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†, Passed away 13 December 2013.

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ADAS UK Ltd

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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.

GROWER SUMMARY

Headline

- Potential new plant protection products have been identified to fill many of the crop protection gaps on edible crops arising from changing legislation.

Background and expected deliverables

Numerous widely used conventional chemical plant protection products 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- some active substances were not supported by crop protection companies for economic reasons and were withdrawn from the pesticides review;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 plant protection products 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 list contains 77 candidates), as required under Regulation (EC) No. 1107/2009.

The effect of these measures on future availability of plant protection products, 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.

At around €300 million per compound, the cost of finding and developing new plant protection products is prohibitive for many crops. Horticultural crops are ‘minor crops’ in a global crop protection market and rarely the primary focus of new product development. Registration of products is complex, usually expensive and requires 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 plant protection product treatments that support sustainable production of edible crops. Opportunities available include:

- new chemical actives;
- a rapidly increasing number of biopesticides in the registration pipeline;
- 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 plant protection products 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 (pests, diseases and weeds) working across the major organizations currently delivering applied crop protection research.

Summary of the project and main conclusions

A total of 137 field, greenhouse and cold-store experiments to determine plant protection treatment efficacy and/or crop safety were conducted on 38 priority crop protection problems between October 2010 and March 2015 (Table 1). Additional trials in 2011 examined herbicide residues in field vegetable crops. The proportion of experiments by sector was: field vegetables 53%, soft fruit 23%, protected edibles 17% and top fruit 7%; the proportion of experiments by target was: diseases 36%, pests 39%, weeds 25%. The specific disease, pest and weed problems examined are detailed in Table 1.

Consultation was undertaken annually with around 25 companies marketing conventional chemical plant protection products and/or biopesticides to identify plant protection products of potential benefit to UK horticulture that might be included in project experiments. Only products where the active substance(s) were listed on Annex 1, had been submitted for listing, or there was a clear intention to seek listing, were considered for inclusion in SCEPTRE experiments. Decisions on which products to include in experiments were made by the project disease, pest and weed Research Management Groups, taking advice from HDC crop protection managers and a biopesticide consultant to the project on likelihood of products coming to the UK market.

Over the project life, a total of 92 conventional synthetic plant protection products and 67 biopesticides were evaluated (Table 2). The numbers of products available for evaluation was 90, 44 and 25 for fungicides, insecticides and herbicides respectively. Very few bioherbicides were available for testing, and only 20 conventional herbicides. The biopesticides examined comprised microorganisms (38), botanicals (17) and other substances (e.g. salts) (12). The greatest number of products was evaluated on field vegetables (98), with similar numbers on soft fruit (74) and protected edibles (64), and the least on top fruit (31); the latter reflects the fact that no pest or weed control work was done on top fruit.

Potential new plant protection products were identified for all the priority disease, pest and weed problems examined, with the exception of new herbicides suitable for rocket, swede and mizuna (benfluralin screened in 2010 was safe, though it did not control groundsel).

Leading novel products for the disease, pest and weed problems examined are detailed in Tables 3-7. Products that were as effective, or more effective, than the standard reference product used in an experiment are identified (in bold type); products that reduced the pest compared with the untreated but were less effective than the reference product are shown in normal type.

For control of the target diseases examined (Table 3), the proportion of leading products performing as well as the grower standard reference product was greater for conventional synthetic fungicides (76.5%) than for biofungicides (44.2%). Biofungicides with treatment efficacy equal to the reference synthetic conventional fungicide were identified for brassica downy mildew, brassica powdery mildew, strawberry powdery mildew, cucumber powdery mildew, apple powdery mildew, leek rust and strawberry crown rot. It is notable that apart from strawberry crown rot (*Phytophthora cactorum*), these diseases are all caused by biotrophic fungi; and most are powdery mildew diseases. The primarily external fungal growth of powdery mildews may explain the greater susceptibility of this group of pathogens to the contact-acting biofungicides.

During the project a total of 90 products were evaluated for disease control, comprising 50 conventional fungicides and 40 biofungicides. Cassiopeia was registered during the project's life. There are a further 6 unique product x crop uses of fungicides in the pipeline and 21 planned.

During the project a total of 44 products were tested for insect control and this included 15 products based on microorganisms, 7 based on botanicals and 22 conventional insecticides. There are now 6 unique product x crop uses of conventional insecticides in the registration pipeline and 11 planned. Steward was approved for use on outdoor strawberry and shown to control European tarnished plant bug. Dipel was registered during the project's life and 9 further uses of biopesticides are planned.

During the project a total of 20 conventional herbicides and 5 other products were tested for weed control. Wing-P was registered for use on outdoor lettuce and Sencorex Flow on outdoor celeriac. Shark gained authorisation and tests confirmed its safety over blackcurrant and efficacy against common nettle. Registration of a further 17 unique product x crop uses of conventional herbicides is planned.

Key results are highlighted below, arranged by crop within the four sectors (field vegetables, soft fruit, protected edibles and top fruit).

Please note: The mention of a named plant protection product on a particular crop in this report does not necessarily indicate that use of that product is permitted on the particular crop; it is always the responsibility of the user to check product registration details, especially target crop and application method, on the CRD database, before use. The active ingredients of named plant protection products are listed in Appendix 1.

1. Field vegetables

Brassica

Diseases

- Novel active substances were identified for control of powdery mildew, downy mildew, ring spot and Alternaria leaf spot.
- Cassiopeia was shown to have good broad-spectrum activity against brassica foliar diseases.
- Effective, sustainable fungicide programmes were developed for powdery mildew and ring spot using information on individual product efficacies.

Pests

- Identification of a number of conventional insecticides (50, 55, 198, 199, 200) that look promising for cabbage root fly control on transplanted crops.
- Insecticides 50, 59 and 60 provided good control of cabbage aphid. Bioinsecticides Naturalis L, 62 and 130 provided some control
- Insecticides 48 and 67 provided effective control of caterpillars on brassica crops. Bioinsecticides 64, 130 and Lepinox Plus also provided good control.
- For control of silver Y moth, the insecticides Tracer, 50 and 48 were 100% effective and four bioinsecticides (51, Lepinox Plus, Nemasys C and 130) showed statistically-significant activity to varying degrees.

Carrot

- Novel insecticides 50, 60, 75 and 100 have the potential to control willow-carrot aphid.

Leek

Diseases

- Vertisan provides a new mode of action group for rust control, increasing options for resistance management.
- Biofungicide 105 applied eight times at 10 day intervals greatly reduced rust.

Pests

- In 2011 and 2013, the insecticide product 50 provided a significant level of control of thrips on leek, as did the commercial standard, Tracer, and product 48 in 2011.

- The commercial standard, Tracer, significantly reduced the numbers of leek moth caterpillars as did insecticide products 48, 50, 67, 75, 149, 198, 200 and bioinsecticides 61, 62, 130, 201.

Lettuce

- For control of currant-lettuce aphid, two of the insecticides (50, 60) provided effective control as foliar sprays in 4 of the six trials in which they were tested. Product 50 was also applied as a drench/spray treatment to the peat blocks in 2014 and provided control for some of the growth period. The insecticide 59 was evaluated in 5 trials and was effective in 4 of them. The bioinsecticides were less effective overall, but product 130 provided some control in 2014.

Field vegetables – weed control

Weeds

- SCEPTRE funded data generation supported new EAMU approvals for use of Wing-P (3044/12) on outdoor crops of lettuce and for use of Sencorex Flow (0916/15) on outdoor crops of carrot, celeriac, mallow and parsnip.
- Two new residual herbicides (191 and 196) were identified for use in bulb onions. In particular, 191 gave good post-emergence weed control with no crop safety issues.
- Bandspraying maximum permitted dose rates of residual herbicides between crop rows, whilst using a safer residual herbicide choice/dose over the crop row, can significantly reduce both overall weed levels in the field and crop phytotoxicity.
- Although not directly funded by SCEPTRE, the first Agricultural Electric Weeder to be built in the UK since the early 1980's was extensively trialled by the project on a range of vegetable crops. The machine showed potential and was comparable in cost-efficacy with standard commercial inter-row mechanical weed control in brassica crops.
- Benfluralin was evaluated for courgettes and umbelliferous crops. Residues data were generated for brassicas as part of SCEPTRE in 2011. Benfluralin is now registered for some vegetables in EU countries (Belgium and the Netherlands) and Dow AgroSciences are working to expedite successful approval in the UK for several crops through Mutual Recognition.
- A linuron alternative was found to be useful for carrot, parsnip, coriander, celery, leek and onion, dwarf and broad beans, vining peas and possibly spinach pre-weed-emergence, and in a few of these crops post-weed-emergence. In 2014 it was further tested, as product 191, in tank-mixes and programmes in 6 umbelliferous crops. The company is generating residues data for many of these crops.

- Herbicide 05 was safe in a number of vegetables and weed control was excellent. The active substances are going through Annex 1 renewal – If successful it may be possible for authorisations in UK, with some uses in vegetables after 2017.
- Herbicide 165, a chloroacetamide with the same mode of action as propachlor, pre-weed-emergence controls groundsel and was safe to onion, leek, lettuce, courgette, vining peas and dwarf green beans. The company is obtaining residues data for vegetables, starting with peas.
- Herbicide 166, in the same class of chemistry as diflufenican, is at an early stage of development. It appears safe in umbellifers and some other crops, but it does not control groundsel or annual meadow-grass.
- Herbicide 190, a sulfonylurea, was most effective applied pre-weed-emergence. The best timing for courgette was soon after transplanting but before weed emergence, dwarf French bean pre-emergence. However, herbicide 190 may not be progressed.
- Groundsel: this has become the worst weed with often more than one flush, reducing quality in some crops because it is toxic. Fortunately new herbicides in the screen (165, 190 and dimethenamid-p, a component of Wing-P) are effective. Herbicide 191 gives some control.
- Mayweeds: a problem in carrots, is controlled by herbicide 191.

Spring onion

- Control of downy mildew was achieved with Cassiopeia and product 197.
- There was a demonstrable benefit of multiple (3 or 4) different actives in each spray application for control of spring onion downy mildew, rather than using a single active.

2. Soft fruit

Blackcurrant

- Shark gained authorisation in 2014 and tests confirmed its crop safety over blackcurrant buds and its efficacy for common nettle control.
- Conventional herbicide 135 gave some control of creeping thistle and good control of common nettle in blackcurrants and raspberries and was safe when applied over blackcurrant buds or to raspberry canes.
- The potential for electric weed control was demonstrated with a test rig used for selective control of perennial weeds in a mature blackcurrant plantation.

Raspberry

- Two biopesticides (62,130; glasshouse and polytunnel trials over 4 years) were selected as providing useful levels of aphid control against two pest species (large raspberry aphid, potato aphid) under protected cultivation. They were compatible with biocontrol using commercially reared and released parasitoid wasps and with predation by endemic hoverflies and other natural enemies.

- At least one novel conventional insecticide (59) provided very good aphid control comparable with the industry standard, Calypso. Another conventional product (50) was also promising against early attack (potato aphid) but is not sufficiently persistent to be effective over a 6 week period if it can only be applied twice (fortnightly). Further work on forecasting, modelling and spray timings is needed to optimize the use of these products against two aphid pests with different population dynamics.
- These new IPM tools are compatible with the raspberry IPM toolbox already developed under previous RESAs and HortLink funding, using pest-resistance varieties and semiochemical-enhanced raspberry beetle traps.

