Annual Project Report
01/01/2016 to 31/12/2016

Project title	Combating resistance to aphicides in UK aphid pests		
Project number	RD-2011-3768		
Start date	1/4/12	**End date**	31/3/17

Project aim and objectives

The project is monitoring the response of live samples of *M. persicae* (collected from field and protected crops) to neonicotinoids and pyrethroids and to a range of novel aphicides. It is also screening for established forms of resistance using DNA-based techniques. This close vigilance is essential to safeguard the contribution of these compounds to aphid pest management in the UK, as resistant aphids that cannot be controlled by insecticides will inevitably cause crop losses. Other important aphid pests (potato aphids, *Macrosiphum euphorbiae*, currant-lettuce aphids, *Nasonovia ribisnigri*, grain aphids, *Sitobion avenae* and rose-grain aphids, *Metopolophium dirhodum*) representing the interests of the project consortium are also being monitored, and baseline bioassay data established for relevant insecticides for these and other important aphid pests.

New bioassays for use as screening tools for novel aphicides have now been developed for use in regional laboratories or by advisors and growers.

The continued work is highly relevant to the policy objectives of Defra-CRD, and the co-ordination of research and decision making among agrochemical companies, farmer and grower organisations and advisors. Its importance is enhanced by current EU-imposed restrictions on neonicotinoid use (as seed treatments) and which may extend to other insecticide classes, coupled with the resistance situation for existing insecticides in *M. persicae*.

The over-riding objective of the project is to retain the availability of effective pesticides by developing appropriate Aphid Management Strategies and providing robust scientific support to the regulatory decision making process. Guidance is available to advisors, growers and the scientific community through the Insecticide Resistance Action Group (IRAG-UK). Other routes of communication include articles in the trade press, presentations to growers and agronomists, and papers in referred journals (see below for this year's outputs).

Key messages emerging from the project

- Screening of *M. persicae* samples taken from the field and protected crops in 2016 showed that there continues to be no significant resistance (that may compromise control) to a range of newer compounds belonging to different chemical classes. Furthermore, there have been no significant shifts in response to diagnostic doses of these insecticides that are currently effective (un-resisted) in the UK.
- Strong pirimicarb resistance and pyrethroid resistance (conferred by MACE and super-kdr target site mechanisms respectively), remain prevalent in the *M. persicae* samples although there is evidence for a slight fall in their frequency over the past several years which reflects changes in the make-up of the population.
- Our findings continue to suggest that at least some aphids in our *M. persicae* samples collected from protected crops may have come from more genetically-diverse, sexual populations on imported plant material. Obtaining samples from these environments remains very important as they are more likely to harbour aphids with new resistance mechanisms (e.g. to neonicotinoids) coming into the UK from abroad.
- The baseline work on important aphid pests other than *M. persicae* continues to add data to the large database and will allow species that are involved in future reports of insecticide control problems to be quickly screened for potential resistance (that has not been seen before).
- Three *M. euphorbiae* samples (collected in England from lettuce and strawberry) and one *N. ribisnigri* sample (collected in England from lettuce) were tested in response to reports of control problems. No evidence for insecticide resistance was found in the *M. euphorbiae* samples. However, resistance to lambda-cyhalothrin was present in the *N. ribisnigri* sample.

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- Several *S. avenae* samples collected from England and Scotland in response to reports of pyrethroid control failures contained aphids carrying pyrethroid resistance but this remained at the expected level for aphids carrying kdr.
- The *S. avenae* super-clone (Sa3), which carries kdr (in the heterozygous form: SR), does not appear to produce males or female sexual aphids when exposed autumn conditions. This probably explains why kdr homozygotes (RRs) have never been found in this species.
- In bioassays done using three *M. persicae* clones, pyrethroid resistance conferred by super-kdr mutations varied depending on the compound applied.

