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01/01/2017 to 31/12/2017

Project title	**Monitoring and managing insecticide resistance in UK pests**		
Project number	21510015		
Start date	1/4/12	**End date**	31/3/18

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 and north Africa and the movement of resistant forms to secondary hosts. The appearance of these highly-resistant aphids in that region represents a substantial threat to aphid control in the UK as any movement into this country (on imported plant material or through winged migration) 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, reliance on other chemistries 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 with a good UK geographical spread) to neonicotinoids and pyrethroids and to a range of novel aphicides including the new aphicide Isoclast (sulfoxaflor). 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 will inevitably cause crop losses. Other important aphid pests: potato aphids (*Macrosiphum euphorbiae*), currant-lettuce aphids (*Nasonovia ribisnigri*), grain aphids (*Sitobion avenae*), bird cherry-oat aphids (*Rhopalosiphum padi*), 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. The project also now includes resistance monitoring in other important UK insect pests including cabbage stem flea beetles (*Psylliodes chrysocephala*), pea and bean weevils (*Sitona lineatus*), pollen beetles (*Meligethes aeneus*), diamond back moths (*Plutella xylostella*) and onion thrips (*Thrips tabaci*).

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) which may extend to flowering crops and cereals and 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 being regularly made 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 and conference proceedings (see below for this year's outputs).

Key messages emerging from the project

- Screening of peach-potato aphid (*M. persicae*) samples taken from the field and protected crops in 2017 showed that there continues to be no significant resistance (that may compromise control) to a range of newer compounds belonging to different chemical classes, including sulfoxaflor. Furthermore, there have been no significant shifts in response to diagnostic doses of these insecticides that are currently effective (un-resisted) in the UK.
- In contrast, 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 some changes in the genetic make-up of the UK population.
- Our findings continue to suggest that at least some *M. persicae* collected from protected crops may have come from more genetically-diverse, sexual populations on imported plant material. Obtaining samples from

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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 other important aphid pests continues to add data to the large database (which currently contains 50 separate baselines). This will allow aphid species linked to future reports of insecticide control problems to be quickly screened for potential resistance (that has not been seen previously).
- Greater pyrethroid resistance than that conferred by kdr has not been found in grain aphids (*S. avenae*).
- Pyrethroid resistance continues to be seen in cabbage stem flea beetles (*P. chrysocephala*), pollen beetles (*M. aeneus*), pea and bean weevils (*S. lineatus*) and diamond back moths (*P*. *xylostella*).
- Pyrethroid resistance was seen in bioassays on several other beetle pests of stored grain and oilseed rape.
- Spinosad resistance was found for the first time in onion thrips (*Thrips tabaci*). This explains reports of reduced efficacy of this compound against this pest on salad onions and leeks. Resistance to pyrethroids was also still found to be present in this pest in the UK. Growers, advisors and CRD have been made aware of these findings.

Summary of results from the reporting year

- In 2017, we received, successfully reared and screened 65 field and 3 protected crop peach-potato aphid (*M. persicae*) samples from a good geographical range of sites in England and Scotland (collected primarily by the sub-contractors and agronomy companies).
- Screening bioassays applying diagnostic doses to live aphids from these samples continued to show no resistance to neonicotinoids, pymetrozine, flonicamid, spirotetramat or cyantraniliprole. Testing with sulfoxaflor, a compound added to the work in 2017, also showed no evidence of resistance.
- In contrast, continued strong resistance to pyrethroids was seen in most of the samples.
- This was backed up by DNA tests showing that *M. persicae* carrying MACE resistance (to pirimicarb) and the new form (north European: *ne*) of super-kdr (conferring resistance to pyrethroids), with both mechanisms in the heterozygous form, continue to be 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), with resistance specifically to esfenvalerate probably being caused by a new, as yet undisclosed, mechanism.
- In the *M. persicae* field samples, there continued to be an absence of *M. persicae* with extreme (R_3) esterase resistance to organophosphates (OPs).
- The frequency of the 'O' super-clone continued to fall in Scotland and England to the point where only a few examples were seen in the micro-satellite testing. This has been replaced by a new super-clone; 'W', which has the same resistance profile of MACE and super-kdr, both in the heterozygous form. The UK *M. persicae* population appears, therefore, to be undergoing a change in its make-up. The 'P' super-clone, which also has the same resistance genotype as 'W', remained common though.
- A comparison of the *M. persicae* insecticide resistance profiles found in our UK field and protected crop samples continued to show that aphids with rarer combinations of resistance mechanisms/genotypes are found more often at the in the protected sites. This is probably due to some of the aphids in these environments originating from more diverse, foreign, sexually-producing, populations, on imported plant material.
- The good news is that Nic-R^{++} *M. persicae*, which are found in southern mainland Europe and north Africa, 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 aphid species with the end product of insecticide-susceptible baselines for a range of aphicides. These data will make quick screening bioassays available to assess whether any new reports of control failures against these aphid pests are due to the evolution of resistance.