Strawberry

Diseases

- This project resulted in the first identification of products (Signum, Switch, Thianosan, 25a, 37, 77) with activity against strawberry fruit soft rots (*Mucor* and *Rhizopus* spp.).
- Identification of two new conventional synthetic fungicides (Cassiopeia and Percos) and two biofungicides (Prestop and 40) with activity against strawberry crown rot.
- Identification of four new conventional synthetic fungicides for control of strawberry powdery mildew (Talius, Galileo, 77, 159).
- Identification of two biofungicides (6, 105) that reduced strawberry powdery mildew and could be used in a programme with conventional fungicides.

Pests

- Chess WG, the industry standard selective insecticide when work commenced, was found to be only partially effective against European tarnished plant bug.
- Steward was identified as a new effective selective insecticide for control of European tarnished plant bug (EAMU approval on outdoor strawberry obtained as a result of this project). Use of the adjuvant Silwet L-77) with Steward increased efficacy (Steward used at ½ dose due to addition of Silwet L-77).
- Coded product 59 is a promising new selective insecticide for control of European tarnished plant bug.
- Treatments with selective insecticides for control of European tarnished plant bug are likely to be best if applied on a large scale, due to pest migration.

Weeds

- Three residual herbicides were identified as safe to use over strawberry foliage. Of these, conventional herbicide 74 has the best potential for an EAMU in the short term.
- One conventional (124) and one bioherbicide (109) have potential for use as strawberry runner control treatments in case the standard treatment glufosinate-ammonium continues to be in short supply. Bioherbicide 109 was also effective as a control for docks.
- One bioherbicide (116) also has potential for runner control although uncertainty over future availability in the UK meant it was not possible to test it in 2014, it should be available on the market in 2016.

3. Protected edibles

Cucumber

- Several novel conventional fungicides (Talius, 08, 25a, 77) and biofungicides (Serenade, 80, 90) were effective in controlling cucumber powdery mildew.
- For Pythium root rot, several conventional fungicides (Amistar, Signum, 183) were identified with potentially higher efficacy than Previcur Energy.
- Identification of conventional synthetic fungicides (Amistar, Signum, 175) with potential to control Phomopsis root rot, a disease where no product with known activity against the pathogen is currently available.

Sweet pepper

- Biopesticide 62 reduced aphids on peppers.
- Several biopesticides were initially promising against WFT in early trials (52, 82, 92), as were the insecticides 48, 50 and 54.
- Insecticide 200 showed promise against WFT in later trials, being the only product to do so at this time.

Tomato

Diseases

- Several conventional fungicides (Vertisan, Galileo, 77) were identified for control of grey mould (Botrytis).

Pests

- Early trials supported potential of biopesticides 01, 51, 52, 53, 81, 91, 92 and 130 and insecticides 54 and 60 to target glasshouse whitefly.
- Biopesticide 62 reduced glasshouse whitefly on tomato in later trials.

- Biopesticide 92 showed promise against red spider mite on tomato in later trials, with earlier trials supporting similar promise for biopesticides 01, 51, 62, 91 and insecticide 131.
- Work revealed significant potential of biopesticide 130 to control multiple pest species (e.g. glasshouse whitefly and aphid species).
- Failure of industry standards in multiple trials supports the need to identify alternative pest control measures.
- Potential compatability of selected biopesticides with biological control was reported in trials with peach potato aphid (and *Aphidius colemani*), glasshouse whitefly (and *Encarsia formosa*) and red spider mite (and *Phytoseiulus persimilis*), though further experimentation is needed to confirm these preliminary results.

4. Top fruit

Apple

- Identification of several new conventional fungicides to control apple powdery mildew (17, 25a, 32, Galileo, Talius, 128 and 159).
- The possibility of reducing the number of conventional synthetic fungicides used in a season-long programme for control of apple powdery mildew by adopting a Managed Disease Control approach was demonstrated. The MDC programme used conventional synthetic fungicides each time mildew levels had increased from the previous week, and biofungicides when it had remained constant or declined.
- All of the biofungicides evaluated to control apple powdery mildew (secondary infection) failed to reduce the disease when treatment commenced at a high level of mildew or from a moderate mildew level but when disease pressure in the orchard was high.
- Novel conventional fungicide 77 gave excellent control of powdery mildew on apple (as well as on cucumber and strawberry).

Pear

- Four biofungicides (Nexy, Serenade ASO, 98 and 99) were identified that reduced botrytis storage rot in cold-stored pears compared with untreated fruit.

Table 1. Summary of field, greenhouse and cold-store experiments conducted on priority pest problems in the SCEPTRE project: October 2010 – March 2015

Sector and crop	Target pest	Number of experiments				Total
		2011	2012	2013	2014	
Field vegetables						
Bulb onion	Weeds	-	2	-	1	3
Brassica	Dark leaf spot	2	1	-	-	3
	Downy mildew	2	-	-	-	2
	Powdery mildew	-	2	1	1	4
	Ring spot	-	2	1	1	4
	Aphids	1	-	-	1	2
	Caterpillars	1	-	-	-	1
	Cabbage root fly	1	1	-	1	3
	IPM (pests)	-	2	2	-	4
	Weeds	-	-	3	-	3
Carrot	Aphid	1	-	-	-	1
Courgette	Weeds	-	-	-	1	1
Leek	Rust	-	1	1	1	3
	Onion thrips	1	2	2	1	6
	Weeds	-	-	3	-	3
Lettuce	Aphid + caterpillar	1	8	6	2	17
Multiple crops	Herbicide screen	1	1	1	1	4
Spring onion	Downy mildew	-	-	1	1	2
Umbelliferous	Weeds	-	-	-	6	6
Bush and soft fruit						
Blackcurrants	Weeds	2	2	1	1	6
Raspberry	Spur blight	-	-	-	1	1
	Aphids	1	1	1	1	4
	Weeds	-	-	1	-	1
Strawberry	Crown rot	-	1	1	1	3
	Powdery mildew	-	-	-	2	2
	Soft rots	1	1	1	-	3
	Lygus	1	1	1	1	4
	Herbicides	1	2	1	3	7

Table 1 cont'd

Sector and crop	Target pest	Number of experiments				Total
		2011	2012	2013	2014	
Protected edibles						
Cucumber	Black root rot	-	-	2	1	3
	Powdery mildew	2	1	-	-	3
	Pythium root rot	-	-	1	1	2
Pepper	Aphids	-	-	1	1	2
	WFT	1	1	-	1	3
Tomato	Grey mould	2	1	2	-	5
	Glasshouse whitefly	1	1	-	-	2
	Spider mite	1	2	1	-	4
Top fruit						
Apple	Powdery mildew	1	2	2	2	7
Pear	Botrytis rot in stored fruit	1	1	1	-	3
Totals		26	39	38	34	137

Table 2. Summary of types of plant protection product (PPP) evaluated in SCEPTRE field and glasshouse experiments

Total number of unique products	Type of PPP		Types of biopesticide		
	Conventional pesticides	Biopesticides	Micro-organism	Botanical	Other
By sector					
Field vegetables	58	40	23	10	7
Protected edibles	39	35	25	8	2
Soft fruit	38	26	11	12	3
Top fruit	14	17	10	2	5
By category					
Fungicides	50	40	23	7	10
Insecticides	22	22	15	7	0
Herbicides	20	5	0	3	2
Total unique products	92	67	38	17	12

Table 3. 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			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	**Inf**	**Cas**	-	-	-	-
	Onion	2014	1.4	Mixtures	**Cas**	181	**197**	*	*	*
Powdery mildew	Brassica	2012	1.1	Rudis	**Cas**	**28**	**89**	**90**	11	**40+90**
	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	**Sig**	**10**	**27**	*	*	*
	Leek	2013	1.1	Amistar Top	**Ami**	**Ver**	**Gal**	Ser	105	-
	Leek	2014	1.3	AmiT/Rud/Nat	**Cas**	**Ver**	**Gal**	**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**	**Gal**	**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	Ver	77	Pre	09	Ser
	Tomato	2012	3.2	Signum	08	25a	Gal	-	-	-
	Tomato	2013	3.1	Rov/Swi/Sig	**Ver**	**77**	**Gal**	-	-	-
Phomopsis	Cucumber	2013	3.1a	-	-	-	-	-	-	-
	Cucumber	2014	3.1b	-	Ami	Sig	175	-	-	-
Powdery mildew	Cucumber	2011	3.1	Systhane	**Tal**	**08**	**77**	**Ser**	**80**	**90**
	Cucumber	2012	3.1	Sys/Nim	**08**	**25a**	**77**	90	105	**154**
Pythium	Cucumber	2013	3.2	Previcur Energy	Ami	Sig	183	-	-	-
	Cucumber	2014	3.2	Previcur Energy	**Ami**	**Sig**	**183**	-	-	-
<u>Top fruit</u>										
Botrytis	Pear	2012	4.2	Rovral WG	*	*	*	Ser	98	99
	Pear	2013	4.2	Rovral WG	*	*	*	Ser	-	-
	Pear	2014	4.3	Rovral WG	*	*	*	Nxy	99	Ser
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**	**Gal**	-	**90**	**105**	**157**

* – no products in this category evaluated. adj – adjuvant; Ami – Amistar; AmiT – Amistar Top; Cas – Cassiopeia; Cos – Cosine; Gal – Galileo; Inf – Infinito; 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; Nxy – Nexy; V- Vertisan; W - wetter

- 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 4. 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	**Mov**	**50**	**54**	-	-	-
	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**	**67**	-	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**	**Ste**	**54**	**53**	-	-
	Strawberry	2012	2.5	Calypso	**Ste**	**60**	-	*	*	*
	Strawberry	2013	2.4	Chess	**Ste**	59	-	*	*	*
	Strawberry	2014	2.6	Chess	**Ste**	**59**	-	*	*	*
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; Mov – Movento; Nat – Naturalis-L; Ste- Steward

† - Bioinsecticides evaluated in combination with release of natural enemies. See also Table 4 footnotes. Please see individual experiment reports, within the annual reports, for full details.

Table 5. Novel herbicide products identified as crop-safe to a range of field vegetable crops

Crop	Safe when applied pre weed emergence	Safe when applied post weed emergence
Drilled		
Broad bean	05, 165, 166	(123)
Bulb onion	164, 165, 166, 191	05, (123), 166
Carrot	Ben, 05, 164, 166, 191	76, 05, 166, 191
Coriander	Ben, 05, 166, 191	76, 05, 191
Dwarf French bean	Ben, 05, 164, 166, 190, 191	190
Flat leaf parsley	191	(191)
Leek	164, 165, 166, 191	76, 05, 166
Parsnip	Ben, 05, 166, 191	76, 05, 166, 191
Pea	Ben, 05, 165, 166, 191	(123)
Transplanted		
Cauliflower	Ben, 05, 165, 166, 191	165
Celery	Ben, 05, 166, (191)	76, 05, 166, (191)
Celeriac	Ben, 191	191
Courgette	Ben, 165, 190	190
Lettuce	Ben, (05), 166	(05), (123)

( ) – slight damage; Ben- benfluralin.

