Annual Project Report
01/04/2019 to 31/3/2020

Project title	**Monitoring and managing insecticide resistance in UK pests**		
Project number	Cross sector: C&O 21510015; Potatoes 1120037; Horticulture 31120004		
Start date	1 April 2012	**End date**	ongoing

Project aim and objectives

The project monitors the sensitivity of key pest species to insecticides to know which actives will work and which will not. The monitoring primarily uses bioassays on live samples. This approach is most effective because it provides an early indication of any reduced sensitivity to currently un-resisted insecticides in anticipation of the evolution of full-blown resistance that would lead to control failures. It is also independent of the need to know initially the exact mechanism of resistance.

Insect sampling has been done across GB through the continued involvement of stakeholders, including agronomy and agrochemical companies and sub-contractors. For some established resistance mechanisms, we are also continuing to use DNA-based diagnostics, which are specific for the mutations associated with particular resistance traits, and are incorporating any new such diagnostics as they become available (through other projects at Rothamsted). Samples of peach-potato aphids (*Myzus persicae*) are being screened for their response to cyantraniliprole, esfenvalerate, flonicamid, lambda-cyhalothrin, neonicotinoids (imidacloprid and acetamiprid), spirotetramat and sulfoxaflor.

We are also screening other important aphid pests: Potato aphid (*Macrosiphum euphorbiae*), Currant-lettuce aphid (*Nasonovia ribisnigri*), Willow-carrot aphid (*Cavariella aegopodii*), Grain aphid (*Sitobion avenae*), Bird cherry-oat aphid (*Rhopalosiphum padi*), and Rose-grain aphid (*Metopolophium dirhodum*) when suspected insecticide control failures occur. Baseline bioassay data is being established for the relevant insecticides.

The project also now includes resistance monitoring in other important UK insect pests including cabbage stem flea beetles (*Psylliodes chrysocephala*), pollen beetles (*Meligethes aeneus*), diamond back moths (*Plutella xylostella*), silver Y moths (*Autographa gamma*) and onion thrips (*Thrips tabaci*).

The over-riding objective of the project is to retain the availability of effective pesticides by developing appropriate insect management strategies and providing robust scientific support to the regulatory decision making process. Guidance is 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). More information on insecticide resistance is available from the Insecticide Resistance Action Committee website.

Key messages emerging from the project

- Screening of Peach-potato aphid (*M. persicae*) samples taken from the field and protected crops in 2019 showed that there continues to be no reduced sensitivity or resistance (that may compromise control) to a range of compounds belonging to different chemical classes: acetamiprid, cyantraniliprole, flonicamid, imidacloprid, spirotetramat and sulfoxaflor. Furthermore, there have been no significant shifts in response to diagnostic doses of these insecticides. Therefore, they should currentlybe effective (un-resisted) in GB.
- In contrast, strong pirimicarb resistance and pyrethroid resistance (conferred by MACE and super-kdr target site mechanisms, respectively), remained prevalent in the *M. persicae* samples although there is evidence for some changes in the genetic make-up of the GB population with aphids carrying kdr alone becoming more common.
- 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 these environments remains very important as they are more likely to contain aphids with new resistance mechanisms (e.g. to neonicotinoids) coming into GB from resistant sources abroad.

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- The baseline work on other important aphid pests continued to add data to the large database (which currently contains over 50 separate insecticide-susceptible baselines). These baselines will allow aphid pests linked to future reports of insecticide control problems to be quickly screened for potential resistance.
- As in previous years, greater pyrethroid resistance than that conferred by kdr alone has not been found in Grain aphid (*S. avenae*) GB samples collected in 2019; i.e.moderate resistance was present in some of the samples tesed.
- Pyrethroid resistance continues to be found in Willow-carrot aphid (*C. aegopodii*) GB samples, although the mechanism conferring it remains unknown.
- Pyrethroid resistance continues to be seen in GB samples of cabbage stem flea beetle (*P. chrysocephala*), conferred primarily by a metabolic mechanism, pollen beetle (*M. aeneus*) conferred by a metabolic mechanism, and diamond back moth (*P. xylostella*), conferred by kdr and super kdr target site mechanisms. The latter species remains susceptible to diamides and spinosad.
- Pyrethroid resistance was seen in asparagus beetle (*Crioceris asparagi*) GB samples, although the mechanism conferring it remains unknown.