Summary of results from the reporting year

- In 2016, we received and successfully reared 21 field and 5 protected crop *M. persicae* samples from sites in England (collected by the sub-contractors: Dewar Crop Protection and ADAS).
- Screening bioassays applying diagnostic doses to live aphids from these samples continued to show no resistance to neonicotinoids, pymetrozine, flonicamid, spirotetramat or cyantraniliprole (with the latter due to be registered in the UK for use against aphids in 2017).
- *M. persicae* carrying MACE resistance (to pirimicarb) and the new form (north European: *ne*) of super-kdr (conferring resistance to pyrethroids), both in the heterozygous form, continue to be relatively common and widespread in the UK.
- A few of the *M. persicae* field samples were found to contain aphids that were susceptible to lambda-cyhalothrin but resistant to esfenvalerate (both pyrethroid insecticides) which is probably being caused by the existence of a new, as yet undisclosed, mechanism.
- In the field samples, there continued to be an extremely low frequency of *M. persicae* with extreme (R_3) esterase resistance to organophosphates (OPs). However, the 'O' and 'P' super-clones were found to carry resistance to OPs which maybe conferred by an unknown mechanism.
- The frequency of the 'O' super-clone appears to have fallen in Scotland and England over the past few years. The UK *M. persicae* population may therefore be undergoing a change in its make-up.
- A comparison of *M. persicae* insecticide resistance profiled found in the UK field and protected crop samples over recent years continued to show that aphids with rarer combinations of resistance mechanisms/genotypes are being found more often at the in the protected sites. This could be due to aphids in these environments originating from more diverse, foreign, sexually-producing, populations, probably on imported plant material.
- The good news is that Nic-SR/RR or super-kdr_{se} (southern European mutation), which currently appear to be mainly restricted to peach orchards in southern mainland Europe, have so far not been seen in either the protected or field UK samples.
- A sample of *N. ribisnigri*, collected in August 2016 from organic lettuce in Cambridgeshire, was resistant to lambda-cyhalothrin.
- We have continued to develop and validate the best bioassay method for various insecticide/aphid species combinations with the end product of susceptible baselines which will allow quick screening for new forms of resistance in aphid samples collected after insecticide control failures.
- The Resistance Factors (RFs), relative to a fully susceptible aphid clone, conferred by super-kdr mutations in *M. persicae* are very large for lambda-cyhalothrin and DDT but are far lower for tefluthrin and fenfluthrin, although these compounds have a lower potency. This demonstrates that RFs to pyrethroids conferred by super-kdr mutations can vary greatly as a result of how they affect pyrethroid binding.
- *S. avenae* samples collected from England and Scotland in response to pyrethroid control failures contained kdr aphids. Bioassays on live insects showed that pyrethroid resistance level was as expected for aphids carrying this mechanism in the heterozygous form.

The results described in this summary report are interim and relate to one year. In all cases, the reports refer to projects that extend over a number of years.

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- A *M. dirhodum* sample, collected from Suffolk, showed no evidence of pyrethroid resistance in a bioassay applying lambda-cyhalothrin.
- A life cycle study on the *S. avenae* super-clone (Sa3,) which carries kdr (in the heterozygous form: SR) and remains common in the UK, has so far not produced males or female sexual aphids when exposed to a short day length and lower temperature (~12ºC).

Key issues to be addressed in the next year

- The current project is due to end on 31/3/17. Over this remaining period, we will continue to monitor the response of live samples of *M. persicae* to a range of aphicides using screening bioassays; an important approach as we cannot predict the mechanism of any new types of resistance. This close vigilance is essential to safeguard the contribution of effective compounds to aphid pest management.
- The project will also continue to test for several known, established forms of insecticide resistance in the *M. persicae* samples using DNA diagnostics (to monitor for any changes in their frequency in the aphid population).
- We will continue to monitor other important aphid pests, where significant resistance is not yet present, in response to any reports of insecticide control problems. We will also continue to establish useful insecticide-susceptible baseline data for various aphid/insecticide combinations to allow quick screening, using diagnostic doses, for resistance in samples associated with control failures.
- We will complete the life cycle study on the Sa3 *S. avenae* super-clone.
- We are seeking funding for a new project which will extend the resistance research to all relevant UK insect pests.