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- Two grain aphid (*S. avenae*) samples (collected from winter wheat in north and south Yorkshire) 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 proportion of the SA3 (kdr-SR) *S. avenae* super-clone in Scotland appears to have stabilised at around 30%.
- No *S. avenae* kdr-RRs (homozygote) genotypes have been found to date. This may relate to a fitness cost associated with this genoype or the inability of the SA3 super-clone to produce males and hence no opportunity to bring the kdr allele together through sexual reproduction.
- One bird cherry-oat aphid (*R. padi*) sample (collected from winter wheat in Hertfordshire) contained aphids with slightly higher pyrethroid resistance than the susceptible baseline standard.
- Twenty cabbage stem flea beetle (*P. chrysocephala*) samples (collected from oilseed rape in England) all contained adults carrying pyrethroid resistance (tested in bioassays). The hot spot of higher frequencies of resistant beetles in the south east of England was seen again, particularly in Suffolk.
- Three samples of pollen beetle (*M. aeneus*) collected in England all contained adults carrying pyrethroid resistance.
- The response of the samples to lambda-cyhalothrin and tau-fluvalinate (pyrethroids) was similar showing that the latter should not be used in preference to the former for controlling this pest.
- Bioassays applying a synergist prior to a pyrethroid gave good control demonstrating a metabolic-based mechanism is responsible for resistance.
- One pea and bean weevil (*S. lineatus*) sample (collected from Suffolk) contained pyrethroid-resistant adults.
- One diamond back moth (*P. xylostella*) sample (collected from Somerset) contained pyrethroid resistant moths. However, diamides and spinosad showed 100% control in the bioassays.
- This resistance profile was the same as seen for *P. xylostella* samples collected in 2016 from England and Scotland. This supports reports from growers and agronomists that this pest is now overwintering in the UK.
- Bioassays showed that pyrethroid resistance has evolved in three other beetle pests in the UK: bean seed beetle (*Bruchus rufimanus*), seed weevil (*Ceutorhynchus assimilis*) and striped flea beetle (*Phyllotreta striolat*)
- Reports of reduced control of onion thrips (*T. tabaci*) with spinosad were followed up by tests on a sample collected in Kent. Bioassays showed that some of the adults were resistant to this insecticide when applied at the recommended field rate. In addition, 100% pyrethroid resistance was found in this sample, as seen in English *T. tabaci* samples that we tested over a decade ago.

Key issues to be addressed in the next year

- The current project is due to end on 31/3/18. However, we are seeking funding for an extension to the current project which will continue to allow resistance research in all relevant UK insect pests.
- If we are successful, we will continue to measure 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.
- We will 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 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 also continue to monitor for resistance, mainly to pyrethroids, in other important UK insect pests (beetles, moths and thrips).

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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Lead partner	Rothamsted Research
Scientific partners	Rothamsted Research
Industry partners	Agrii, AHDB-Cereals & Oilseeds, AHDB-Horticulture, AHDB-Potatoes, Bayer, BBRO, Belchim, Dow, DuPont, Frontier, Hutchinsons, NuFarm, Sumitomo, Syngenta.
Government sponsor	Chemicals Regulation Directorate/Defra (in-kind contribution).

