper	Aphid	1	3	0	4	0	4
3.4	Pepper	WFT	1	2	0	3	1	4
4.1	Apple	Powdery mildew – IPM	NA	NA	NA	NA	NA	NA
4.2	Apple	Powdery mildew - IPM	NA	NA	NA	NA	NA	NA
4.3	Pear	Botrytis (2013/14)	6	0	0	6	0	6
	Annual unique products for FV[c]		9	4	0	13	29	42
	Annual unique products for PE		5	2	0	7	13	20
	Annual unique products for SF		7	8	0	15	23	38
	Annual unique products for TF		2	2	1	5	7	12
	Annual unique products – herbicides		0	2	0	2	7	9
	Annual unique products – fungicides		9	4	1	14	31	45
	Annual unique products – insecticides		8	2	0	10	10	20
	TOTAL UNIQUE PRODUCTS Y4		17	8	1	26	48	74

[a] Excluding the standard (reference) product and treatments using 2 or more products.

[b] Experiment still in progress.

[c] Annual totals include products used in IPM programmes.

N/A – not applicable.

Table 3. Overview of experiment results on individual products[a] – 2014

Topic		Number products demonstrating control*			Pest level on untreated
		Pesticides	Bio-pesticides	Other method	
Field vegetables					
1.1	Brassica: Powdery mildew	5	NT	NT	Severe
1.2	Brassica: Ring spot	2	2	NT	Low/Mod
1.3	Leek: Rust	5	1	NT	Moderate
1.4	Spring onion: Downy mildew	2	NT	NT	Mod/Sev
1.5	Leek: Onion thrips	6	4	NT	Low
1.5	Leek: Moth	6	4	NT	Moderate
1.6	Lettuce: Aphid	3	1	NT	Moderate
1.6	Lettuce: Caterpillar	NT	NT	NT	Nil
1.7a	Brassica (sprouts): aphids, caterpillar	6	5	NT	Low
1.7b	Brassica (sprouts): cabbage root fly	4	3	NT	Severe
1.8	Courgette: Annual weeds	4	0	NT	Severe
1.9	Umbellifers: Annual weeds	3	0	NT	Severe
1.10	Field Vegetables: Annual weeds	1	0	NT	Severe
1.11	Alliums: Annual weeds	2	0	NT	Severe
1.12a	Cauliflower: Band spray	NA	NA	NT	Moderate
1.12b	Leek: Band spray + electric weed control	NA	NA	1	Severe
Soft fruit					
2.1	Raspberry: Cane diseases	-	-	-	In progress
2.2	Strawberry: Crown rot				Moderate
2.3	Strawberry: Powdery mildew (C)	10	-	-	Mod/Sev
2.4	Strawberry: Powdery mildew (B)	-	9	-	Severe
2.5	Raspberry: Aphid	2	2	-	Moderate
2.6	Strawberry: Capsid (Lygus)	2	0	NT	Moderate
2.7	Strawberry: Herbicide crop safety	NA	NA	NA	NA
2.8	Strawberry: Runner control	1	1	0	Moderate
2.9	Blackcurrant: Weed control	NT	NT	1	Low
Protected edibles					
3.1a	Cucumber: Phomopsis	NA	NA	NA	Very low
3.1b	Cucumber: Phomopsis	6	0	NT	Moderate
3.2	Cucumber: Pythium	5	0	NT	Low
3.3	Pepper: Aphid	2	2	NT	Low/Mod
3.4	Pepper: WFT	1	1	NT	Moderate
Top fruit					
4.1	Apple: Powdery mildew (C)	2 programmes	-	-	Severe
4.2	Apple: Powdery mildew (B)	10 C/B programmes		-	Severe
4.3	Pear: Botrytis (2013/14)	NT	3	NT	Moderate

[a] Many experiments also tested treatment programmes using two or more products applied alternately or in mixture; results on such programmes are presented in the individual experiment reports and are not included here.

* Compared with untreated; excludes approved reference products. ( ) – number equal to or better than the chemical reference product. NR – no reference product for comparison. NT – none tested. NA – not applicable.

Products causing significant crop damage excluded.

Table 4. Leading novel products (product name or code number in numerical order) identified for control of diseases: 2011-2014

Target	Crop	Year	Exp ref.	Reference product	Leading 3 products: Fungicides			Leading 3 products: Biofungicides		
<u>Field vegetables</u>										
Alternaria	Brassica	2011	1.1	Rudis	**Sig**	**Cas**	**28**	06	43	47
	Brassica	2012	1.4	Signum	*	*	*	06	40	49
Downy mildew	Brassica	2011	1.2	Folio Gold	Cas	Sig	**26**	**47**	**-**	-
	Onion	2013	1.4	Mixtures	**20**	**Cas**	**-**	-	-	-
	Onion	2014	1.4	Mixtures	**Cas**	181	**197**	*	*	*
Powdery mildew	Brassica	2012	1.1	Rudis	**Cas**	**28**	**89**	**90**	**134**	**136**
	Brassica	2013	1.2	Rudis	**Cas**	**28**	**89**	11	90	90+40
	Brassica	2014	1.1	Rudis	**Tal**	**25a**	**28**	*	*	*
Ring spot	Brassica	2012	1.2	Signum	**10**	**Cas**	**Nat**	Ser	43	90
	Brassica	2013	1.3	Ami/Rud	**10**	**Cas**	**25a**	90	-	-
	Brassica	2014	1.2	Ami/Rud	**Cas**	**25a**	**-**	90	Ser	-
Rust	Leek	2012	1.3	Amistar	**10**	**27**	**46**	*	*	*
	Leek	2013	1.1	Amistar Top	**Ami**	**31**	**118**	Ser	105	-
	Leek	2014	1.3	Ami/Rud/Nat	**Cas**	**31**	**118**	**105**	*	*
<u>Soft fruit</u>										
Crown rot	Strawberry	2012	2.3	Paraat	**Cas**	-	-	**40**	**Pre**	-
Powdery mildew	Strawberry	2014	2.3/4	Systhane	**Tal**	**77**	**118**	**6**	**105**	**157**
Soft rot	Strawberry	2011	2.1	-	Sig	Thi	77	-	-	-
		2012	2.3	Signum	25a	**77**	-	-	-	-
		2013	2.2	-	37	-	-	-	-	-
Spur blight	Raspberry	2012	2.1	Switch	08	32	77	*	*	*
<u>Protected edibles</u>										
Botrytis	Tomato	2011	3.2	Switch	08	31	77	Pre	09	Ser
	Tomato	2012	3.2	Signum	08	25a	118	-	-	-
	Tomato	2013	3.1	Rov/Swi/Sig	**31**	**77**	**118**	-	-	-
Phomopsis	Cucumber	2013	3.1a	-	**-**	**-**	**-**	-	-	-
	Cucumber	2014	3.1b	-	46	139	175	-	-	-
Powdery mildew	Cucumber	2011	3.1	Systhane	**Tal**	**10**	**77**	**Ser**	**80**	**90**
	Cucumber	2012	3.1	Sys/Nim	**08**	**25a**	**77**	90	105	**154**
Pythium	Cucumber	2013	3.2	Previcur Energy	46	139	183	-	-	-
	Cucumber	2014	3.2	Previcur Energy	**46**	**139**	**183**	-	-	-
<u>Top fruit</u>										
Botrytis	Pear	2012	4.2	Rovral WG	*	*	*	178	98	99
	Pear	2013	4.2	Rovral WG	*	*	*	178	-	-
	Pear	2014	4.3	Rovral WG	*	*	*	Nxy	99	178
Powdery mildew	Apple	2011	4.1	Systhane	**47**	**77**	**Cos**	**Ser**	**80**	**90**
	Apple	2012	4.1	Systhane	**25a**	**32**	**159**	**158**	**160**	**162**
	Apple	2013	4.1	Systhane	**Tal**	**118**	-	**90**	**105**	**157**

