Annual Project Report
01/04/2015 to 31/03/2016

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 continuing research on aphicide resistance management for the UK farming industries and providing up-to-date information for agronomic and regulatory procedures. The need for this work is heightened by the occurrence of control failures with neonicotinoids against peach-potato aphids, *Myzus persicae*, in southern mainland Europe. The appearance of these resistant aphids in that region represents a substantial threat to aphid control in the UK as any move into this country would have very serious repercussions for neonicotinoid treatments on a range of crops. The loss of effective neonicotinoids due to resistance and, as a result, a move to other chemistry would accentuate the risk of the evolution of resistance to the alternative non-neonicotinoid compounds.

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*, and grain aphids, *Sitobion avenae*) 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 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 recent EU-imposed restrictions on neonicotinoid use (as seed treatments), which has now continued past the initial two year period 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 2015 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.
- There were no reports of insecticide control problems in other aphid pests such as *M. euphorbiae* and *N. ribisnigri.*
- 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 particularly important as they are more likely to harbour aphids with new resistance mechanisms (e.g. to neonicotinoids) coming from abroad.

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- 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).
- A kdr-SR *S. avenae* clone (carrying resistance to pyrethroids in the heterozygous form) was repelled less than a kdr-SS (fully pyrethroid-susceptible) *S. avenae* clone from barley shoots that had been sprayed with a pyrethroid.
- These kdr-SR and kdr-SS *S. avenae* clones showed similar repellence by *E-B*-farnesene (the aphid alarm pheromone) in small scale bioassays.
- In bioassays done using three *M. persicae* clones, resistance conferred by super-kdr mutations varied depending on the insecticide applied.

Summary of results from the reporting year

- In 2015, we received and successfully reared *M. persicae* samples from 26 field and 4 protected crop 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).
- MACE resistance (to pirimicarb), in the heterozygous form, continues to be common and widespread in *M. persicae* in the UK.
- There continues to be a very high frequency of *M. persicae* with the new form (north European: *ne*) of super-kdr in the heterozygous form (which we have previously shown to confer strong resistance, measured by survival, to some pyrethroids).
- In the field samples, there continued to be an extremely low frequency of *M. persicae* with extreme (R_3) esterase resistance to organophosphates (OPs) which is most likely due to the low of use of these compounds in the UK and fitness costs associated with this resistance mechanism.
- A comparison of the resistant *M. persicae* genotypes found in the field and protected crops over recent years continued to show that aphids with rarer combinations of resistance mechanisms/genotypes are being found more often in the UK protected crop samples. This could be due to aphids in the protected 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 restricted to peach orchards in southern mainland Europe, have so far not been seen in either the protected or field UK samples.
- 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.
- In large scale assays using winged *S. avenae*, kdr-SR aphids were repelled significantly less than kdr-SS aphids from barley shoots (in pots) that had been sprayed with lambda-cyhalothrin at the recommended field rate for aphids. Furthermore, the percentage of aphids producing nymphs was much higher for kdr-SR forms. Indeed, none of the kdr-SS aphids found on treated shoots reproduced. This suggests that pyrethroid sprays will not deter kdr-SR aphids from flying into ceral crops.
- In small scale assays using *S. avenae*, kdr-SR and –SS forms showed similar responses to alarm pheromone suggesting that there are no differences in repellence between them. They are therefore likely to have similar vulnerability to beneficial insects such as ladybirds and parasitoids.
- 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, although this

compound has 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 molecule binding.

Key issues to be addressed in the next year
• The project will continue to monitor the response of live samples of *M. persicae* (collected from UK field and protected crops) 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 pest/insecticide combinations to allow quick screening, using diagnostic doses, for resistance in samples associated with control failures. • We will continue to measure potential differences in fitness between kdr-SR and –SS *S. avena*e. • We will also continue to look for variation in resistance factors to different pyrethroids conferred by different super-kdr mechanisms in *M. persicae*.

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	***Press articles***
L Field. Insect control: what are the issues? *NFU Meeting*, Ware, March 2016. 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. M Tait. A view on neonicotinoids in oilseed rape. *Cambridgeshire Bee Keepers Association*, Fulbourn, December.	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).

S Foster. Insecticide resistance in UK pests: growing problems. *Frontier Agriculture Meeting*, Wansford, December 2015. S Foster Resistance in aphids, beetles and weevils in the UK: growing problems. *Rothamsted Research Association Winter Meeting*,. Rothamsted Research, Harpenden, December 2015. S Foster Insecticide resistance in key UK pests: growing problems. *Vegetable Consultants Association*, Stilton, November 2015. S Foster. Insecticide resistance in UK pests: growing problems. *Frontier Agriculture Norfolk Team Autumn Farmers Meeting*, Norwich, October 2015. S Foster. Combating resistance to aphicides in UK aphid pests. *IRAG-UK*, Dunmow, October 2015. S Foster. IRAG-UK. *IRAC Meeting*, Rothamsted Research, Harpenden, September 2015. S Foster. Insecticide resistance in UK pests: growing problems. *AHDB Crop Protection Group*, Stoneleigh, August 2015. S Foster. Update on resistant pests in cereals and oilseed rape. *Bayer Commercial Technical Managers Meeting*, Huntingdon, March 2015. S Foster. Combating resistance in UK pests. *IRAG-UK*, Sand Hutton, March 2015.	
Conference presentations, papers or posters	***Scientific papers***
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.* C Bass, M Puinean, CT Zimmer, I Denholm, LM Field, SP Foster, R Nauen, R Slater & MS Williamson (2015) The evolution of insecticide resistance in the peach-potato aphid, *Myzus persicae*. *Antenna Special Edition*, pages 59-60. **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.	

S Foster, G Malloch, B Fenton & M Williamson. Insecticide resistance: the attack of the clones. *Aphid Special Interest Group*, Paris, November 2015. M Puinean. Insecticide resistance. *Aphid Special Interest Group*, Paris, November 2015. S Foster. Insecticide resistance in peach-potato aphids: the good news and the bad news. *IIRB Seminar: Resistance Management*, Vienna, September 2015. M Puinean, C Bass, E Davies, L Field, S Foster & M Williamson. Insecticide resistance: uncovering mechanisms and mitigating threats to crop production. *National Institutes of Bioscience Conference*, Harpenden, June 2015.	
Other	
Book Chapters SP Foster, G Devine & AL Devonshire (2015) Insecticide resistance in aphids. In *Aphids as Crop Pests*. HF van Emden & R Harrington (eds) CABI Wallingford, UK). 3rd Edition.	