In a 2010 HDC herbicide screen, benfluralin (coded as H3) was safe to most crops including mizuna, rocket and swede but it killed baby-leaf spinach. HDC H1 (a different formulation of 191) was safe to baby-leaf spinach but killed mizuna, rocket and swede. No other safe solutions were identified for baby-leaf spinach, mizuna, rocket and swede in SCEPTRE.

The fruit herbicide work focused on conventional herbicides as relatively few bioherbicides were made available and they were all non-selective contact acting. Three conventional herbicides were suitable for use as residual herbicides in strawberry (Table 6). One conventional and one bioherbicides was suitable for runner control in strawberry (Table 6). Four conventional herbicides and two bioherbicides were suitable for use as directed treatments for the control of perennial weeds (Table 7). Electric weed control was shown to have some potential as a selective control measure in blackcurrant plantations.

Table 6. Novel herbicide products identified as crop-safe to strawberries

Safe when applied over foliage	Safe when applied as runner control between rows
(05), 74, 76, 165	109, 124

( ) = slight damage

Table 7. Leading novel products (product name or code number in numerical order) identified for control of perennial weeds as directed treatments in bush and cane fruit: 2011-2013

Crop	Weed	Year	Exp. Ref.	Reference product	Leading 3 products					
					Herbicides			Bioherbicides		
Fallow	Dock	2011	2.4	-	R+S	72	102	-	-	-
Raspberry	Dock	2012	1.12	Rosate 36	124	-	-	116	-	-
Fallow	Dock	2013	2.8	Rosate 36	124	-	-	109	116	-
Fallow	Nettle	2011	2.4	-	R+S	72	102	-	-	-
Raspberry	Nettle	2012	1.12	Rosate 36	124	-	-	-	-	-
Blackcurrant	Nettle	2012	2.7	Roundup	72	-	-	*	*	*
Fallow	Nettle	2013	2.8	Rosate 36	124	-	-	109	116	-
Fallow	Thistle	2011	2.4	-	R+S	72	102	-	-	-
Raspberry	Thistle	2012	1.12	Rosate 36	124	-	-	116	-	-
Blackcurrant	Thistle	2012	2.7	Roundup	72	135	-	109	-	-

Please see individual reports, within the Annual SCEPTRE reports, for details. R+S – Roundup + Shark.

SCIENCE SECTION

Field vegetables

Brassica dark leaf spot (*Alternaria brassicicola*)

2011

Fungicide (Trial 1) and biofungicide (Trial 2) treatments were compared with an untreated control and an industry standard fungicide Nativo 75WG (tebuconazole + trifloxystrobin) for the control of *Alternaria* on Chinese cabbage seedlings cv. Bilko. Fungicides were applied once and inoculated later the same day while biofungicides were applied twice, at this time and 7 days before inoculation. After 14 days, several products in Trial 1 significantly reduced the incidence and severity of Alternaria leaf spot. Nativo 75WG gave the best control while fungicides Cassiopeia (dimethomorph + pyraclostrobin), Rudis (prothioconazole) and Signum (boscalid + pyraclostrobin) also significantly reduced incidence by 80%. In Trial 2, biofungicides 06, 40, 43 and 47 significantly reduced dark leaf spot at 7 days but no products showed significant persistence of activity.

2012

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.

Brassica downy mildew (*Hyaloperonospora parasitica*)

2011

Fungicide (Trial 1) and biofungicide (Trial 2) treatments were compared with an untreated control and an industry standard fungicide Folio Gold (chlorothalonil + metalaxyl-M) for the control of downy mildew on cauliflower seedlings cv. Brunel. Fungicides were applied once and inoculated later the same day while biofungicides were applied at this time and 7 days before. After 14 days, several products in Trial 1 significantly reduced downy mildew incidence and severity. Cassiopeia gave the best control at this time and Infinito, Percos and

Signum all reduced incidence by two-thirds and severity greatly. In Trial 2, only product 47 (subsequently classed as a conventional fungicide) significantly reduced downy mildew, evident at 14 and 21 days after inoculation; this product also resulted in some crop damage.

Brassica powdery mildew (*Erysiphe cruciferarum*)

2012

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 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; Cassiopeia was the most effective (2% leaf area affected). In Trial 2, two biofungicides (90 and 40 + 90) 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.

2013

A trial was conducted in an unheated polythene tunnel in summer 2013 to evaluate seven fungicides, three biofungicides and two fungicide/biofungicide programmes for control of powdery mildew (*Erysiphe cruciferarum*) on swede cv. Emily. Rudis and Nativo 75WG were included as grower standards. Fungicides were applied twice at a 14 day interval from inoculation, and biofungicides and the fungicide/biofungicide programmes at 7 day intervals. At 6 weeks after inoculation disease severity on untreated plants was high (73% leaf area affected). All treatments reduced powdery mildew with Cassiopeia, Rudis and coded fungicide 28 and one five spray programme (90 applied 3x followed by Rudis twice), reducing it by >90%. The three biofungicide treatments (90, 90+40 and 11) each reduced mildew by around 25%. The biofungicide 90 applied four times, followed by Rudis, was much more effective than Rudis at inoculation followed by biofungicide 90 applied three times. Moderate phytotoxicity was observed with the biofungicide 11, which was used as recommended with a wetter; and slight phytotoxicity with biofungicide 90.

2014

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, were included. Conventional fungicides (Cassiopeia, Rudis, Talius, 25a and 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 inoculated, and increased to affect 27% leaf area on untreated plants by 6 August. At this time, just before the fourth spray application, all treatments except one had significantly reduced the disease; the programme Serenade ASO (*Bacillus subtilis*) alternating with Rudis had least disease (5.7 % leaf area affected; LAA) and appeared slightly better than Rudis alone (9.5 % LAA). At one week after the final assessment, four programmes (Rudis alone; Serenade ASO /Rudis; biofungicide 11/Rudis and biofungicide 105/Rudis) had reduced powdery mildew to around 3% LAA compared with 14% on the untreated control. Programmes of three sprays of Talius, 25a, 28 or 89 all reduced the disease to 5-7% LAA and were not significantly different from the grower standard, Rudis. Only Cassiopeia was ineffective. No phytotoxic symptoms or crop vigour differences were observed.

Brassica ring spot (*Mycosphaerella brassicicola*)

<u>2012</u>

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, preventatively, with inoculation the same day; biofungicides were applied four times at 7d intervals commencing 7d before inoculation. Each trial included an untreated control and Signum 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; fungicide 10 reduced infection to <1%. Five of the biofungicides reduced ring spot, with product 90 the most effective (4% leaf area infected). Some treatments also reduced downy mildew (*Hyaloperonospora parasitica*), light leaf spot (*Pyrenopeziza brassicae*) and dark leaf spot (*Alternaria* sp.), but levels on untreated plants were low.

<u>2013</u>

A field trial was conducted in Lincolnshire in autumn 2013 to evaluate three fungicide products (Cassiopeia, Rudis, and coded product 25a), four fungicide programmes (Amistar/Rudis/Amistar; Signum/Rudis/Signum; Nativo 75WG/Rudis/Nativo 75WG; 10/Amistar Top/10), two biofungicides (Serenade ASO and coded product 90) and one programme of mixtures of a biofungicide (105) with Amistar and Rudis, for control of ring spot

(*Mycosphaerella brassicicola*) and other leaf spots on cabbage cv. Caraflex. Brassica leaf debris affected by ring spot was laid between plots to provide natural infection. Fungicide treatments consisted of three sprays at 14 day intervals and biofungicides of six sprays at 7 day intervals. Widespread ring spot occurred in late November and affected 3% leaf area and 1% area of heads. The disease was reduced by all treatments except Serenade ASO. Several treatments were still providing good control over 1 month after the final spray. Low levels of downy mildew (*Hyaloperonospora parasitica*), dark leaf spot (*Alternaria* spp.), white blister (*Albugo candida*), black rot (*Xanthomonas campestris* pv. *campestris*) and light leaf spot (*Pyrenopeziza brassicae*) occurred naturally. The most effective treatment for ring spot was biofungicide 105 admixed with Amistar alternating with 105 admixed with Rudis in a 3-spray programme. Cassiopeia was the best single product for ring spot and also reduced downy mildew and dark leaf spot. Total yield and mean head weight were increased by the Nativo 75WG/Rudis/Nativo 75WG programme and by fungicide 25a.

<u>2014</u>

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 alternating with Rudis 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/Rudis, a programme of Nativo 75WG/Rudis and Cassiopeia were most effective, all reducing ring spot incidence to 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 Cassiopeia. No symptoms of phytotoxicity were observed with any of the treatments.

Brassica aphids (*Brevicoryne brassicae*)

2011

Insecticides and bioinsecticides were investigated for control of aphids on Brussels sprout cv. Doric. Plots were assessed weekly and spraying commenced when sufficient insects had colonised. Out of the conventional insecticides, Movento (spirotetramat), 50, 59 and 60 gave good control of aphids 8 days post spray. Movento, 50 and 59 gave best control of aphids 21 days post spray. Out of the bioinsecticides, 62 gave best control of aphids and 92 showed some activity.

2014

Two field trials (one for 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. 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. Insecticides Movento and 59 and bioinsecticide 130 appeared to reduce aphid levels; conventional insecticides Steward, 48, 50, 67 and 200 and Lepinox Plus appeared to reduce caterpillars. All conventional insecticides (48, 50, 59, 67, 200) and none of the bioinsecticides reduced whitefly.

Brassica caterpillars (*Plutella xylostella*)

2011

Insecticides and bioinsecticides were evaluated for control of caterpillars on Brussels sprout cv. Doric. The bioinsecticide treatment plots were infested with diamond-back moth adults and spraying commenced when the insect population was sufficient. Caterpillar counts and identification were done pre- and post-spraying. Caterpillar numbers were low but data for insecticides suggest the most effective treatments were 48, 50 and 67.

Brassica cabbage root fly (*Delia radicum*)

2011

Insecticides and bioinsecticides applied as seed or drench treatments were evaluated for control of cabbage root fly larvae on cauliflower cv. Skywalker in a pot trial. Approximately 4 weeks after inoculation with cabbage root fly eggs, the roots were harvested and assessed for damage and the cabbage root fly pupae were washed from the soil and counted. Insecticides 50, 55 and Tracer (spinosad) were the most effective products in controlling cabbage root fly larvae. These products reduced the number of pupae per plant, produced plants with the greatest mean root weight and limited root damage. None of the three bio-insecticides evaluated was effective.

2012

A trial was conducted in winter 2012 to evaluate the efficacy of four 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). Bioinsecticide 130 was partially effective when applied either as a granule to the soil surface or as a drench (post transplanting), but was extremely phytotoxic when granules were incorporated and ineffective when drenched onto modules pre-transplanting. The other three bioinsecticides gave no control. Tracer gave good control both as a drench pre-transplanting and when incorporated at sowing ('Phytodrip' application).

2014

A field trial was conducted in summer 2014 to evaluate the efficacy of four 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 Nemasys C 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 insecticides (Tracer, 50, 198, 199, 200) and one bioinsecticide (130) had reduced root damage; three insecticides (198, 199, 200) also reduced stem damage. Tracer, 198 and 199 resulted in increased root and foliage weight.