* – no products in this category evaluated. Ami – Amistar; Cos – Cosine; Nat – Nativo 75WG; Nim – Nimrod; Pre – Prestop; Rov – Rovral WG; Ser – Serenade ASO; Sig – Signum, Swi – Switch; Sys – Systhane 20EW; Tal – Talius; Thi – Thianosan DG; Cas – Cassiopeia; adj – adjuvant; Nxy – Nexy; - no (other) product gave control.

Please see individual experiment reports, within the annual reports, for full details.

Up to 3 leading products are listed, arranged in numerical order. All products listed resulted in a significant reduction compared with the untreated control; those shown in bold were equal to or better than the reference product, where one was included. Products resulting in severe phytotoxicity have been excluded.

Table 5. Leading novel products (product name or code number in numerical order) identified for control of pests: 2011-2014

Target	Crop	Year	Exp ref.	Reference product	Leading 3 products					
					Insecticides			Bioinsecticides		
Field vegetables										
Aphid	Brassica	2011	1.4	Movento	**50**	**59**	**60**	62	92	-
	Brassica	2013	1.7	Movento	59	60	-	62	130	-
	Brassica	2014	1.7	Movento	-	-	-	-	-	-
	Carrot	2011	1.8	Biscaya	**50**	**54**	**75**	-	-	-
	Lettuce	2011	1.6	Movento	54	-	-	-	-	-
	Lettuce	2013	1.6	Movento	**50**	**59**	**60**	-	-	-
	Lettuce	2014	1.6	Movento	**50**	**59**	60	130	-	-
Caterpillar	Brassica	2013	1.7	Steward	**48**	**143**	-	64	Lep	130
	Brassica	2014	1.7	Steward	-	-	-	-	-	-
	Lettuce	2013	1.6	Tracer	**48**	**50**	-	**Lep**	94	130
Cabbage root fly	Brassica	2011	1.5	Tracer	**50**	**55**	-	-	-	-
	Brassica	2012	1.8	Tracer	**50**	**55**	-	*	*	*
	Brassica	2013	1.7a	Tracer	*	*	*	130	-	-
	Brassica	2013	1.7	Tracer	**50**	55	-	*	*	*
	Brassica	2014	1.7	Tracer	**50**	**198**	**199**	130	-	-
Moth	Leek	2012	1.7	Tracer	**50**	-	-	62	130	-
	Leek	2013	1.5	Tracer	48	**50**	142	62	-	-
	Leek	2014	1.5	Tracer	**50**	**198**	**200**	**62**	**130**	-
Thrips	Leek	2011	1.7	Tracer	48	**50**	54	-	-	-
	Leek	2013	1.5	Tracer	48	**50**	142	62	130	-
	Leek	2014	1.5	Tracer	-	-	-	-	-	-
Whitefly	Brassica	2012	1.8	Movento	**54**	**59**	**60**	*	*	*
Soft fruit										
Aphid	Raspberry	2011	2.2	Calypso	**70**	-	-	**62**	-	-
	Raspberry	2012	2.4	Calypso	**50**	**54**	**60**	51	62	130
	Raspberry	2013[†]	2.5	Calypso	**50**	-	-	62	**130**	-
	Raspberry	2014[†]	2.5	Calypso	**50**	**59**	-	**62**	**130**	-
Lygus	Strawberry	2011	2.3	Calypso	**Che**	**149**	**54**	**53**	-	-
	Strawberry	2012	2.5	Calypso	**60**	**149**	-	*	*	*
	Strawberry	2013	2.4	Chess	59	**149**	-	*	*	*
	Strawberry	2014	2.6	Chess	**59**	**149**	-	*	*	*
Protected edibles										
Aphid	Pepper	2013	3.5	Chess	*	*	*	**130**	-	-
	Pepper	2014	3.3	Chess	*	*	*	**62**	**130**	-
	Tomato	2011	3.3	-	53	86	-	01	52	62
Spider mite	Tomato	2012	3.3	Oberon	131	-	-	**01**	**62**	92
	Tomato	2012	3.3	Borneo	131	-	-	**62**	**Nat**	**92**
	Tomato	2013[†]	3.4	Borneo	*	*	*	**51**	**62**	**130**
WFT	Pepper	2011	3.5	-	48	50	54	52	81	82
	Pepper	2012	3.5	Pyrethrum	*	*	*	**01**	**62**	**Nat**
	Pepper	2014	3.4	Calypso	**200**	-	-	-	-	-
Whitefly	Tomato	2011	3.4	-	54	60	-	52	62	92
	Tomato	2012	3.4	Chess	**54**	**106**	-	**01**	**62**	**130**
	Tomato	2013[†]	3.4	Chess	*	*	*	**51**	-	-

* – no products in this category evaluated. Che – Chess; Lep- Lepinox Plus; Nat – Naturalis-L

See Table 4 footnotes. Please see individual experiment reports, within the annual reports, for full details.

† - Tested in combination with macrobiologicals.

† - Bioinsecticides evaluated in combination with release of natural enemies.

Table 6a. Leading novel herbicide products[a] identified for crop safety to field vegetables, Lincolnshire. Pre = applied pre-emergence of drilled crop or pre-transplanting crop; post = post-emergence of drilled crop or post-transplanting crop; () possibly safe

Crop	2011		2012		2013				2014	
	pre	post	post	post	pre	pre	pre	post	pre	post
Drilled										
Broad bean	05			(123)		165	166			
Bulb onion		05	76	(123)	164	165	166	166		
Carrot	05	05	76		164		166	166		
Coriander	05	05	76				166			
Dwarf French bean	05				164	165	166		190	190
Leek		05	76	(123)	164	165	166	166		
Parsnip	05	05	76				166	166		
Pea	05			(123)		165	166			
Transplanted										
Cauliflower	05					165	166			
Celery	05	05	76				166	166		
Courgette	NT	NT	NT	NT		165	166		190	190
Lettuce	(05)	(05)		(123)			166			

NT not tested.

[a] 05 tested pre-and post-weed emergence in 2011; 123 (at low doses); 164, 165 and 166 tested pre- and post-weed emergence in 2013. 165 did not control emerged weeds. 76 (500 g/L formulation) was tested post-weed-emergence in 2012; it was tested further (400 g/L formulation, as 191) pre and post weed emergence of Umbelliferous crops in 2014 (see Table 6b).

Please see Sceptre Annual Reports for full details. A gap in the above table indicates the treatment was not safe to the test crop. Post-drilling/planting application of 164 was not safe to any of the listed crops.

For mizuna, rocket, swede and baby leaf spinach, no safe solutions were identified.