Lead partner	Rothamsted Research
Scientific partners	Rothamsted Research
Industry partners	AHDB-Cereals & Oilseeds, AHDB-Horticulture, AHDB-Potatoes, Bayer, BBRO, Belchim, DuPont, NuFarm, Sumitomo, Syngenta.
Government sponsor	Chemicals Regulation Directorate/Defra.

Has your project featured in any of the following in the last year?

Events

S Foster. Insecticide resistance in UK pests. *Procam*, Harpenden, December 2016.

C Nicholls. Can we maintain pyrethroid efficacy? AHDB Agronomists Conference, December 2016.

M Stevens & S Foster. Insecticide resistance in *Myzus persicae*: practical implications for virus control. *Webex for Focus on Potatoes*. November 2016.

S Foster. Insecticide resistance in cabbage stem flea beetles and aphids. *OSR Value Chain Conference.* Stoneleigh, November 2016.

S Foster. Update on insecticide resistance in UK pests. *Frontier Winter Meeting.* Nassington, November 2016.

S Foster. Insecticide resistance in UK pests. *British Leafy Salad's Association*, Harpenden, November 2016.

A Dewar. Control of aphids and flea beetles in oilseed rape, and aphids in cereals. *Growers Meeting*, Bishops Stortford, November 2016.

S Foster. Combating resistance to aphicides in UK aphid pests. *IRAG-UK*, Sandy, October 2016.

S Foster. Combating resistance to aphicides in UK aphid pests. *IRAG-UK*, Warwick, April 2016

L Field. Insect control: what are the issues? *NFU Meeting*, Ware, March 2016.

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S Foster. Pesticide Resistance. *Environmental Risk Assessment Group Meeting.* Rothamsted Research, Harpenden, March 2016.
R Collier. Bugs and things. *Lettuce Research Update Meeting*, Harper Adams University, February 2016.
L Field. Can we continue to grow oilseed rape in the UK? *First Annual BCPC Pests and Beneficials Review*, Histon, February, 2016.

Press articles

Resistance in aphids (*Crops Magazine*, September 2016).
Insecticide resistance – why monitoring is important (*ADAS News Webpage*, August 2016).
Insecticide resistance (*Farmers Weekly*, July 2016).
Have pyrethroid insecticides shot the agricultural industry in the foot? (*Outlooks on Pest Management*, June 2016).
Aphid threat looms as winged pests fly into crops (*Farmers Weekly*, May 2015).
Managing aphids; a growers' guide (*CPM*, May 2016).
Combating resistance to aphicides in UK aphid pests (*Monthly Newsletter for BGA Members*, April 2016
Peach-potato aphid pesticide resistance update (*Farmers Guardian*, November 2015).
Industry must change habits to keep pest control toolbox (*Crops*, November 2015).
Strategic approach for persistent pests (*AHDB 'From Theory to Field' Article*, August 2015).
Peach-potato aphids are particularly good at evolving resistance to many insecticides (*Potato Review*, May 2015).
Use the latest brassica alerts to keep one step ahead of the pests (*Syngenta News*, May 2015).

Conference presentations, papers or posters

Conference Papers

G Malloch, J Pickup, F Highet, S Foster, M Williamson & B Fenton (2016) Assessment of the spread of pyrethroid resistant *Sitobion avenae* in the UK and an update on changes in the population structure of *Myzus persicae* in Scotland. *Proceedings Crop Protection Conference in Northern Britain 2016.*

Conference Presentations

G Malloch, J Pickup, F Highet, S Foster, M Williamson & B Fenton. Assessment of the spread of pyrethroid resistant grain aphid (*Sitobion avenae*) and an update on changes in the population structure of peach potato aphid (*Myzus persicae*) in Scotland. *Crop Protection in Northern Britain*, Dundee, February 2016.

Other

Book Chapters

SP Foster, G Devine & AL Devonshire. Insecticide resistance in aphids. In *Aphids as Crop Pests*. HF van Emden & R Harrington (eds) CABI Wallingford, UK). 3rd Edition.