Brassica IPM programmes – aphids, cabbage root fly, caterpillars

2012

Two trials were conducted simultaneously in summer 2012 to evaluate six insecticide programmes (Trial 1) and five bioinsecticide 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, 50 and 55). 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, 54, 59 and 60 significantly reduced whitefly infestation. There was also evidence that all of these products and 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 bioinsecticide products tested in Trial 2 significantly reduced either pest. No caterpillar treatments were applied.

<u>2013</u>

Two field trials were conducted simultaneously in 2013 to evaluate five insecticide programmes (Trial 1) and five bioinsecticide programmes (Trial 2) for control of cabbage root fly (*Delia radicum*), aphids (cabbage aphids – *Brevicoryne brassicae*) and caterpillars (small white butterfly – *Pieris rapae*) on Brussels sprout cv. Faunus. Insecticides were applied once and bioinsecticides three times at 7 day intervals. A standard programme of Tracer (spinosad) for cabbage root fly, Movento (spirotetromat) for aphids and Steward (indoxacarb) for caterpillars was included. The biopesticides trial used Dursban (chlorpyrifos) for cabbage root fly control in all programmes. Levels of pest infestation were high. All three insecticides tested (Tracer, 50 and 55) gave excellent control of CRF damage on roots; moderate control on stems. No bioinsecticides were tested. Movento and insecticides 59 and 60 gave good control of aphids, with Movento appearing the most effective (although there were no statistical differences). Bioinsecticides 62 and 130 gave reasonable control (but this was only statistically significant with 130) while 01 and 92 were ineffective. All three insecticides (Steward, 48 and 67) gave good control of caterpillars, with 67 the most effective. Bioinsecticides Lepinox Plus, 64, and 130 gave good control of caterpillars, whereas 93 was ineffective.

Carrot aphid (*Cavariella aegopodii*)

<u>2011</u>

Insecticides and bioinsecticides were evaluated for control of aphids on carrot cv. Nairobi. Aphid activity was monitored. The data suggest the most effective treatments were conventional insecticides Movento, 50 and 60. Neither of the two novel bioinsecticides was effective.

Leek rust (*Puccinia allii*)

<u>2012</u>

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, were included.

Fungicides were applied once, prior to inoculation later the same day. Disease severity was low with 1% leaf area affected on untreated plants. Amistar and five of the novel products reduced rust severity; product 10 was most effective reducing the disease to 0.1%.

2013

A trial was conducted outside in summer 2013 to evaluate nine fungicides and three biofungicides for control of rust (*Puccinia allii*) on leek cv. Darwin. An untreated control and a grower standard, Amistar Top (azoxystrobin + difenoconazole) were included. Fungicides were applied twice at 14 day intervals from immediately prior to inoculation and biofungicides five times at 7 day intervals from 1 week pre-inoculation. Although disease severity was low (1% leaf area affected on untreated plants) there were significant differences between treatments. At 6 weeks after inoculation, rust severity was reduced by Amistar, Amistar Top, Cassiopeia, Rudis, Signum, Vertisan, Galileo and two coded fungicides (10, 25a). Amistar Top, Vertisan and Galileo gave >90% control. Serenade ASO and two coded biofungicides (40, 105) gave no reduction at 6 weeks although Serenade ASO and 105 had less disease than the untreated at 8 weeks. No phytotoxic symptoms were observed.

2014

A field trial was conducted in summer 2014 in Lincolnshire to evaluate the efficacy of 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, Rudis and Nativo 75 WG were included. Fungicides (except 47) were applied four times at 20 day intervals; fungicide 47 and biofungicide 105 were applied eight times at 10 day intervals, commencing 10 days before the first fungicide spray application. A high incidence (100%) and moderate severity (4.2% LAA) developed on untreated plants. All treatment 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, Galileo, Vertisan and an alternating programme of Cassiopeia and Vertisan. Biofungicide 105 reduced the disease to 0.8%. No evidence of phytotoxicity or differences in crop vigour were observed. Vertisan provides a new fungicide mode of action group for rust control and if it becomes available will be useful for resistance management, for use in conjunction with triazole and strobilurin fungicides currently used against leek rust.

Leek – onion thrips (*Thrips tabaci*) and moth (*Acrolepiosis assectella*)

2011

Insecticides and bioinsecticides were evaluated for control of thrips on leek cv. Bandit. The insecticides were applied at 2-week intervals (total of 4 applications) and the bioinsecticides were applied at 1-week intervals (total of 4 applications). All four insecticides (Tracer, 48, 50 and 54) reduced thrips damage but none of the bioinsecticides were effective.

2012

Two field trials were conducted in 2012 to evaluate the efficacy of insecticides (Trial 1) and bioinsecticides (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 50, and to a lesser extent by 48. In Trial 2 both 62 and 130 reduced caterpillar damage (up to 36%) at two spray volumes (200 and 1000 L/ha).

2013

Two field trials were conducted in 2013 to evaluate the efficacy of insecticides (Trial 1) and bio-insecticides (Trial 2) for control of onion thrips (*Thrips tabaci*) on leek cv. Surfer. Insecticides were applied at 14 day intervals and bioinsecticides at 7 day intervals with four sprays of each. Damage by the pest was moderate with 20% leaf area affected on untreated plants. All four insecticides reduced damage with the standard product Tracer (spinosad) and coded insecticide 50 being the only 2 which reduced damage significantly, reducing the damage by around 50%. Bioinsecticide 62 gave a slight reduction in thrips damage when applied at 1,000 L/ha, but not at 200 L/ha. Leek moth caterpillar (*Acrolepiosis assectella*) also occurred and affected 60% of untreated plants. Damage by this pest was reduced by all four insecticides, with Tracer and 50 the most effective, reducing the incidence of affected plants by 90%; the two bioinsecticides (62 and 130) at both application volumes gave a small reduction.

2014

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. 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.

Leek – Band spray weed control

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.

Lettuce aphid (*Nasonovia ribis-nigri*) and caterpillar (*Autographa gamma*)

<u>2011</u>

Insecticides and bioinsecticides were evaluated for the control of aphids on lettuce cv Saladin. When the aphids had established, a pre-spray assessment was made. The most effective treatment 7 days after spraying was Movento and the most effective treatments 15 days after spraying were Movento and 54. Neither bioinsecticide tested showed any activity.

<u>2012</u>

Eight field trials (four for insecticides and four for bioinsecticides) 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.

<u>2013</u>

Six field trials (three for insecticides and three for bioinsecticides) were conducted in 2013 to evaluate the efficacy of products in an IPM programme for control of currant-lettuce aphid

(*Nasonovia ribisnigri*) and caterpillars on lettuce cv. Saladin. Treatments for aphid control were applied once (insecticides) or twice (bioinsecticides) when a moderate infestation was present. Movento (spirotetramat) was included as a standard. Movento and insecticide 59 were the most effective conventional products; little efficacy on aphids was observed with any of four bioinsecticides (51, 62, 92 and 130). No caterpillars occurred in any of the field trials so treatments were tested on pot grown lettuce infested with a culture of silver Y moth (*Autographa gamma*). Treatments were applied once and plants assessed 7 days later. Tracer (spinosad) was included as a standard. Tracer and two conventional insecticides (48 and 50) resulted in 100% mortality of caterpillars. Four bioinsecticides (Lepinox Plus, 51, 94, 130) all resulted in some caterpillar mortality and a reduction in feeding holes; Lepinox Plus was the most effective.

<u>2014</u>

Two field trials were conducted in 2014 to evaluate the efficacy of three insecticides and three bioinsecticides for control of currant-lettuce aphid (*Nasonovia ribisnigri*) and caterpillars on lettuce cv. Lobjoits Green Cos. Sprays of 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. Insecticide 50 was applied as a spray and, in a separate treatment, as a pre-planting 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.

Field vegetables – Herbicide screen on multiple crops

<u>2011</u>

This study was carried out on a light, sandy silt loam soil to evaluate herbicide 05 for crop safety and weed control on 14 crops. Applied pre-emergence at 2.0 L/ha, it was safe to peas and broad beans. At a lower application rate it had potential for carrots, parsnips and coriander pre- and post- emergence and possibly iceberg lettuce at 0.5 L/ha. Applied post-emergence it was also safe at 2.0 L/ha in drilled bulb onion, leek and post-planting in celery.

Herbicide 05 gave excellent control of small nettle and shepherd's purse pre- and post-emergence at 1.0 L/ha and it was effective on groundsel at 2.0 L/ha.

2012

This study was carried out on a light, sandy silt loam soil to evaluate herbicides 76 and 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, 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. Herbicide 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. Herbicide 123 at 0.75 L/ha severely stunted potato growth and there were no flowers or berries produced and few tubers.

2013

Field trials were conducted in 2013 on a light, sandy silt loam soil to evaluate three conventional hericides 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 herbicides suppressed their growth. Untreated control plots were included for comparison. The season was characterised by lower than average temperatures from March to June resulting in slow crop emergence and growth; and by heavy rainfall after application of the pre-weed-emergence herbicides. Herbicide 164 applied pre-emergence has potential for use in drilled carrot, parsnip, leek and bulb onion. It controlled a wide weed spectrum including mayweeds and groundsel but not annual meadow grass. No crop was safe to post-emergence applications of this product. Herbicide 165 (same mode of action as propachlor) applied pre-emergence has potential for bulb onion, broad bean, vining pea and dwarf French bean. Weed control was excellent on all species at 2.0 L/ha but at 1.0 L/ha it was less effective on small nettle and fat hen. Applied post-emergence, 165 did not control emerged weeds but was safer to the crops and has potential for use soon after planting, before weeds emerge, on cauliflower and courgette. Herbicide 166 (same mode of action as diflufenican) applied pre-emergence has potential for use in carrot, parsnip and coriander at 0.5 L/ha and to bulb onion, leek, dwarf French bean, broad bean and pea used at 0.25 L/ha. It did not control groundsel and annual meadow grass. Applied post-emergence, 166 suppressed volunteer potato foliage by up to 75% and has potential for use in carrot, parsnip, onion and leek. None of the three herbicides tested was safe to rocket or baby-leaf spinach.

2014

Field trials were conducted in 2014 on a silt loam soil to evaluate 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 potential for use in courgette transplants, drilled dwarf French beans and potatoes. It caused severe damaged when used either pre-emergence / pre-transplanting or post-emergence / post-transplanting to broad beans, carrot, 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 applied post-emergence.

Field vegetables – Herbicides for alliums

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 196 and 191 gave transient phytotoxicity symptoms.

Field vegetables – Herbicides for courgettes

2014

A field trial was conducted in 2014 on a light, sandy silt loam soil in Lincolnshire to evaluate four novel herbicides (benfluralin, 165, 190, 191) 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 control 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 (Stomp Aqua, Wing P) applied over the top of courgettes remained weed-free but affected the growing point and killed the crop.

Field vegetables – Herbicides for umbelliferous crops

<u>2014</u>

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.

Field vegetables – Herbicide residue studies

2011

Two herbicides, benfluralin and Wing P (dimethenamid-P + pendimethalin), were examined to gain residues data to support new applications for authorisations of extension of use on products where satisfactory efficacy and phytotoxicity data is already available. Wing P was tested on lettuce, benfluralin on cabbage, calabrese, cauliflower, kale and swede. Field trials were done across a range of grower sites (Bedfordshire, Cornwall, Essex, Lancs, Lincs and Warwickshire) to provide good geographical diversity. Each treatment was applied at one rate as recommended by the manufacturer. Data were submitted to CRD in 2012.