Table 6b. Leading novel herbicides identified for crop safety to courgette and six umbelliferous crops – 2014

	165	190		191		Benfluralin
	Pre	Pre	Post	Pre	Post	Pre
<u>Drilled</u>						
Carrot				✓	✓	✓
Coriander				✓	✓	
Flat leaf parsley				✓	(✓)	
Parsnip				✓	✓	✓
<u>Transplanted</u>						
Celeriac				✓	✓	✓
Celery				(✓)	(✓)	✓
Courgette	✓	✓	✓			✓

Pre – pre weed emergence; post – post weed emergence; ✓ - safe; (✓) slight damage.
See Science Section for range of weed species controlled by each herbicide. 165 and 190 not safe to umbellifers; 165 does not control emerged weeds.

Table 6c. Leading novel products (product name or code number in numerical order) identified for control of weeds: 2011-2014

Target	Crop/weed	Year	Exp. Ref.	Reference product	Leading 3 products					
					Herbicides			Bioherbicides		
Field vegetables										
Annual weeds	Cauliflower	2012	1.10	Rapsan + Gamit	74	DG	SA	*	*	*
	Cauliflower	2013	1.9	Rapsan + Gamit	A	B	-	*	*	*
	Cauliflower	2014	1.12a	Wing P + Butisan S + Gamit	E	-	-	*	*	*
	Leek	2013	1.9	Wing P + Defy	C	D	-	*	*	*
	Onion	2012	1.10	Stomp Aqua	WP	DG	-	*	*	*
	Onion	2014	1.11	Wing P	165	191	-	*	*	*
Fruit										
Annual weeds	Mixture	2012	1.12	Rosate 36	*	*	*	116	-	-
		2013	2.7	Shark	124	-	-	109	116	-
Perennial weeds	Dock	2011	2.4	-	R+S	72	102	-	-	-
	Dock	2012	1.12	Rosate 36	124	-	-	116	-	-
	Dock	2013	2.8	Rosate 36	124	-	-	109	116	-
	Nettle	2011	2.4	-	R+S	72	102	-	-	-
	Nettle	2012	1.12	Rosate 36	124	-	-	-	-	-
	Nettle	2012	2.7	Roundup	72	-	-	*	*	*
	Nettle	2013	2.8	Rosate 36	124	-	-	109	116	-
	Thistle	2011	2.4	-	R+S	72	102	-	-	-
	Thistle	2012	1.12	Rosate 36	124	-	-	116	-	-
	Thistle	2012	2.7	Roundup	72	109	135	*	*	*

* – no products in this category evaluated.

Please see individual reports, within the Annual Sceptre reports, for details.

A – Wing P + Dual Gold + Gamit 36CS + Kerb Flo; B – Rapsan 500 (in row) with Wing P + Dual Gold + Gamit 36CS + Kerb Flo between rows; C – Wing P (in row) with Wing P + Defy between rows; D – Wing P (in row) with Stomp Aqua + Defy between rows; E – Springbok over crop roots with Wing P + Dual Gold + Gamit 36CS between rows.

DG – Dual Gold; SA – Stomp Aqua; WP – Wing P; R+S – Roundup + Shark.

Field vegetables

1.1 Brassica (swede): evaluation of fungicide and biofungicide programmes for control of powdery mildew (transplant field trial, Lincs; ADAS)

A field trial was conducted in Lincolnshire in summer 2014 to evaluate five fungicide and three integrated fungicide and biofungicide programmes for control of powdery mildew (*Erysiphe cruciferarum*) on swede cv. Emily. An untreated control and a grower standard, Rudis (prothioconazole), were included. Conventional fungicides (Talius, Rudis, Cassiopeia, 25a, 89) were applied three times at 20 day intervals. In the integrated programmes biofungicides were applied four times in alternation with Rudis at 10 day intervals resulting in seven sprays in total. Powdery mildew occurred naturally and was first observed on 14 July, the same day plants were also inoculated, and increased to affect 27% leaf area on untreated plants by 12 August. All treatments significantly reduced the disease. The programme Serenade ASO/Rudis had least disease (5.7% LAI) and appeared slightly better than Rudis alone (9.5% LAI). On 3 September, one week after the final spray, four programmes (Rudis; Serenade ASO/Rudis; biofungicide 11/Rudis and biofungicide 105/Rudis) had reduced powdery mildew to around 3% LAI compared with 14% on untreated plants. Programmes of three sprays of 28, Talius, 89 or 25a all reduced the disease to 5-9% LAI; only Cassiopeia was ineffective. No phytotoxic symptoms or vigour differences were observed.

1.2 Brassica (cabbage): evaluation of fungicide and biofungicide programmes for control of ring spot (transplant field trial, Lincs; ADAS)

A field trial was conducted in Lincolnshire in autumn 2014 to evaluate two conventional fungicides (Cassiopeia and 25a), two biofungicides (90 and Serenade ASO), three programmes of fungicides applied in alternation and one programme of fungicides and a biofungicide used as a mixture for control of ring spot (*Mycosphaerella brassicicola*) and other leaf diseases on cabbage cv. Caraflex. Conventional fungicides were applied as programmes of five sprays at 2-3 week intervals; biofungicides as programmes of nine sprays at 1-2 week intervals. An untreated control and a grower standard of Amistar (azoxystrobin) alternating with Rudis (prothioconazole) were included. Brassica leaf debris affected by ring spot was placed on the soil between plots on 27 August and 29 September 2014. Ring spot was confirmed on 14 October, 3 weeks before the final spray, and soon became widespread. On 11 November, ring spot affected 35% of untreated plants and was reduced by all treatments except Serenade ASO; the grower standard, a programme of Signum (boscalid +

pyraclostrobin)/Rudis, a programme of Nativo 75WG (tebuconazole + trifloxystrobin)/Rudis and Cassiopeia were most effective, all reducing ring spot incidence fo 3%. Disease severity on untreated heads was low (1.3%) and was reduced by all treatments; most treatments reduced it to 0.1 – 0.2%. White blister (*Albugo candida*) affected 5% of untreated plants and was absent on plants treated with conventional fungicide Cassiopeia. No symptoms of phytotoxicity were observed with any of the treatments.

1.3 Leek: evaluation of fungicide and biofungicide programmes for control of rust (field trial, Lincs; ADAS)

A field trial was conducted in summer 2014 in Lincolnshire to evaluate the efficacy of conventional fungicide and biofungicide programmes for control of rust (*Puccinia allii*) on leek cv. Prelina. An untreated control and a grower standard programme alternating Amistar Top (azoxystrobin + difenoconazole), Rudis (prothioconazole) and Nativo 75 WG (trifloxystrobin + tebuconazole) were included. Conventional fungicides (except 47) were applied four times at 20 day intervals; 47 and biofungicide 105 were applied eight times at 10 day intervals, commencing 10 days before the first conventional fungicide spray application. A high incidence (100%) and moderate severity (4.2% LAI) developed on untreated plants. All treatments reduced both disease incidence and severity. The five best treatments had <0.1% leaf area infected at 2 weeks after the final spray compared with 4.2% on untreated plants; these were: grower standard, Rudis, 31, 118 and an alternating programme of Cassiopeia (dimethomorph + pyraclostrobin) and 31. Biofungicide 105 reduced the disease to 0.8%. No evidence of phytotoxicity or differences in crop vigour were observed. Fungicide 31 provides a new mode of action group for rust control and would be useful for resistance management, for use in conjunction with triazole and strobilurin fungicides currently used against leek rust.