Summary of results from the reporting year

- In 2019, we received, successfully reared and screened 16 open field and 2 protected crop peach-potato aphid (*M. persicae*) samples collected in England and Scotland (sent primarily by the sub-contractor, Dewar Crop Protection). The number of field samples was lower than in 2017 and 2018 due to climatic conditions and high levels of parasitoid and pathogen pressure.
- A *M. persicae* acetamiprid-susceptible baseline was gained for acetamiprid and a screening dose of 100 ppm selected (using a topical micro-application assay).
- Screening bioassays applying diagnostic doses to live aphids from these samples continued to show no resistance to neonicotinoids, cyantraniliprole, flonicamid, spirotetramat or sulfoxaflor.
- In contrast, continued strong resistance to pirimicarb and pyrethroids was seen in most (75%) 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) continue to be common and widespread in the GB. Both mechanisms were found only in the heterozygous form. Kdr, in the heterozygous form, conferring moderate resistance was found in some of the samples.
- 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 2019 *M. persicae* field samples, there were a few (13%) *M. persicae* with high (R_2) or extreme (R_3) esterase-based resistance. Neither of the protected samples contained R_2 or R_3 aphids.
- A comparison of the *M. persicae* insecticide resistance profiles found in GB field versus protected crop samples showed that aphids with rarer combinations of resistance mechanisms/genotypes are found significantly more often at the protected sites. This is probably due to some of the aphids in these environments originating from more diverse, sexually-producing populations on imported plant material.
- *M. persicae* carrying strong (Nic-R^{++}) neonicotinoid resistance, found in southern mainland Europe, north Africa and, recently in Belgium, have so far not been seen in either the protected or field GB samples. However, the continued monitoring for these forms remains important as they are strongly resistant to the remaining neonicotinoid products approved for use in UK.
- 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 large range of aphicides and aphid pests. 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 Cambridgeshire and Suffolk) did not contain aphids with pyrethroid resistance (in coated glass vial assays).
- One Grain aphid (*S. avenae*) sample (collected from winter wheat in East Yorkshire) contained aphids with reduced sensitivity to pyrethroids (in coated glass vial assays).
- As in previous years, no *S. avenae* kdr-RRs (homozygote) genotypes were found. This may relate to a fitness cost associated with this genoype or the inability of kdr-SR (heterozygotes) to produce both males and females.
- One Rose-grain aphid (*Metopolophium dirhodum*) sample (collected from Cambridgeshire from wheat) showed full susceptibility to pyrethroids (in a coated glass vial assay).
- Two Willow-carrot aphid (*C. aegopodii*) samples (collected from Essex and Kent) contained aphids that were resistant to lambda-cyhalothrin applied at an equivalent of the 100% field rate (in coated glass vial assays).
- Over 150 cabbage stem flea beetle (*P. chrysocephala*) samples (collected from oilseed rape in England) were screened for pyrethroid resistance. The majority of these samples contained resistant adults. Unlike in previous years, resistance was equally spread across the counties sampled.
- One Scottish cabbage stem flea beetle sample did not contain resistant adults.
- Seven samples of pollen beetle (*M. aeneus*) contained adults carrying pyrethroid resistance. One sample (collecterd from Lincolnshire) did not contain resistant adults.
- One diamond back moth (*P. xylostella*) sample (collected from Brussels sprouts in East Fife in Scotland) contained pyrethroid- resistant moths. However, there was no evidence of resistance to diamides and spinosad as there was 100% control in the bioassays with these two actives.
- Four asparagus beetle (*Crioceris asparagi*) samples (collected from East Sussex, Kent, Shropshire and Suffolk and Worcestershire) contained pyrethroid-resistant adults. Two samples (both collected from Shropshire) were fully pyrethroid-susceptible (in a coated glass vial assay).