Field vegetables – Band spray weed control

2012

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 (prosulfocarb). 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.

<u>2013</u>

A field trial was conducted in 2013 to evaluate a banded herbicide treatment for control of weeds and crop safety in a July planted crop of cauliflower cv. Diwan on sandy loam soil in Lincolnshire. Whole plots were treated once with either Rapsan 500SC (metazachlor) + Gamit 36CS (clomazone) or Wing P + Dual Gold (S-metolachlor) + Gamit 36CS + Kerb Flo (propyzamide). In the banded treatment, the first mixture was applied to crop rows and the second mixture between rows. An untreated was included. The weed population was very low and no firm conclusions could be drawn with regard to weed control. The second herbicide mixture applied over whole plots caused some phytotoxicity and reduced crop vigour. The banded treatment of Rapsan SC (metazachlor) applied to crop rows and Wing P + Dual Gold (metolachlor) + Gamit 36CS (clomazone) + Kerb Flo (propyzamide) applied between rows did not cause damage or reduce vigour.

The same treatments were evaluated in spring 2013 in cauliflower cv. Skywalker on a silt soil in Lincolnshire. The weed population was very high and was greatly reduced by all treatments; the banded herbicide treatment gave 94% control, equally effective as the best whole plot treatment. One herbicide mixture (Wing P + Dual Gold + Gamit 36CS + Kerb Flo) appeared to cause slight phytotoxicity both when used over whole plots and as a band spray. There were no significant effects on crop vigour.

A field trial was conducted in spring 2013 to evaluate a banded herbicide treatment for control of weeds and crop safety in leeks cv. Triton on a sandy loam soil in Lincolnshire. Whole plots were treated once with Wing P (dimethenamid-P + pendimethalin) at 2 and 4 L/ha and with Wing P at the high rate plus Defy (prosulfocarb). One banded treatment consisted of Wing P (2 L/ha) applied to rows and Wing P (4 L/ha) + Defy applied between rows. A second banded treatment consisted of Wing P (2 L/ha) applied to rows and Stomp Aqua (pendimethalin) + Defy between rows. An untreated control was included. The first banded treatment of Wing P/Wing P + Defy gave the best overall control, reducing weeds by 82.5%. The high rate Wing P + Defy whole plot treatment and the second banded treatment (Wing P + Stomp Aqua) reduced weeds by 67.5 and 65% respectively. No phytotoxic symptoms were observed and no treatments reduced crop vigour.

The same treatments were evaluated in spring 2013 in leeks cv. Galvani on a silt soil in Lincolnshire. The two banded spray treatments and the high rate Wing P whole plot treatment gave similar high levels (86-88%) of weed control. These three treatments gave slight crop phytotoxicity 1 month after spray application which was not evident two weeks later. No treatment reduced crop vigour.

2014

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 also caused slight phytotoxicity but plants grew away satisfactorily.

Field vegetables – Electric weed control

2012

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.

2013

A field trial was conducted in summer 2013 to evaluate electrical weeding used alone and one month after a herbicide spray for control of weeds and crop safety in cauliflower cv. Skywalker on a silt soil in Lincolnshire. The electrical treatments were compared with Rapsan 500SC (metazachlor) + Gamit 36CS (clomazone) herbicide treatment, mechanical weeding and the herbicide spray followed one month later by mechanical weeding. An untreated control was included. The combined treatments of herbicide followed by electrical or mechanical weeding gave similar high levels (86-88%) of weed control. Mechanical weeding alone and herbicide alone were comparable, with 54-56% control. The electrical treatment alone gave a 19% reduction in weeds; treatment efficacy was reduced due to a cloddy seedbed. No phytotoxicity symptoms were observed and no adverse effects on crop vigour.

Similar treatments were evaluated in summer 2013 in drilled leeks cv. Galvani on a silt soil in Lincolnshire. The herbicide treatment in this trial was Wing P (dimethenamid-P + pendimethalm) at 2 L/ha. The combined treatments of herbicide followed by electrical or mechanical weeding gave similar moderate levels of weed control (56-63%), slightly better than the herbicide alone (54%). The electrical treatment alone (11% weed control) and mechanical treatment alone (19% weed control) were poor, probably due to a delay in treatment due to rainfall. No phytotoxicity symptoms and no differences in crop vigour were observed.

Field vegetables – Bioherbicides

2012

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 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 124 applied once gave excellent control of common nettle and good control of broad-leaf dock and creeping thistle, the bioherbicide 116 gave moderate to good control of these weed species when applied twice. The novel herbicide 124 and the bioherbicide 116 gave some control of strawberry runners but were not as effective as the standard treatment Harvest (glufosinate ammonium).

Field vegetables – Weed seed germination enhancer

2012

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.

Spring onion downy mildew (*Peronospora destructor*)

2013

A field trial was conducted in summer 2013 to evalute seven fungicides, three biofungicides and a fungicide + biofungicide mixture for control of downy mildew (*Peronospora destructor*) on spring onion cv. Slender Star. An untreated control and a spring onion standard programme of Invader (dimethomorph + mancozeb) + Amistar/Invader + Signum/Invader + Olympus (azoxystrobin + chlorothalonil) and a bulb onion standard programme of Valbon + Olympus/Unicur + Dithane/Valbon + Dithane were included. Fungicides and the mixture were applied four times while biofungicides received two earlier applications in addition; treatments were at 7-14 day intervals. Disease severity was moderate with 6% leaf area affected on untreated plants at 2 weeks after the final spray, rising to 36% at 4 weeks. The two grower standard programmes, each of which used six different active ingredients, were very effective, reducing downy mildew by ≥75%. Novel fungicides Cassiopeia and 20 both significantly reduced downy mildew by >50%. Signum used alone was ineffective as were fungicides Percos, 22, 25a and 41 and the fungicide + biofungicide mixture (22 + 105). None of the biofungicides (40, 47 and 188) reduced the disease. Persistence of control was greatest with the bulb onion standard programme, with <2% leaf area affected 4 weeks after the final spray.

2014

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 + Amistar, Invader + Signum, Invader + Olympus 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 severity 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 Cassiopeia + 197 alternating with Percos + 197 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 alternated 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.

Bush and Soft fruit

Blackcurrant – Electrical weed control

2011

A shielded high-power electrode was applied to creeping thistle, broad-leaved dock and nettle in a blackcurrant crop in Norfolk, comparing two voltages (3.5 and 5.0 KV) and two travelling speeds (3 and 5 Km/h). Treatment gave good control of thistle and some control of dock and nettle. Control was generally better at the slower travelling speed. Contact with the blackcurrant bush stem or side branch for 1 second had no adverse effect, but contact for 5 seconds caused leaf death.

2012

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.

2014

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 browning 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.

Bush and cane fruit – Herbicides for weed control

2011

Six herbicide treatments (predominantly sulfonylureas) were evaluated for control of creeping thistle, broad-leaved dock and nettle. Four treatments gave control of all three weeds; one coded product (102) was outstanding with a vigour score of zero and no re-growth of all three species at 6 weeks after treatment.

2012

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 (72, 102, 109, 135 and Roundup) had some effect on thistle. Herbicide 72 was particularly effective against both weeds, more so than the standard treatment Roundup (glyphosate) and did not result in crop damage. Herbicide 102 caused obvious damage to both blackcurrant and raspberry.

2013

A trial was conducted in spring 2013 on 1-year-old pot grown blackcurrants cvs Ben Gairn and Ben Tirran to determine the crop safety of five herbicides and two bioherbicides applied as directed sprays to the base of bushes around bud break (23 March and 21 April). Following the March application, Roundup, 72 and 151 caused damage to basal buds on Ben Gairn; damage was insignificant on the later variety Ben Tirran. The April application caused more damage to basal buds than the earlier spray, including bud death and leaf yellowing and scorch. No treatments were safe to buds of Ben Gairn at this timing but herbicide 135 and bioherbicide 109 resulted in least damage when applied to breaking buds of Ben Tirran and no damage was evident when whole plants were assessed 6 weeks after the April treatment.

A field trial was conducted in spring 2013 to evaluate the efficacy and crop safety of two herbicides and two bioherbicides applied to the base of raspberry canes, cv. Glen Ample, for control of weeds and initial raspberry spawn growth. An untreated control and the grower standard treatment Shark (carfentrazone-ethyl) were included. Herbicide 124 and bioherbicide 109 showed the greatest control of weeds, including thistle, and appeared better than Shark. No phytotoxicity and no significant effect on spawn control were observed with these products although Shark showed a slight reduction in spawn cover. The lack of overall plant phytotoxicity was likely because the season was late so treatments did not come into contact with broken buds. Bioherbicide 116 gave no sustained weed control.

A field trial was conducted in spring 2013 to evaluate the efficacy of two herbicides and two bioherbicides for control of the perennial weeds broad-leaved dock (*Rumex obtusifolius*) and stinging nettle (*Urtica dioica*). An untreated control and a grower standard Rosate 36 (glyphosate) were included. Each product was applied twice, on 7 and 22 May. At 56 days after the first application, docks were significantly reduced by the bioherbicide 109 and Rosate 36; the latter gave complete control from 28 days after treatment (DAT)1. Herbicide 124 and bioherbicide 116 were ineffective on docks. All products initially reduced nettles, up to 21 DAT1, but by 56 DAT1 re-growth had occurred in all plots, comparable to the untreated, except for Rosate 36 and bioherbicide 116.

Raspberry spur blight

An inoculated trial was established in autumn 2014 to evaluate the efficacy of Signum (pyraclostrobin + boscalid), Switch (cyprodinil + 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.

Raspberry aphid (*Amphorophora idaei*) and potato aphid (*Macrosiphum euphorbiae*)

<u>2011</u>

Six novel insecticides were compared with Calypso (thiacloprid) and a water control in a glasshouse experiment. Sprays were applied three times at weekly intervals after loading plants with aphids, apart from 70 which was sprayed once at the start of the experiment. Aphid numbers increased greatly on the untreated control and appeared to be reduced by all treatments. The coded product 70 and Calypso were particularly effective.

<u>2012</u>

A glasshouse trial was conducted in summer 2012 to evaluate three insecticides and three bio-nsecticides 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 (50, 54 and 60) gave good control, similar to Calypso. The three bioinsecticides (51, 62 and 130) also gave control, though were less effective than the insecticides; they look promising if compatible with biocontrol agents.

2013

A field trial was conducted in summer 2013 to evaluate one insecticide and three bioinsecticides used in conjunction with macrobiologicals for control of large raspberry aphid (*Amphorophora idaei*) and potato aphid (*Microsiphum euphorbiae*) in a polytunnel crop of raspberry cv. Glen Ample. Treatments were compared with a water control and the standard insecticide Calypso (thiacloprid). The parasitoid Ervipar (*Aphidius ervi*) was released to suppress potato aphid and Spidex (*Phytoseiulus persimilis*) was used to suppress spider mites; endemic hoverflies were encouraged. Calypso and insecticide 50 gave best control of both aphid species. Biopesticide 62 was the best biopesticide and reduced both aphid species. Biopesticide 130 was very effective against large raspberry aphid but not potato aphid; this bioinsecticide resulted in fruit taint after 4 sprays. Both insecticides had a strong negative effect on released parasitoids and endemic hoverflies whereas none of the biopesticides did.