1.4 Spring onion: evaluation of fungicide and biofungicide programmes for control of downy mildew (field trial, Warwicks; ADAS)

A field trial was conducted in summer 2014 to evaluate 10 programmes of conventional fungicides and two of conventional fungicides and biofungicides for control of downy mildew (*Peronospora destructor*) on spring onion cv. Photon. An untreated control and a grower standard were included; the latter comprised sprays of Invader (dimethomorph + mancozeb) + Amistar (azoxystrobin), Invader + Signum (boscalid + pyraclostrobin), Invader + Olympus (azoxystrobin + chlorothalonil) and Invader + Switch (cyprodinil + fludioxonil). Sprays were applied at 7 day intervals from

25 July (biofungicides) or 7 August (conventional fungicides). Programmes of conventional fungicides consisted of five spray applications; those utilising biofungicides had seven. Disease was severe with 37% leaf area affected on untreated plants at 4 days after the final spray timing, rising to 76% after 15 days. At 4 days after the final spray, disease severity was reduced by the grower standard (21% leaf area affected) and nine other programmes. A programme of 197 + Cassiopeia alternating with 197 + 23 was the most effective, with only 7% leaf area affected at 15 days after the final spray. A programme of biofungicide 40 (3 sprays) followed by Cassiopeia and finishing with biofungicide 40 significantly reduced downy mildew compared with the untreated. Only two treatments reduced downy mildew to a commercially acceptable level (<10% severity) at 4 days after the final spray; both utilised a mixture of two conventional fungicides at each application. No phytotoxicity was observed with any treatment.

1.5 Leek: evaluation of insecticides and bioinsecticides for control of thrips (field trial, Warwick Crop Centre)

One field trial was conducted in 2014 to evaluate the efficacy of six insecticides and four bioinsecticides for control of onion thrips (*Thrips tabaci*) on leek cv. Surfer. Insecticides were applied at 14 day intervals and bioinsecticides at 7 day intervals from the first sign of pests (early July) with 4 and 7 sprays respectively. Tracer (spinosad) was included as a standard. Damage by thrips was low with 11% leaf area affected on untreated plants. There were no differences between treatments. Leek moth caterpillar (*Acrolepiosis assectella*) also occurred and affected 87% of untreated plants. Damage by this pest was reduced by all treatments. Conventional insecticides 50, 198 and 200 were all more effective than the standard treatment, Tracer. Bioinsecticides 62 and 130 were more effective than bioinsecticide 61 and comparable to Tracer.

1.6 Lettuce: evaluation of insecticides and bioinsecticide for control of aphids and caterpillars (field trial, Warwick Crop Centre)

Two field trials were conducted in 2014 to evaluate the efficacy of three conventional insecticides and three bioinsecticides for control of currant-lettuce aphid (*Nasonovia ribisnigri*) and caterpillars on lettuce cv. Lobjoits Green Cos. Sprays of conventional insecticides were applied once (Trial 1) or twice (Trial 2) at 14 day intervals after aphid colonisation; sprays of bioinsecticides were applied twice (Trial 1) or three times (Trial 2) at 7 day intervals. Conventional insecticide 50 was applied as a spray and, in a separate treatment, as a pre-plant treatment dripped onto the peat blocks. Movento (spirotetramat) was included as a standard for aphid control. In Trial 1 there was a moderate infestation of aphids. At the first assessment one week after spray application, conventional insecticides Movento, 50 (spray), 50 (pre-plant), 59 and 60 and bioinsecticide 130 all reduced aphid numbers. Movento, 50 (spray) and 59 were the most effective. Seventeen days later Movento and bioinsecticide 130 still had lower numbers of aphids than the untreated control. In Trial 2 there was moderate infestation of aphids. The same pattern of control was observed although treatment differences were not quite significant at the 5% level. No caterpillars occurred.

1.7a Brassicas: evaluation of insecticides and bioinsecticide for control of aphids and caterpillars (field trial, Warwick Crop Centre)

Two field trials (one for conventional insecticides and one for bioinsecticides) were conducted in 2014 to evaluate products for control of cabbage aphid (*Brevicoryne brassicae*) and caterpillars on Brussels sprout cv. Faunus. Conventional insecticides were applied twice (16 day interval) and bioinsecticides three times (7 day intervals) from the first sign of pests. Movento (spirotetramat) and Steward (indoxacarb) were included as standards for aphids and caterpillars respectively. There was a moderate level of aphids and low levels of caterpillar (mostly small white butterfly, *Pieris rapae*) and whitefly (*Aleyrodes proletella*) on untreated controls. For both aphids and caterpillars, treatment differences were not quite significant at the 5% level. Conventional insecticides Movento and 59 and bioinsecticide 130 appeared to reduce aphid levels; conventional insecticides Steward, 48, 50, 67 and 200 and bioinsecticide 68 appeared to reduce caterpillars. All conventional insecticides (48, 50, 59, 67, 200) and none of the bioinsecticides reduced a low infestation of whitefly.

1.7b Brassicas: evaluation of insecticides and bioinsecticides for control of cabbage root fly (field trial, Warwick Crop Centre)

A field trial was conducted in summer 2014 to evaluate the efficacy of four conventional insecticides and three bioinsecticides for control of cabbage root fly (*Delia radicum*) on cauliflower cv. Skywalker. Results were compared with an untreated control and with a standard insecticide, Tracer (spinosad). Treatments were applied as a pre-plant drench and modules were planted in the field 1 day later. For bioinsecticide 94 only, a repeat drench application was made 2 weeks after planting. Cabbage root fly eggs were laid in high numbers by a field population of the pest. At 5 weeks after planting, all conventional insecticides (Tracer, 50, 198, 199, 200) and one bioinsecticide (130) had reduced root damage; three conventional insecticides (198, 199, 200) also reduced stem damage. Tracer, 198 and 199 resulted in increased root and foliage weight.

1.8 Courgette transplants: evaluation of herbicides for control of weeds and crop safety (field trial, Lincs; ABC)

A field trial was conducted in 2014 on a light, sandy silt loam soil in Lincolnshire to evaluate four novel herbicides (165, 190, 191, benfluralin) applied either alone or in mixture with registered herbicides for crop safety to transplants of courgette cv. Milos and weed control. The most effective and crop safe treatments applied within 7 days of transplanting (pre-weed emergence) were herbicides 165 at 2 L/ha and 190 at 35 g/ha. Herbicide 190 controlled a wide weed spectrum including groundsel, small nettle and redshank; herbicide 165 was excellent on annual meadow grass, groundsel, mayweed, small nettle and fat-hen. Herbicides 165, 190 and Gamit 36CS (clomazone) all controlled groundsel and are in different classes of chemistry and so are potentially useful to avoid herbicide resistance development in this weed. Gamit 36CS (EAMU for use on courgette) was useful in a programme following soil incorporation of benfluralin pre transplanting; it was safe in a tank mix with 165 or 190. Neither 165 or 190 controlled knotgrass. Herbicide 191 caused severe scorch and was not safe. Herbicides 165 and 190 are promising herbicides with potential for use on courgette. All treatments containing pendimethalin (Wing P, Stomp Aqua) applied over the top of courgettes remained weed-free but affected the growing point and killed the crop.