Has your project featured in any of the following in the last year?	
Events	***Press articles***
C Wallwork. Practicality of emerging problems. *FPC & CPA Meeting*, January 2018. R Collier. Pest monitoring. *Vegetable Consultants Association Meeting*, Stilton, December 2017. S Foster. Aphid monitoring, control and resistance. *Advanced Sugar Beet Course*, Norwich, November 2017. S Ellis. Integrated pest management of cabbage stem flea beetle. *AgriiFocus Autumn iFarm Event*, Aldbourne, November 2017. S Foster. Monitoring and managing insecticide resistance in UK pests. *IRAG-UK*, Edinburgh, November 2017. C Nicholls. Integrated pest management. *AHDB Monitor Farm Event*, Basingstoke, October 2017. C Nicholls. Integrated pest management. *NIAB TAG/Prime Ag Professional Development Grower Group*, Stoneleigh, October 2017. S Foster & Sacha White. The rise and rise of pyrethroid resistance in UK pests. *NFU Resistance Management Workshop*, Stoneleigh, October 2017. S Foster. Combating resistance to aphicides in UK aphid pests. *IRAG-UK*, Wellesbourne, April 2017. S Foster. Challenges with controlling insecticide resistant pests. *Rothamsted Research Association Meeting*, Rothamsted, February 2017. S Foster. Insecticide-resistant OSR pests. *BCPC* Pests *and Beneficials Review Meeting*. Rothamsted Research, January 2017. S Foster. Insecticide resistance in UK Diamond Back Moths in 2016. *AHDB DBM Meeting*. PGRO Headquarters, January 2017.	*SCEPTREplus Website*: Onion thrips (January 2018) *AHDB News Release*: Pyrethroid resistant diamondback moths now overwintering in the UK (December 2017). Diamonds are forever? (*Vegetable Farmer*, December 2017). *Rothamsted Statemen*t: Diamond back again (November, 2017). *Rothamsted Statement*: Rothamsted questions EU pesticide ban as chemicals industry eyes Brexit for breakthrough on bees (2017). *AHDB News Release*: Growers better equipped to manage Diamondback moth outbreaks (2017). Seed treatment "more essential than ever" in late-drilled wheat pest control (*Crop Protection Magazine*, July 2017). Life after neonics? (*Crop Protection Magazine*, May 2017). On-going aphid resistance research essential (*Arable Farming Magazine*, May 2017). Extended neonics ban threatens crop production, scientists warn (*Farmers Weekly*, May 2017). War of the aphids: r*esistance in a world without neonicotinoids* (*Bayer Article*, April 2017). Aphid resistance update (*Aphid News*, April 2017). Achieving sustainable pest control – hard lessons from the pyrethroid story and implications for an IPM future (*Report for Second BCPC Pests and Beneficials Working Group Meeting*, March 2017) Diamond-back moth likely to become regular UK pest (*The Vegetable Farmer*, March 2017). IPM methods crucial to Peach-potato aphid control (*Vegetable Year Book*, February 2017). UK growers better equipped for diamondback moth

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<table>
<tr><td></td><td>outbreaks (HortiDaily, February 2017).</td></tr>
<tr><td>Conference presentations, papers or posters</td><td>Scientific papers</td></tr>
<tr><td>Conference Presentations
S Foster. The rise and rise of pyrethroid resistance in UK pests. AICC Conference, Towcester, January 2018.
O Hansson. Diamondback moth – how do we tackle future threats. Brassica Conference 2017, Alnarp, Swedish University of Agriculture, March 2017.
L Field. Insecticide resistance. AICC Annual Conference, Towcester, January 2017.
A Dewar. Ecology and control of insecticide-resistant cereal aphids. AICC Annual Conference, Towcester, January 2017.</td><td>AM Dewar & SP Foster (2017) Overuse of pyrethroids may have caused recent BYDV epidemics in cereals. Outlooks in Pest Management 28 (1) pages 7-12.</td></tr>
<tr><td colspan="2">Other</td></tr>
<tr><td colspan="2">Book Chapters
SP Foster, G Devine & AL Devonshire (2017) Insecticide resistance. In Aphids as Crop Pests. HF van Emden & R Harrington (eds) CABI Wallingford, UK). 2nd Edition, pp 426-447.</td></tr>
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