2014

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 levels of potato aphid and all except 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.

Strawberry crown rot (*Phytophthora cactorum*)

2012

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 (24) and two biofungicides (40 and 98). Occurrence of dead plants was reduced by Paraat and biofungicide 40.

2013

A polytunnel trial was conducted in summer 2013 to evaluate three fungicides and two biofungicides, each applied by three application methods, for control of crown rot (*Phytophthora cactorum*) in strawberry cv. Elsanta grown in peat bags. Two crown rot infected plants were placed in each bag as a source of inoculum. By February 2014, crown rot symptoms had developed in only two plants. It was not possible therefore to draw any conclusions on treatment efficacy from this work.

2014

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 fungicides and two biofungicides were each examined as a pre-plant dip, a post-plant drench and a post-plant spray. 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. A high level of crown rot was found in all treatments due to natural infection in the plants at planting and no conclusions could be drawn on treatment efficacy.

Strawberry powdery mildew (*Sphaerotheca macularis*)

2014

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. At the final disease assessment, powdery mildew affected 24% leaf area on untreated plants. All treatments reduced mildew compared with the untreated control. Seven products (Talius, 17, 25a, 77, Galileo, 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.

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.

Strawberry soft rots (*Mucor* and *Rhizopus* spp.)

<u>2011</u>

Eleven treatments were compared with an untreated control in a Spanish tunnel crop of Elsanta. Sprays were applied from green fruit and soft rot was assessed in post-harvest tests. *Mucor* was the predominant casue of soft rotting. *Mucor* soft rot was reduced by Switch (cypodinil + fludioxonil), Signum (boscalid + pyraclostrobin), Thianosan DG (thiram) and one coded product.

<u>2012</u>

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 77 were consistently the best treatments, reducing the disease by over 50%. None of the biofungicides gave any control.

2013

A trial was conducted in summer 2013 to evaluate the efficacy of one fungicide, one biofungicide, two alternative products, three fungicide programmes and two fungicide + alternative products programmes for control of fruit soft rots (*Mucor* and *Rhizopus* spp.) in a tunnel crop of strawberry cv. Finesse. Treatments were compared with an untreated control. Products were applied on five occasions during fruit development and resultant mature fruit were assessed in post harvest tests. Over 40% of untreated fruit developed *Mucor* soft rot. Fungicide 37 and two programmes (Thianosan, Switch, Signum; Thianosan, Switch, fungicide 77) were consistently the best treatments, reducing the disease by 30-34%; the other treatments (fungicide 47, products 186 and 187 and three programmes) had no effect. Botrytis affected 24% of fruit from untreated plants in post harvest tests. This disease was reduced by the same three treatments and also by a programme of Thianosan, Switch and fungicide 25a.

Strawberry – European tarnished plant bug (*Lygus rugulipennis*)

2011

Four novel insecticides were compared with Calypso, Chess WG (pymetrozine), Steward (indoxacarb) and an untreated control in a cage experiment in an unheated polytunnel. Adults and nymphs were placed on everbearer strawberry plants 8 days before the first treatment. Populations of the pest failed to increase. Nevertheless, differences were observed between treatments. Chess WG and Steward reduced the pest by around 80%; the other treatments were ineffective.

2012

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), Steward and 60. Spruzit used at the maximum label rate for protected crops (higher than is used in commercial practice) caused damage on this variety.

2013

A caged trial in a glasshouse was conducted in summer 2013 to evaluate insecticide 59 applied alone and Steward applied alone and in mixtures with Chess (pymetrozine), Spruzit (pyrethrum) and Silwet L-77 (silicon wetter) for control of European tarnished plant bug (*Lygus rugulipennis*) on strawberry cv. Finesse. An untreated control and the standard treatment Chess were included; Spruzit alone was also tested. Each cage was artificially infested with adults of the pest and plants were sprayed 3 and 5 weeks later. Insecticide 59 greatly reduced numbers of adults and nymphs. Insecticide 149 alone reduced numbers of adults and reduced numbers of nymphs when in admixture with Chess, Spruzit and Silwet-L77. Chess or Spruzit used alone (at a low rate) did not reduce the pest.

2014

A field trial was conducted in summer 2014 to evaluate two insecticides (Steward and 59) 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* nymph, with Equity consistently the most effective (85% reduction). Steward and 59 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; Equity was 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.

Strawberry – Herbicides for runner control

2014

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 whereas herbicides 109 and 124 significantly scorched foliage and reduced coverage but did not appear to kill runner crowns.

Strawberry – Herbicides for weed control

2011

Four novel herbicides were compared with an untreated control in an open-field unirrigated strawberry crop in Cambridgeshire. Weed seed germination was low due to dry weather and no conclusions could be drawn on levels of weed control. Two of the herbicides caused no crop damage and two caused some foliar damage, from which plants grew away. None of the treatments reduced fruit yield.

2012

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 (74, 76 and 119) reduced yield. Herbicide 119 caused obvious crop damage both on treated rows and adjacent plots. Herbicide 74 is being taken forward for off label approval as a short term residual herbicide for use on strawberry.

2014

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.

Protected edibles

Cucumber black root rot (*Phomopsis sclerotioides*)

2013

Two inoculated short-duration glasshouse trials were conducted in winter 2013 to evaluate the efficacy and crop safety of 11 fungicide (Trial 1) and nine 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. Fungicides were applied twice, once before and once after inoculation; biofungicides were applied twice before and once after inoculation. 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 at 2 months after inoculation so no conclusions could be drawn on product efficacy. Eight of the 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.

<u>2014</u>

An inoculated long-duration glasshouse trial was conducted in summer 2014 to evaluate the efficacy and crop safety of eight 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 pathogens 19 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. Fungicides and biofungicide 98 were applied four times to the first crop (at planting and then at three week intervals) and twice to the second crop (at 2 and 5 weeks after placement of plants on the slabs). Serenade ASO 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 the fungicides Amistar, Signum, 37, 175 and 176; neither of the biofungicides reduced wilting. The effective conventional fungicide treatments also resulted in greater root vigour and reduced root rot symptoms of the disease. Two of the 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.

Cucumber powdery mildew (*Podosphaera xanthii*)

2011

Novel fungicide (Trial 1) and biofungicide (Trial 2) treatments were compared with an untreated control and industry standards (Systhane 20EW, myclobutanil; Rocket, triflumizole) for control of powdery mildew (*Podosphaera xanthii*) on cucumber cv. Roxanna. Fungicides were applied twice and biofungicides three times from immediately after inoculation. In Trial 1, where moderately severe powdery mildew developed, fungicide 77 provided almost complete control and Talius and 10 were also very effective. The standard fungicides provided relatively poor control, reflecting current commercial practice; this is most likely due to fungicide resistance. In Trial 2, powdery mildew failed to spread from the inoculated leaf so disease levels were low. At this low disease pressure, four biofungicides (Serenade ASO, 06, 80 and 90) significantly reduced powdery mildew levels.

2012

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 control. Fungicides 77 and 25a were particularly effective keeping the crop clean throughout the trial. One biofungicide (105) reduced disease for one month after inoculation and two biofungicides (90 and 154) reduced it for two weeks. The biofungicide 135 reduced disease slightly by the end of the trial. Three of the fungicides (14, 77 and Talius) and Systhane 20EW caused phytotoxicity after the first application, to young plants; damage was nil or slight on older plants.

Cucumber Pythium root rot (*Pythium aphanidermatum*)

2013

A glasshouse inoculated trial was conducted in summer 2013 to evaluate 11 fungicides and nine biofungicides for control of Pythium root and stem base rot (*Pythium aphanidermatum*) in cucumber cv. Shakira grown in rockwool blocks. A water-only treatment and a standard fungicide Previcur Energy (propamocarb-HCl + fosetyl-Al) were included. Products were drenched into blocks at 65 ml/block. Fungicides were applied 2 days before and 10 days after inoculation; biofungicides at these times and additionally at seed sowing (2 weeks before inoculation). At 7 weeks after inoculation, stem base lesion severity was reduced by six of the fungicides (Amistar, Signum, 44, 169, 171, 183) and none of the biofungicides (Serenade

ASO, 40, 43, 47, 98, 105, 121, 188 and 189). Fungicide 183 was best, with no stem lesions and no root discolouration. Amistar and 171 were phytotoxic at the rates used, resulting in stunting and chlorosis. Biofungicide 189 appeared to reduce the disease. Previcur Energy failed to reduce root discolouration or stem base lesion severity.

<u>2014</u>

A glasshouse trial was conducted in summer 2014 to evaluate seven 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-HCl + fosetyl-Al) 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 3 week intervals. Both the first and second crops were inoculated with *P. aphanidermatum,* 11 and 6 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 the fungicides Amistar and 46 in crop 1 and by Previcur Energy in crop 2. Transient wilting in crop 1 was reduced by most of the 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 Amistar, Previcur Energy, Signum and 47 in crop 1; plants grew out of these effects and no further symptoms occurred in either crop. There were no differences between treatments in fruit yield.

Sweet pepper – Aphids (*Myzus persicae*)

<u>2013</u>

A glasshouse trial was conducted in late summer 2013 to evaluate three bioinsecticides against aphids (*Myzus persicae*) on pepper cv. Ferrari. Treatments were compared with the insecticide Pyrethrum 5EC (pyrethrum) and a water-only control. Treatments were applied three times at 7 day intervals. Aphid levels at the start of the experiment were 5-15 per leaf. The bioinsecticide 130 reduced aphids to around 2 per leaf whereas Pyrethrum and bio-insecticides 51 and 62 were ineffective.

A glasshouse trial was conducted in late summer 2013 to evaluate the bioinsecticide 130 against aphid (*Myzus persicae*) on pepper cv. Ferrari. Treatment was compared with the conventional insecticide Chess (pymetrozine) and a water-only control. Chess and 130 were each applied once followed one day later by introduction of the macrobiological *Aphidius colemani*; an *Aphidius*-only treatment was also included. At the time of treatment there were

28-48 aphids/plant. Two weeks after application, both Chess and 130 followed by *A. colemani* had reduced aphid numbers compared with the water only treatment; *A. colemani* alone was ineffective at this time.

2014

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.

Sweet pepper – Western flower thrips (*Frankliniella occidentalis*)

2011

Three insecticides and four bioinsecticides were evaluated for control of WFT (*Frankliniella occidentalis*) in a glasshouse crop of sweet pepper cv. Ferrari. The pest was established at a low level throughout the crop before treatments were applied. The three conventional insecticides (48, 50 and 54) and three bioinsecticide (Mycotal, 52, 82) significantly reduced the pest compared with the untreated control. The capacity to integrate these treatments within an IPM programme using macrobiologicals requires evaluation.

2012

Six treatments, comprising the insecticide Pyrethrum 5EC (pyrethrins) and five bioinsecticides, 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 (01, 51, 60, 62, 91) were as effective as the standard treatment, Pyrethrum 5EC.

2014

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.