1.9 Umbelliferous crops: evaluation of herbicides for control of weeds and crop safety (field trial, Lincs; ABC)

A field trial was conducted in 2014 on a light, sandy silt loam soil in Lincolnshire to evaluate two herbicides 191 (a new alternative to linuron) and benfluralin applied alone and in programmes or in tank mixtures, for crop safety and weed control in six umbellifers (carrot cv. Nairobi, parsnip cv. Palace, coriander cv. Filtro, flat-leaf parsley cv. Rialto, celery cv. Plato and celeriac cv. Prinz). Benfluralin at 2.0 kg/ha was safe to carrots and parsnips when incorporated into the soil pre-sowing, and to celery and celeriac when soil-incorporated pre-transplanting. It gave good control of Polygonums, fat-hen and annual meadow-grass. Benfluralin did not control groundsel, shepherd’s purse, mayweed and fool’s parsley, but Gamit 36CS (not safe on parsnip) as a follow-up pre-emergence treatment was effective on these species. Linuron will be withdrawn 31 July 2016 and cannot be used after 31 July 2017. On carrot, the linuron alternative 191 caused no damage when applied pre-emergence at 2 L/ha alone or in tank-mix with Stomp Aqua (or Anthem) + Gamit 36CS; 191 was also safe applied at 1-2TL post-emergence (1.25 L/ha). On parsnip 191 applied pre-emergence at 2 L/ha alone or in tank-mix with with Stomp Aqua (or Anthem) were safe, but the addition of Goltix Flowable at 3 L/ha (to control groundsel) resulted in severe damage (1.5 L/ha was safer); 191 was also safe applied at 1TL post-emergence (1.25 L/ha). On coriander 191 was very safe applied pre-emergence at 1.25 L/ha alone, and early post-emergence at the same rate. On flat-leaved parsley 191 was safe applied pre-emergence at 1.25 L/ha but caused severe scorch and stunting when applied post-emergence, even as a split dose. In celery 191 applied soon after transplanting before weeds emerged in tank-mix with Gamit caused some transient scorch. The best treatment post-weed-emergence was with Defy + 191. Celeriac transplants were more tolerant of herbicides than celery. Here the best safe pre-weed-emergence treatment was with Stomp Aqua + Gamit 36CS + 191 although this also caused transient bleaching from Gamit and scorch from 191. Sencorex Flow at 0.233 L/ha applied when weeds were 1-2TL was promising and plots were weed-free until mid-September. Applied pre-weed-emergence alone 191 failed to control redshank or red dead-nettle, and groundsel control was incomplete and partners were needed. Post-weed-emergence 191 needs to be applied when weeds are small (<2 true leaves); applied at 1.25 L/ha post weed emergence it controlled small nettle, chickweed, annual meadow-grass, shepherd's purse, fat-hen, mayweed and field pennycress. Weaknesses were on red dead-nettle, field speedwell and Polygonums. For volunteer potato control in carrot and parsnip with a repeat treatment with a tank-mix of Defy + 191, the dose of 191 at 0.625L/ha was inadequate.

1.10 Field vegetables: evaluation of herbicides for crop safety and weed control (field trial, Lincs; ABC)

Field trials were conducted in 2014 on a silt loam soil to evaluate one conventional herbicide (190, a sulfonylurea) applied pre or post weed emergence at a range of dose rates for weed control and crop safety in 15 crops. Additionally, 'volunteer' potatoes were planted to determine if the herbicide suppressed their growth. Untreated control plots were included for comparison. The test herbicide has both soil residual and foliar activity. There were frequent and some very heavy showers in May, after application of the pre-emergency treatment, which would have both enhanced efficiency of residual activity and increased risk of crop damage due to herbicide leaching. Herbicide 190 was found to have good potential for use in courgettes transplants, drilled dwarf French beans and potatoes. The product caused severe damaged when used either pre-emergence / pre-transplanting or post-emergence/post-transplanting to broad beans, celery, coriander, leek, lettuce, onion, parsnip, pea, rocket, spinach or swede; cauliflower transplants survived probably because the planter pushed herbicide-treated soil aside in the row. Carrots suffered severe damage from 190 applied pre-emergence; 35 g/ha post-emergence may be safe. Herbicide 190 gave excellent control of groundsel both pre and post-emergence. Applied pre-emergence it was also very effective on small nettle, red dead nettle, chickweed, annual meadow-grass and redshank. It was less effective when applied post-emergence.

1.11 Alliums: evauation of herbicides for control of weeds and crop safety (field trial, Lincs; ABC)

A field trial was conducted in 2014 on a gravelly sand loam soil in Bedfordshire to evaluate three novel herbicides (165, 191, 196), applied alone or as components of spray programmes with registered herbicides, for weed control and crop safety to drilled bulb onion cv. Red Baron. The main weeds were volunteer oilseed rape, creeping buttercup, fat hen, small nettle and annual meadow grass. Herbicide 165 applied pre-emergence was safe to onion but poor on weed control. Herbicide 191 applied post-emergence, after Wing-P (pendimethalin + dimethenamid P) applied pre-emergence, gave both good weed control and was crop safe. Herbicide 196 applied post-emergence after use of Wing-P pre-emergence was an equally good programme. Herbicides 165 and 191 gave transient phytotoxicity symptoms.

1.12a Brussels sprouts: evaluation of herbicides for weed control and crop safety (field trial, Lincs; ABC)

A field trial was conducted in 2014 to evaluate a banded spray herbicide treatment for control of weeds and crop safety in a June-planted crop of Brussels sprouts cv. Victoria on a silt soil in Lincolnshire. Springbok (metazachlor + dimethenamid-P) was applied over crop rows and Wing P (dimethenamid-P + pendimethalin) + Dual Gold (metolachlor) + Gamit 36 CS (clomazone) was applied between crop rows in a single pass 4 days after planting. Treatment was compared with a commercial standard of Wing P applied pre-planting and Butisan S (metazachlor) + Gamit 36 CS applied over whole plots 4 days after planting. An untreated control was also included. Planned inter-row electrial weeding and cultivation to supplement the herbicide treatments were not applied due to rapid weed growth in warm wet weather, beyond the appropriate growth stages for treatment. The main weeds were black bindweed, fat hen, annual nettle and redshank. Both the commercial standard and the banded spray treatment gave good weed control compared with the untreated; there was no significant difference between the commercial standard and band spray. The two treatments both caused slight phytotoxicity but plants grew away satisfactorily.

1.12b Leeks: evaluation of herbicides and electrical treatment for weed control and crop safety (field trial, Lincs; ABC)

A field trial was conducted in 2014 to evaluate a banded spray herbicide treatment combined with inter-row electrical weeding for control of weeds and crop safety in an April planted crop of leeks cv. Pluston on a sandy clay loam soil in Lincolnshire. The experimental treatment consisted of a pre-emergence spray of Wing P (dimethenamid P + pendimethalin) over rows and Stomp Aqua (pendimethalin) + Defy (prosulfocarb) + Intruder (chlorpropham) between rows, followed by electrical weeding at two-true leaf stage and two subsequent herbicide sprays, Basagran (bentazone) + Tortril (ioxynil) + Starane 2 (fluroxypyr) and Basagran + Tortril. The commercial standard spray programme comprised a pre-emergence spray of Wing P and four post-emergence sprays: Stomp Aqua + Better DF (chloridazon) + Tortril; Defy + Better DF + Tortril; Tortril + Afalon (linuron) and Basagran + Tortril. No untreated was included. The main weeds were black bindweed, redshank, groundsel, creeping thistle, mayweed and nettle. Both treatments resulted in relatively poor control with 66-79% of plot areas covered by weeds at the final assessment; there was no difference between the two treatments at any of the assessments. None of the herbicide treatments caused phytotoxicity; the electrical weeder caused death of leek plants at a few points where rows were not straight.

Soft fruit

2.1 Raspberry: evaluation of fungicides and biofungicides for control of spur blight (pot grown plant work, Kent; EMR)

An inoculated trial was established in autumn 2014 to evaluate the efficacy of Signum (pyraclostrobin + boscalid), Switch (cyprodonil + fludioxonil), six other conventional fungicides and five biofungicides for control of spur blight (*Didymella applanata*) on container-grown raspberry cvs Glen Ample and Octavia in Kent. An untreated control and a grower standard, Folicur (tebuconazole) were included. Conventional fungicides were applied once and biofungicides twice at the onset of leaf senescence and immediately prior to the introduction of infector plants into the trial. Plants will be assessed for cane lesions in spring 2015; results will be reported separately from this report, in summer 2015.

2.2 Strawberry: evaluation of fungicide and biofungicide products and application method for control of crown rot (polytunnel trial, Kent; EMR)

An inoculated trial was established in spring 2014 to evaluate the effect of plant protection product and application method on control of crown rot (*Phytophthora cactorum*) in strawberry cv. Malling Opal grown in peat bags in a polytunnel. Three conventional fungicides and two biofungicides were each examined as a pre-plant dip, a post-plant drench and a post-plant spray. Conventional fungicides were applied once and biofungicides three times at 14 day intervals. The biofungicide pre-plant dip treatments were followed by two drenches. An untreated control and a grower standard, Paraat (dimethomorph) were included. Visual symptoms suggestive of crown rot occurred in October and affected 38% of untreated plants. Levels of dead and dying plants in other treatments at this time ranged from 23% to 42%. None of the treatments reduced crown rot visual symptoms compared with the untreated control. Plants were dug up in December/January and examined for staining typical of *P. cactorum* infection within the crown. Results will be reported separately.

2.3 Strawberry: evaluation of fungicide products for control of powdery mildew (polytunnel trial, Kent; EMR)

A field trial was conducted in summer 2014 to evaluate the efficacy and crop safety of 10 conventional fungicides for control of powdery mildew (*Podosphaera aphanis*) on post-harvest re-growth of strawberry cv. Elsanta in a soil-grown polytunnel crop in Kent. An untreated control and a grower standard Systhane 20EW (myclobutanil) were included. Sprays were applied six times mostly at 7 day intervals. Powdery mildew was assessed 1 week after the fifth spray application. At this time the disease affected 24% leaf area on untreated plants. All treatments reduced mildew compared with the untreated control. Seven products (Talius, 17, 25a, 77, 118, 159 and 177) were more effective than Systhane 20EW. Systhane 20EW reduced mildew by 80% and fungicides Talius and 77 gave complete control. No phytotoxic symptoms or crop vigour differences were observed.

2.4 Strawberry: evaluation of biofungicide products for control of powdery mildew (polytunnel trial, Kent; EMR)

A field trial was conducted in summer 2014 to evaluate the efficacy and crop safety of 10 biofungicides for control of powdery mildew (*Podosphaera aphanis*) on newly planted strawberry cv. Elsanta in a soil-grown polytunnel crop in Kent. An untreated control and a grower standard, Systhane 20EW (myclobutanil) were included. Sprays were applied six times at 7 day intervals. Powdery mildew was assessed on 20

August, 1 week after the fourth spray application. At this time, powdery mildew affected 33% leaf area on untreated plants. All treatments reduced mildew compared with the untreated control. Biofungicides 6 and 105 were as effective as the standard fungicide Systhane 20EW; none were better. The level of control achieved by Systhane 20EW in this trial was relatively poor (around 50% reduction). No phytotoxic symptoms or crop vigour differences were observed. Biofungicide 105 reduced Mucor fruit rot at harvest (from 6.7% to 3.4%) whereas no product reduced this disease, or Botrytis fruit rot, in post-harvest tests. None of the treatments affected fruit yield.

2.5 Raspberry: evaluation of bioinsecticides and macrobiologicals for control of large raspberry aphid (polytunnel trial, Tayside; JHI)

A field trial was conducted in 2014 to evaluate two insecticides and two bioinsecticides used in conjunction with macrobiologicals for control of large raspberry aphid (*Amphorophora idaei*) and potato aphid (*Macrosiphum euphorblae*) in a polytunnel crop of raspberry cv. Glen Ample in Scotland. Treatments were compared with a water control and the standard insecticide Calypso (thiacloprid). There were moderate levels of both pests on untreated plants. All products (Calypso, 50, 59, 62, 130) reduced the level of potato aphid and all except insecticide 50 reduced large raspberry aphid. All products were compatible with introduced parasitoid wasps (*Aphidius ervi* and *Aphidus abdominalis*). When potato aphids were most abundant, conventional insecticide 50 and bioinsecticides 62 and 130 were as effective as Calypso. When large raspberry aphids were most abundant, conventional insecticide 59 was the best product, giving almost complete control of both adults and nymphs. Cane height was not affected by the treatments and all plots produced high quality fruit in large quantities.

2.6 Strawberry: evaluation of pesticides for control of European tarnished plant bug (*Lygus rugulipennis*) (field trial, Kent; EMR)

A field trial was conducted in summer 2014 to evaluate two conventional insecticides (59 and Steward) for control of European tarnished plant bug (*Lygus rugulipennis*) on strawberry cv. Flamenco. Steward was used at half rate in mixture with a wetter, Silwet-L77. An untreated control and two grower standard insecticides, Chess WG (pymetrozine) and Equity (chlorpyriphos), were included. Flowering plants were planted in strips on two sides of each plot to encourage *L. rugulipennis* into the area; weeds were also present surrounding the strips. Weeds were strimmed on 30 July 2014 and flowering plants on 5 August to encourage the pest to move onto the strawberry crop. High levels resulted. All treatments reduced the mean number of *L.*

rugulipennis nymphs, with Equity consistently the most effective (85% reduction). The coded insecticide 59 and Steward, reduced numbers of nymphs by 30-40%, comparable to Chess. Equity and Steward were the only products that reduced numbers of adults compared with the untreated. All treatments reduced fruit damage with Equity the most effective. Treatments may be more effective when applied to larger areas than the 25 m length x 1 bed plots as used in this work due to reduced immigration of adults. No symptoms of phytotoxicity were observed.