Tomato grey mould (*Botrytis cinerea*)

2011

Novel fungicide (Trial 1) and biofungicide (Trial 2) treatments were compared with an untreated control and industry standards (Switch, cyprodinil + fludioxonil; Teldor, fenhexamid; Prestop, *Gliocladium catenulatum*) for control of grey mould (*Botrytis cinerea*) on tomato cv. Elegance. Fungicides were applied to the crop twice and biofungicides three times. Levels of stem botrytis that developed on inoculated treated plants were highly variable and there were no significant differences between treatments. In Trial 1, laboratory experiments on inoculated detached leaves showed 08 and 77 gave some control; neither Teldor nor Switch were effective in this severe test. In Trial 2, one product (09) significantly reduced Botrytis; both Teldor and Prestop were ineffective in this detached leaf test.

2012

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 08, 25 and Galileo; the standard programme and the other fungicides had no effect. None of the biofungicices reduced the disease.

2013

A glasshouse trial was conducted in 2013 to evaluate four fungicides and five biofungicides against grey mould (*Botrytis cinerea*) in tomato cv. Elegance grown on Maxifort rootstock. Treatments were compared with an untreated control and a standard fungicide programme of Rovral WG (iprodione) alternated with Signum (boscalid + pyraclostrobin) and Switch (cyprodinil + fludioxonil). Fungicides and biofungicides were evaluated in separate, identical glasshouses to preclude possible interactions. Biofungicides were applied eight times at 7 day intervals over a 2 month period and fungicide six times at 14 day intervals, both from the first sign of natural leaf infection in early July; the exception was Prestop (*Gliocladium catenulatum*), which was applied every 3 weeks, as per label. Severe leaf botrytis and ghost spot developed and there was a high incidence of leaf dieback and stem lesions by the final assessment on 6 September. The standard fungicide programme, Galileo, Vertisan and the two coded fungicides (25a, 77) all reduced leaf Botrytis with product 77 better than all other treatments; 25a, 77 and Galileo also appeared to reduce stem lesions. None of the biofungicides (40, 105, 132, Serenade ASO and Prestop) reduced Botrytis at any assessment. No fungicide or biofungicide reduced ghost spot symptoms on fruit.

Tomato – Glasshouse whitefly (*Trialeurodes vaporariorum*)

<u>2011</u>

Two insecticides and five bioinsecticides were evaluated for control of glasshouse whitefly (*Trialeurodes vaporariorum*) on a glasshouse tomato crop, cv. Dometica. The pest was established throughout the crop before spray treatments commenced. All treatments significantly reduced the number of whitefly adults and scales compared with a water-treated control. Two new insecticide treatments (54 and 60) gave a high level of control. The five bioinsecticide treatments could offer part of a solution to glasshouse whitefly when used in a programme with other treatments.

<u>2012</u>

Two insecticides and three bioinsecticides 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.

Tomato spider mite (*Tetranychus urticae*)

<u>2011</u>

Seven insecticides were examined for control of spider mites (*Tetranychus urticae*) on a glasshouse tomato crop, cv. Dometica. At an assessment 7 days after the first spray, results suggested that all treatments were reducing levels of the pest. The glasshouse heating subsequently failed and no more valid assessments were possible. This experiment was repeated in spring 2012.

2012

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 131 was most effective. In Trial 2, six treatments reduced numbers of nymphs and two treatments, Borneo (etoxazole) and 131, also reduced numbers of eggs after two sprays. The four bioinsecticides in Trial 2 (51, 62, 91, 92), applied when pest densities were low, gave similar control to that of the two insecticides.

2013

A glasshouse trial was conducted in summer 2013 to evaluate the efficacy of three bioinsecticides against relatively high levels of spider mite (*Tetranychus urticae*) and whitefly (*Trialeurodes vaporariorum*) on tomato cv. Cheramy. Each treatment was applied twice at 7 day intervals and followed by two introductions of *Phytoseiulus persimilis* for spider mite and of *Encarsia formosa* for whitefly. Treatments were compared with Chess (pymetrozine) for spider mite and Borneo (etoxazole) for white fly each followed by the macrobiologicals; water only and macrobiologicals only treatments were included. At the start of the experiment the mean number of adult plus nymph spider mites was 1-8 per leaflet; the mean number of adult whiteflies was 3-13 per leaflet. All treatments reduced all stages of spider mite with Borneo and the three biopesticides (51, 62, 130) followed by *P. persimilus* giving high levels of control, better than *P. persimilis* only. Spider mite levels were greatly reduced in all treatments by treatment with sulphur for powdery mildew control 4 days after the second biopesticide application; however, whereas levels in the water treatment subsequently increased, the macrobiologicals maintained control in all other treatments. Whitefly adults were reduced by Chess and biopesticide 51, but whitefly scales were not reduced by any treatment. The sulphur spray did not reduce whitefly populations. The experiment provides evidence that Chess and biopesticide 51, 62 and 130 can reduce spider mite, and Borneo and biopesticide 51 can reduce whitefly, to levels sufficient for macrobiologicals to maintain control.

Top fruit

Apple powdery mildew (*Podosphaera leucotricha*)

2011

Five fungicides and five biofungicides were evaluated for control of powdery mildew (*Podesphaera leucotricha*) on apple cv. Cox in an established orchard. Products were applied five times at 2-3 week intervals from post-blossom. High levels of powdery mildew developed on untreated trees. Powdery mildew was significantly reduced by all five fungicide treatments and three of the biofungicide treatments, albeit the level of control provided by the latter was small (around 20% reduction). One fungicide (77) was outstanding (75% reduction), and another (47) was better than the standard fungicide treatment Systhane 20EW (myclobutanil). All treatments reduced fruit russet, a problem part-caused by powdery mildew, compared with the untreated control. The biofungicides will be re-evaulated in 2012 on container-grown apples with treatments applied at a shorter spray interval of 7-10 days; weather conditions in 2011 constrained the planned 7-day spray application interval.

<u>2012</u>

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 (32) reduced mildew by over 50%. In Trial 2 (biofungicides), the reference product Systhane 20EW was the most effective. Potassium hydrogen carbonate (now registered for use on apple as a conventional fungicide, Karma) and sulphur (conventional fungicide) and a mixture of these were almost as good. Three biofungicides based on microorganisms gave a small reduction in powdery mildew.

<u>2013</u>

A trial was conducted in summer 2013 to evaluate the efficacy of six fungicide programmes and two fungicide products (Talius and Galileo) in comparison with a standard fungicide Systhane 20EW (myclobutanil) for control of powdery mildew on apple trees cv. Cox. Five sprays were applied at 7-14 d intervals from the start of extension growth using a motorised knapsack sprayer. Four of the programmes comprised three fungicides from different fungicide groups; two programmes involved two fungicides. The severity of mildew was high. All treatments reduced mildew at all assessments. Talius and Galileo were both very effective, reducing mildew from 82% to 33 and 32% leaves affected respectively. The most effective programme used fungicides 32 and 159, reducing mildew to 30%. The standard fungicide Systhane 20EW gave relatively poor control (63% leaves affected), probably due to reduced sensitivity.

A trial was conducted in summer 2013 to evaluate the efficacy of six biofungicides in comparison with a standard fungicide Systhane 20EW (myclobutanil) and an inorganic fungicide Kumulus DF (sulphur) for control of powdery mildew (*Podosphaera leucotricha*) on apple cv. MM106 grown in pots. A programme of two sprays of a conventional fungicide (32) followed by three sprays of a biofungicide (105); and a programme alternating one biofungicide (06) with another (105) were also tested. Untreated and water-only controls were included. Treatments were applied five times at 7 day intervals. Conditions were conducive to mildew and over 50% of leaves on untreated and water-treated plants were affected by secondary mildew. All treatments reduced the disease, with Systhane 20EW, Kumulus DF, biofungicide 90, and a programme based on conventional fungicide 32 and biofungicide 105 reducing it to <30%.

<u>2014</u>

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 the 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.

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 T3-T9, when programmes changed to biofungicides (7 sprays at 7 day intervals), powdery mildew rapidly increased back to the starting level. 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.

Pear – Botrytis rot in store (*Botrytis cinerea*)

<u>2012</u>

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, Serenade ASO, 99 and 98. 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.

<u>2013</u>

An inoculated trial was conducted between September 2012 and March 2013 to evaluate four biofungicides against fruit rot (*Botrytis cinerea*) in cold-stored pears, cv. Conference. Treatments were compared with the fungicide Rovral WG (iprodione) and untreated controls. Treatments were applied as a dip immediately before transfer to a cold store (0°C). Spread of *B. cinerea* from inoculated to healthy fruit was good with 50% of fruit becoming affected in untreated crates. Botrytis rot was reduced by Rovral WG and Serenade ASO and not by other treatments (06, 99 and Nexy 1). Rovral WG (13% fruit rot) was better than Serenade ASO (39% fruit rot).

<u>2014</u>

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 the 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 (*Candida oleophila*) and products 99 and Serenade ASO. Rovral WG was the most effective (fruit rot incidence reduced to 20%). Serenade ASO 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 Serenade ASO also reduced the disease. Nexy and biofungicide 99 failed to reduce the disease in the CA storage trial. Serenade ASO is a bacterial-based product whereas 99 and Nexy are both yeast-based products. Possibly yeast-based biofungicides do not perform as well under CA storage conditions as in air, whereas the bacterial-based product is more resilient.

Technology transfer (1 October 2010 – 31 March 2015)

Scientific papers

Berrie A, Saville R and Xu X (2015). Management and control of apple powdery mildew in the UK. *IOBC Proceedings* (in press).

George D, Banfield-Zanin J, Collier R, Cross J, Birch N, Gwynn R and O'Neill T (2015). The role of the SCEPTRE project in identifying novel pesticides for use against glasshouse invertebrate pests in UK tomatoes and peppers. *Insects* (in press).

Tatnell LV, Atwood J, Sparkes JL, Richardson A and Jackson S (2013). The potential for electrical weed control in a range of horticultural crops. *16th European Weed Research Society Symposium*, Samsun, Turkey, 24-27 June 2013, p 149 (abstract).

Factsheet

O'Neill TM & Gwynn R (2014). Getting the best from biopesticides. HDC Factsheet 10/14.

Articles

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

Atwood J (2015). SCEPTRE for soft fruit: the final analysis. *HDC News* **211**, 28-30

Atwood J (2014). SCEPTRE: Latest results in soft fruit. *HDC News* **201**, 28-30

Atwood J (2013). SCEPTRE: progress in soft fruit. *HDC News* **191,** 28-30.

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

Atwood R (2013). *HDC Field Vegetables Review 2013*, p 13.

Atwood R (2012). New generation of controls for vegetables. *HDC Field Vegetables Review 2012*, p. 21.

Berrie A (2014). SCEPTRE: latest results in apples. *HDC News* **204**, 12-13

Berrie A (2013). Mildew mitigation. *HDC News* **195**, 24-25.

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

Brough W (2014). From Sceptre to MOPS – crop protection research for ornamentals. *HDC Ornamentals Review*.

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

Collier R, Huckle A, Jukes A and Mayne S (2014). SCEPTRE: latest results on field vegetables. *HDC News* **202**, 28-30.

Collier R, Huckle A, Jukes A and Mayne S (2014). SCEPTRE: latest results in brassicas. *HDC News* **203**, 28-29.

Collier R and Gladders P (2013). SCEPTRE: progress in field vegetables. *HDC News* **193**, 19-21.

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

Croft P, McPherson M and Wright K (2014). SCEPTRE: latest results in protected edibles. *HDC News* **205**, 28-30.

Croft P, Wright K and McPherson M (2013). SCEPTRE: progress in protected edibles. *HDC News* **194**, 28-30.