2.7 Strawberry: evaluation of herbicides for crop safety (polytunnel trial, Cambridgeshire; ADAS)

A field trial was conducted in summer 2014 to evaluate the crop safety of one conventional herbicide to protected strawberry cv. Elsanta grown in coir bags in Cambridgeshire. A grower standard treatment Dual Gold (S-metolachlor) and an untreated control were included. Herbicide 165 caused no phytotoxicity symptoms and had no effect on total or marketable fruit yield when applied over the crop either 1 day or 10 days after planting.

2.8 Strawberry: evaluation of herbicides for control of runners (field trial, Cambridgeshire; ADAS)

A field trial was conducted in autumn 2014 to evaluate the efficacy of herbicides for control of runners and weeds in alleyways of strawberry cv. Elsanta grown in the soil in Cambridgeshire. An untreated control and a grower standard Harvest (glufosinate ammonium) were included. Conventional herbicide 124 + adjuvant and bioherbicide 109 were each applied twice at a 14 day interval in September; Harvest was applied once. Conventional herbicide 124 + adjuvant was evaluated at two rates. At the final assessments 36% of untreated alleyway ground area was covered by runners and 12% by weeds. All treatments reduced alleyway ground area covered by runners compared with the untreated; products 109 and 124 (4-10% alleyway area covered) were as effective as the standard herbicide, Harvest (4%). All treatments also reduced weeds compared with the untreated and were equivalent to Harvest. Although not significantly different from the other herbicide treatments, Harvest appeared to give the best runner and weed control. The two rates of conventional herbicide 124 used in this experiment showed no difference in efficacy. Harvest resulted in almost complete scorch of green tissues and death of some runners; herbicides 109 and 124 significantly scorched foliage and reduced runner coverage but did not appear to kill runner crowns.

2.9 Blackcurrant: evaluation of an electrical treatment for control of perennial weeds (field trial, Norfolk; ADAS)

A field trial was conducted in spring 2014 to evaluate the efficacy of electrical weed control using a tractor-mounted, shielded high power electrode for control of perennial weed species in a blackcurrant crop in Norfolk. The main weed species were creeping thistle (*Cirsium arvense*) and stinging nettle (*Urtica dioica*). Three voltages (3.5, 6.5 and 7.5 KV) were compared using a single pass at 4.3 kph. The low and medium voltages (5.5 and 6.5 KV) controlled creeping thistle but did not affect stinging nettle. The high voltage controlled all weeds touched by the probe. Stinging nettles recovered around 6 weeks after treatment with re-growth from the base. There was no effect on weeds not directly touched by the probe. Leaf wilting and leaf and stem browning occurred where the probe touched young blackcurrant branches, at all voltages. At 6 weeks after treatment death of some individual branches was noted; the rest of the bushes were unaffected.

Protected edibles

3.1. Cucumber: evaluation of fungicides and biofungicides for control of black root rot (rockwool crop trial, Yorkshire; STC)

3.1a 2013 trials

Two inoculated short-duration glasshouse trials were conducted in winter 2013 to evaluate the efficacy and crop safety of 12 conventional fungicides (Trial 1) and eight biofungicides (Trial 2) for control of black root rot (*Phomopsis sclerotioides*) in cucumber cv. Shakira grown in rockwool blocks in trays. Treatments were compared with an untreated control; currently there is no grower standard treatment or approved product for this disease. Limited information was available on appropriate rates of use for the products as drench treatments in a hydroponic crop. Conventional fungicides were applied twice, once before and once after inoculation; biofungicides were applied twice before and once after inoculation. The first application of biofungicides was at the cotyledon stage due to poor germination when applied at sowing. All treatments were applied as 65 ml drenches to the rockwool propagation block. Plants were inoculated by placing agar-bearing mycelium of *P. sclerotioides* onto roots. Minimal symptoms of black root rot had developed in either trial after 1 month so no conclusions could be drawn on product efficacy. Eight of the conventional fungicides and four of the biofungicides caused obvious phytotoxicity at the rates and timings used. The conventional fungicides were subsequently tested for inhibition of mycelial growth in agar plate tests. All of the products significantly reduced *P. sclerotioides* growth; eight products gave complete inhibition at 100 ppm ai; products 37 and 175 gave complete inhibition at 2 ppm ai.

3.1b 2014 trial

An inoculated long-duration glasshouse trial was conducted in summer 2014 to evaluate the efficacy and crop safety of eight conventional fungicides and two biofungicides for control of black root rot (*P. sclerotioides*) in cucumber cv. Shakira grown on rockwool slabs. The disease was established in a first crop (June – August) and a second crop (September – October) was then grown on the same slabs and re-inoculated with the pathogen 5 days after planting by application of 2 x 3 ml of dispersed mycelium to the base of each slab; the main disease assessment was on the second crop. Conventional fungicides and biofungicide 98 were applied four times to the first crop (at planting and then at 3 week intervals) and twice to the second crop (at 2 and 5 weeks after placement of plants on the slabs). Biofungicide 178 was applied seven times to the first crop (at planting and then at 10 day intervals) and four times to the second crop (2 weeks after planting and then at 10 day intervals). All products were applied as drenches to the rockwool block at 500 ml/plant. Symptoms typical of black root rot were seen on roots remaining in the slab at removal of the first crop. Wilt symptoms developed in the second crop 3 weeks after inoculation. Wilting was significantly reduced by conventional fungicides 37, 46, 139, 175 and 176; neither of the biofungicides nor conventional fungicides 10 and 47 reduced wilting. The effective conventional fungicide treatments also resulted in greater root vigour and reduced root rot symptoms. Two of these products (37 and 175) resulted in transient leaf phytotoxicity after the first application in the first crop; no phytoxicity was observed in the second crop.

3.2. Cucumber: evaluation of fungicides and biofungicides for control of Pythium root and stem base rot (rockwool crop trial, Yorkshire; STC)

A glasshouse trial was conducted in summer 2014 to evaluate seven conventional fungicides and two biofungicides for control of Pythium root and stem base rot (*Pythium aphanidermatum*) in cucumber cv. Shakira grown on rockwool slabs. A water-only treatment and a standard fungicide Previcur Energy (propamocarb-HCI + fosetyl-AI) were included. Products were drenched onto blocks at 500 ml/plant. Conventional fungicides and biofungicide 98 were applied four times to crop 1 and twice to crop 2 at 3 week intervals. Biofungicide 189 was applied seven times and four times to crops 1 and 2 respectively at 7-12 day intervals. Both the first and second crops were inoculated with *P. aphanidermatum*, 11 and six days after the first treatment application respectively. Pythium infection was confirmed in both crops although symptom severity was slight. Compared with the inoculated control, root discolouration was reduced by conventional fungicides 46 and 139 in crop 1 and by Previcur Energy in crop 2. Transient wilting in crop 1 was reduced by most of the conventional fungicides. Incidence of stem base rot was low and no plants died. Neither biofungicide reduced disease symptoms. Mild transient phytotoxicity symptoms occurred after the first application of Previcur Energy, 46, 47 and 139 in crop 1; however, plants grew out of these effects and no further symptoms occurred in either crop. There were no differences between treatments in fruit yield.

3.3. Pepper: evaluation of bioinsecticides for control of aphids (glasshouse trial, Yorkshire; STC)

A glasshouse trial was conducted in summer 2014 to evaluate the efficacy and crop safety of four bioinsecticides for control of foxglove aphid (*Aulacorthum solani*) on pepper cv. Ferrari. An untreated control and a standard insecticide Chess (pymetrozine) were included. Chess was applied three times and the bioinsecticides four times at 7 day intervals. The pest was introduced to each plant before treatments commenced; a natural infestation of *Myzus persicae* also occurred before treatments commenced. Low to moderate levels of aphids developed on untreated plants. Both aphid species were reduced by Chess and bioinsecticides 62 and 130. There was no evidence of phytotoxicity from any of the treatments.

3.4. Pepper: evaluation of conventional insecticides and bioinsecticides for control of western flower thrips in pepper (glasshouse trial, Yorkshire; STC)

A glasshouse trial was conducted in summer 2014 to evaluate the efficacy and crop safety of one conventional insecticide and three bioinsecticides for control of western flower thrips (WFT) (*Frankliniella occidentalis*) on pepper cv. Ferrari. An untreated control and a standard insecticide Calypso (thiacloprid) were included. Calypso was applied twice and all other products four times at 7 day intervals. WFT were introduced into each plot prior to the first spray applications and a moderate-high population developed on untreated plants. At 6 days after the final spray, numbers of WFT nymphs were reduced by conventional insecticide 200; Calypso, 130 and 209 were ineffective. A natural infestation of aphids (*Myzus persicae*) occurred and was reduced by Calypso, conventional insecticide 200 and bioinsecticides 62 and 130. None of the treatments caused phytotoxicity.

Top fruit

4.1 Apple: evaluation of fungicide programmes for control of powdery mildew (field trial, Kent; EMR)

A field trial was conducted in 2014 to compare the efficacy of two fungicide programmes for control of powdery mildew (*Podosphaerea leucotricha*) on apple cvs Cox and Gala in an orchard in Kent. A standard fungicide programme based on Captan (captan), Cosine (cyflufenamid), Kumulus DF (sulphur), Stroby (kresoxim-methyl), Systhane 20EW (myclobutonil) and Topas (penconazole) was included. A common treatment of three sprays was applied up to blossom in all programmes for control of scab. Thereafter, from 30 April to 7 August, a series of 12 sprays was applied to the standard programme and the two experimental programmes. At the start of the trial the incidence of secondary mildew on extension growth was high (80% of leaves affected) on both cultivars. All three programmes steadily reduced mildew to around 10-20% leaves affected by 27 June. On cv Gala, Experimental programme 1, which included conventional fungicides Talius, 25a, 32 and 128, gave the best control, and the standard programme was the least effective, with 12% and 39% of leaves affected respectively at the final assessment. On cv. Cox the two experimental programmes (9-10% of leaves affected) appeared better than the standard programme (36% leaves affected). Experimental programme 1 reduced russet score on cv. Cox from 100 (standard programme) to 78. There were no phytotoxic effects observed on the trees or harvested fruits in any of the treatments.

4.2 Apple: evaluation of biofungicide and fungicide programmes for control of apple powdery mildew (field trial, Kent; EMR)

A field trial was conducted in 2014 to evaluate the efficacy of 10 fungicide and biofungicide programmes for control of powdery mildew (*Podosphaera leucotricha*) on apple cv. Cox in Kent. In each programme a series of 10 sprays was applied from the start of extension growth (22 May) until the end (28 July). An untreated control and a standard fungicide Systhane 20EW (myclobutanil) were included. In all programmes, conventional fungicides (two sprays) were used at the start to rapidly reduce the incidence of secondary mildew, and at the end (one spray) to reduce risk of infection of terminal buds. Biofungicides were used in the middle (sprays 3-9). Despite a pre-flowering fungicide programme, a high incidence of secondary mildew (80% of leaves) was present at the start of programmes. In all treatments the two sprays of conventional fungicide at the start reduced mildew to 20-40% leaves affected. In the eight programmes where biofungicides were used in the middle of the spray sequence, powdery mildew rapidly increased back to the starting level as programmes changed to biofungicides (7 sprays at 7 day intervals). Mildew incidence fell or remained the same following the final spray, which was a conventional fungicide. Best control was achieved with two ‘managed disease programmes’ where treatment switched to a conventional fungicide when mildew increased from the previous assessment. Managed programme A used 7 sprays of conventional fungicides and three of biofungicides; managed programme B used six and four respectively. Managed programmes A and B were more effective than the standard Systhane 20EW programme (35, 37 and 50% leaves affected respectively) and all three were better than the untreated (99% leaves affected). These three programmes, and also programmes using biofungicides 6 or 90, reduced fruit russet severity.

4.3 Stored pear: evaluation of biofungicides applied as post-harvest fruit dips for control of Botrytis rot (cold-store trial, Kent; EMR)

Two inoculated trials were conducted between September 2013 and April 2014 to evaluate biofungicide treatments for control of fruit rot (*Botrytis cinerea*) in stored pears cv. Conference. In Trial 1 fruit were stored in air at -1ºC; in Trial 2 they were stored in a controlled atmosphere (2% oxygen, 0% carbon dioxide) at -1ºC. Nine and three treatments were examined in Trials 1 and 2 respectively. Both trials included an inoculated untreated control dipped in water and a standard fungicide, Rovral WG (iprodione). In Trial 1, an uninoculated untreated control dipped in water was also included. Treatments were applied as a 1 minute dip, then allowed to drain before transfer to the stores within 30 minutes. Spread of Botrytis from inoculated to healthy fruit was good with 42% and 40% affected in Trials 1 and 2 respectively. In Trial 1 (air store), Botrytis rot was reduced by Rovral WG, Nexy and products 99 and 178. Rovral WG was the most effective (fruit rot incidence reduced to 20%). Biofungicide 178 was effective when used on ambient temperature fruit but not on cold fruit; Nexy was less effective on cold fruit. In Trial 2 (CA store), Rovral WG was again the most effective treatment (13% fruit affected) and biofungicide 178 also reduced the disease. Nexy and biofungicide 99 failed to reduce the disease in the CA storage trial. Possibly some of the biofungicides do not perform as well under CA storage conditions as in air due to the nature of the active substances.

Milestones

Milestone	Target month	Title	Status
2.4	48	<u>Disease and pest efficacy tests for Y4 completed</u>	
		Leek rust	Complete
		Leek thrips	Complete
		Lettuce aphid	Complete
		Lettuce caterpillar	Complete
		Raspberry cane diseases	In progress
		Strawberry crown rot	In progress
		Strawberry powdery mildew	Complete
		Strawberry *Lygus* sp.	Complete
		Cucumber black root rot	Complete
		Cucumber Pythium root rot	Complete
		Pear Botrytis	Complete
3.4	48	<u>Disease and pest IPM work for Y4 completed</u>	
		Brassica powdery mildew	Complete
		Brassica ring spot	Complete
		Spring onion downy mildew	Complete
		Brassica insect pests	Complete
		Raspberry aphids	Complete
		Pepper aphids	Complete
		Pepper WFT	Complete
		Apple powdery mildew	Complete
4.4	48	<u>Herbicide crop safety tests for Y4 completed</u>	
		Courgette	Complete
		Umbelliferous crops	Complete
		Field vegetables	Complete
		Alliums	Complete
		Strawberry	Complete
5.3	48	<u>Sustainable weed control work for Y4 completed</u>	
		Vegetables – electric + herbicide	Complete