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

Knott C (2015). Herbicides for carrots and their allies. *HDC News* **209**, 20-23.

Knott C (2014). Total workout for herbicide trio. *HDC News* **199**, 24-25.

Knott C (2014). Double hit for courgette weed control. *HDC News* **208**, 25-27.

Knott C (2013). Emerging weed controls, results from 2012 SCEPTRE trials. *HDC News* **189,** pp. 19-20

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

Mayne S, Wedgwood E, Huckle A, Collier R and Jukes A (2015). SCEPTRE: Latest results in brassica pest and disease control. *HDC News* (in press).

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

O'Neill TM (2015). Approvals in the fast lane. *HDC Crop Protection Review*, pp. 15-17.

O'Neill TM (2014). Sceptre progress report. *HDC Crop Protection Review*

O'Neill TM (2013). Biopesticides that make the grade. *HDC News* **196**, 24-26.

O'Neill TM (2011). Sceptre: new crop protection measures for soft fruit. EMRA Members Day Booklet.

O'Neill TM (2011). Securing pesticides and biopesticides for sustainable production. Project launch publicity abstract.

O’Neill TM (2011). First results emerge from Sceptre crop protection trials. *HDC News*, **176**, p.8.

O’Neill TM (2011). The cutting edge of crop protection. *HDC News,* **173**, 15-17.

O’Neill TM (2011). Sceptre: new crop protection methods for soft fruit. East Malling Research Association – Members Day 23 November 2011.

Raffle S (2013). Sceptre opens up future options. *HDC Soft fruit review 2013*, p 8

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

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

Richardson A (2013). Weed control in brassicas. Brassica Grower Association Newsletter (December)

Richardson A (2013). Controlling weeds using electricity – the shocking truth! Brassica Growers Association Newsletter (March).

Presentations

Atwood J (2014). Blackcurrant weed projects in SCEPTRE. Blackcurrant Growers Association R&D Meeting, 3 December 2014.

Berrie A (2014). Soft fruit disease management. EMRA/HDC Soft Fruit Day, East Malling Research, 26 November 2014.

Berrie A (2012). Evaluation of products for control of crown rot in strawberry, HDC/EMR Soft Fruit day, 21 November 2012.

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

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

Birch N (2013). Management of aphids on raspberry, Fruit for the Future, James Hutton Institute, Dundee, 18 July 2013.

Collier R (2014). Field vegetable pest control update, 7 February 2014, Pershore College, Worcs.

Collier R (2013). IPM in outdoor lettuce: filling the gaps?!, AAB Conference - Advances in Biological Control and IPM, 16-17 October 2013.

Collier R (2011). Research into IPM strategies to control the pest insects of vegetables. IOBC working group meeting on integrated control in field vegetables, September 2011.

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

Huckle A (2015). Developing new fungicide and biofungicide treatments for control of leek rust. Leek Growers Association meeting. Night Layer Leek Company, Wimblington, Cambs, 17 February 2015.

Jukes A (2015). Thrips and leek moth control in leeks. Leek Growers Association meeting. Night Layer Leek Company, Wimblington, Cambs, 17 February 2015.

Knott C (2013). Potential herbicide solutions for vegetables? Vegetable Consultants Association, 26 November 2013.

McPherson M (2012). Sceptre – Control of powdery mildew, Cucumber Conference, 3 October 2012.

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

O'Neill TM (2015). The Sceptre project: Aims, Overview and Outcomes. Sceptre Project Conference, Kingsgate Conference Centre, Peterborough, 24 February 2015.

O'Neill TM (2014). Securing plant protection products for sustainable tomato production. Annual Tomato Conference, Warwick, 26 September 2014.

O'Neill TM (2014). New crop protection methods for edible crops. IBMA (UK) Annual Meeting, Cambridge, 15 May 2014.

O'Neill TM (2013). New crop protection methods for field vegetables, 4 February 2014, Bayer Vegetable Conference, Peterborough.

O'Neill TM (2013). Protected edible work in Sceptre, 4 December 2013, TGA Technical Committee, Stoneleigh.

O'Neill TM (2013). New technologies for disease control, HDC / TGA Tomato Conference, 26 September 2013.

O'Neill TM (2013). Sceptre – filling crop protection gaps, BPOA meeting, 6 February 2013.

O'Neill TM (2012). New crop protection measures for edible crops. AgriFood Panel, Campden BRI, Chipping Campden, 23 May 2012.

O'Neill TM (2012). Update on Sceptre - field vegetables. ADAS-Syngenta Vegetable Conference, Peterborough, 8 February 2012.

O'Neill TM (2012). Sceptre – An introduction to work on protected edible crops, 3 October 2012, Cucumber Conference.

O'Neill TM (2011). Sceptre: new crop protection measures for soft fruit. HDC/EMRA Members Day, East Malling, 23 November 2011.

O'Neill TM (2011). Securing pesticides and biopesticides for sustainable production. ADAS-Syngenta Vegetable Conference, Peterborough, 1 February, 2011.

Powell V (2012). Giving growers access to tested biocontrol tools through a Member State Programme – SCEPTRE, Annual Biocontrol Industry Meeting, Lucerne, Switzerland, 23 October 2012.

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

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

Powell V and Neve B (2011). An Introduction to SCEPTRE. AAB Biopesticides Conference, Grantham, 29 November 2011.

Raffle S (2014). Sceptre Update – Soft fruit and top fruit. HDC Fruit Agronomists Day, 25 February 2014.

Richardson A (2013). Sceptre work on onions, 20 November 2013, UK Onion and Carrot Conference, Peterborough.

Tatnell L (2013). The potential for electrical weed control in a range of horticultural crops. 16th European Weed Research Society Symposium, Samsun, Turkey, 24-27 June 2013.

Tatnell L (2012). Evaluating Bioherbicides: current research, BCPC Weed Review, 24 October 2012.

Wedgwood E (2012). The Sceptre project – field vegetable diseases. Sceptre project conference: Securing plant protection products for sustainable crop production. Kingsgate Conference Centre, Peterborough, 24 February 2015.

Wedgwood E (2014). EMR/HDC Soft fruit day. East Malling Research, Kent, 24 November 2014.

Wedgwood E (2014). Sceptre work on onion downy mildew, 29 January 2014, Onion Growers Association Technical Meeting, Lincs.

Wright K (2013). Sceptre work on cucumbers, 18 October 2013, Cucumber Growers Day, Waltham Abbey.

Posters

Huckle A, Atwood J, Tatnell L, Richardson A, Knott C, and O'Neill T (2011). Solutions to the loss of active ingredients for weed control in field vegetable and fruit crops. European Weeds Research Society - workshop, Huesca, Spain, September 2011.

Events

Sustainable Crop Protection. Project Conference, Peterborough, 24 February 2015 (Tim O'Neill, Roma Gwynn, Erika Wedgwood, Rosemary Collier, Nick Birch, Jerry Cross, Angela Berrie, Robert Saville, Martin McPherson, David George, John Atwood, Andy Richardson, Cathy Knott).

HDC Biopesticides Workshop – Protected Edibles. Stoneleigh, Warwickshire, 27 January 2015 (Roma Gwynn, David George).

Fruit for the Future. James Hutton Institute Open Day, 17 July 2014 (Nick Birch, William Deasy).

Field vegetable disease and weed control. ADAS Boxworth Open Day, 3 June 2014 (Lynn Tatnell, Maria Tzortzi, Angela Huckle, Sarah Mayne, Tim O'Neill).

Vegetable Weed Control Open Day, Elsom Seeds Trial Ground, Spalding, 25 and 26 June 2014 (Cathy Knott, Andy Richardson).

Elsom Seeds Open Day, Spalding, 10-11 October 2013 (Angela Huckle, Peter Gladders, Sarah Mayne, Tim Boor).

Field vegetable disease and weed control. ADAS Boxworth Open Day, 5 June 2013 (Lynn Tatnell, Jessica Sparkes, Angela Huckle, Sarah Mayne, Tim O'Neill).

Vegetable weed control Open Day, Elsoms Seeds Trial Ground, Spalding, 27 June 2013. (Cathy Knott, Andy Richardson, John Atwood, Angela Huckle).

Warwick Crop Centre Open afternoon, 18 September 2013 (Rosemary Collier).

Vegetable weed control Open Day, Elsoms Seeds Trial Ground, Spalding, 20 June 2012 (Cathy Knott, Andy Richardson).

Vegetable weed control Open Day, Elsoms Seeds Trial Ground, Spalding, 22 June 2011 (Cathy Knott, Andy Richardson)

Sceptre project work on soft fruit and top fruit. Fruit Focus, East Malling, July 2011. HDC staff.

Website

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

Appendix 1 Active substances of named products

Product	Active substance(s)
Afalon	linuron
Amistar	azoxystrobin
Amistar Top	azoxystrobin + difenoconazole
Basagran	bentazone
Better DF	chloridazon
Biscaya	thiacloprid
Borneo	etoxazole
Butisan S	metazachlor
Calypso	thiacloprid
Cassiopeia	dimethomorph + pyraclostrobin
Chess WG	pymetrozine
Cosine	cyflufenamid
Defy	prosulfocarb
Dithane	mancozeb
Dual Gold	s-metolachlor
Dursban	chlorpyrifos
Equity	chlorpyriphos
Erpivar	*Aphidius ervi*
Folicur	tebuconazole
Folio Gold	chlorothalonil + metalaxyl-M
Galileo	picoxystrobin
Gamit 36CS	clomazone
Goltix Flowable	metamitron
Harvest	glufosinate ammonium
Infinito	flupicolide + propamocarb HCl
Intruder	chlorpropham
Invader	dimethomorph + mancozeb
Karma	potassium hydrogen carbonate
Kerb Flo	propyzamide
Lepinox Plus	*Bacillus thuringiensis*
Movento	spirotetramat
Mycotal	*Verticillium lecanii*
Nativo 75WG	tebuconazole + trifloxystrobin

Product	Active substance(s)
Naturalis-L	*Beauvaria bassiana*
Nexy	*Candida oleophila*
Nimrod	bupirimate
Oberon	spiromesifen
Olympus	azoxystrobin + chlorothalonil
Paraat	dimethomorph
Prestop	*Gliocladium catenulatum*
Previcur Energy	propamocarb HCI + fosetyl-Al
Pyrethrum 5EC	pyrethrins
Rapsan 500SC	metazachlor
Rocket	triflumazole
Roundup	glyphosate
Rovral WG	iprodione
Rudis	prothioconazole
Sencorex Flow	metribuzin
Serenade ASO	*Bacillus subtilis*
Signum	boscalid + pyraclostrobin
Shark	carfentrazole-ethyl
Silwett L-77	silicone-based wetter
Spidex	*Phytoseiulus persimilis*
Springbok	metazachlor + dimethenamid-P
Spruzit	pyrethrins
Starane 2	fluroxypyr
Steward	indoxacarb
Stomp Aqua	pendimethalin
Switch	cyprodinil + fludioxonil
Systhane 20EW	myclobutanil
Talius	proquinazid
Thianosan DG	thiram
Totril	ioxynil
Tracer	spinosad
Unicur	fluoxastrobin + prothioconazole
Valbon	benthiavalicarb-isopropyl + mancozeb
Vertisan	penthiopyrad
Wing P	dimethenamid + pendimethalin