Key issues to be addressed in the next year

- It is anticipated that there will be another one year extension to the project (with similar aims and approach). This is now dependent on gaining funding from AHDB, with financial support being provided by all three AHDB crop sectors. All the other participants, apart from Adama, who have withdrawn from the project from April onwards, have agreed to continue their participation and funding.

Lead partner	Rothamsted Research
Scientific partners	Rothamsted Research
Industry partners (for reporting year)	Adama, Agrii, AICC, AHDB, BASF, Bayer, BBRO, Belchim, Certis, Corteva, FMC, Frontier, Hutchinsons, NuFarm, Procam, Sumitomo and 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***
S Foster. Aphid resistance the UK story and how it relates to Ireland. Plenary Talk at *National Crops Forum*. Naas, Ireland, September 2019.	Flea beetle alert, *AF Crop Production*, September 2019. Guard OSR against mounting aphid threat, *Bayer Press Release*. September 2019.

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K Norman BYDV – a grower's perspective. *Launch of Wolverine - 1st UK BYDV-resistant wheat.* Hinxton, Cambridge, August 2019. S White. An integrated approach to CSFB management. (*BASF Cabbage Stem Flea Beetle Workshop*. Great Tew Estate, Oxfordshire, July 2019. A Dewar. The consequences of a total ban on neonicotinoid seed treatments for pest control in oilseed rape cereals and sugar beet in the UK *Syngenta Meeting,* Rougham, April 2019.	Flea beetle trials look to integrated tools, *Syngenta Media Release*, September 2019. Cereals without Deter for BYDV, *Bayer Crop Focus Magazine*, September 2019. New UK testing highlights the need for TuYV resistant oilseed rape, *Release to National/Regional Agricultural Pres*, July 2019. Social media warns growers about moth invasion, *AHDB News Release* June 2019. Rethinking the growing of oilseed rape-CSFB Management, *BASF Press Briefing - Rethinking the growing of oilseed rape*, Boxworth June 2019. New UK testing highlights the need for TuYV-resistant oilseed rape, *Crop Production Magazine*, June 2019.
Conference presentations, papers or posters	***Scientific papers***
S Foster, Winter oilseed rape without neonicotinoids. *The Rural Economy and Agricultural Societies Conference*. Linköping. Sweden. February, 2020. C Willis. Investigating insecticide resistance in UK populations of oilseed rape pests. *AICC Conference*, Towcester, January 2020. S Foster. Aphid and BYDV control after neonicotinoids. *CAFRE/UAS/UFU 8th Annual Conference,* Belfast, Northern Ireland, January 2020. S Foster. Aphid resistance the UK story and how it relates to Ireland. Plenary Talk at *National Crops Forum*. Naas, Ireland, September 2019. S Foster, L Oliphant & M Williamson. New challenges with aphid control after the EU ban of neonicotinoid seed treatments on all outdoor crops. *UK-France Joint Meeting on Aphids*, Rothamsted Research, Harpenden, April 2019.	LE Walsh, MT Gaffney, GL Malloch, **SP Foster**, MS Williamson & G Purvis. First evidence of retained sexual capacity and survival in the pyrethroid resistant *Sitobion avenae* (F.) (Hemiptera: Aphididae) SA3 super-clone following exposure to a pyrethroid at current field-rate. *Irish Journal of Agricultural and Food Research. In Press*
Other	
Posters C Willis, E Davies, M Williamson, S Foster, X Chang, J Elias & C Zimmer Investigating insecticide resistance in UK populations of cabbage stem flea beetle, *Psylliodes chrysocephala*. Resistance 2019, Rothamsted Research, Harpenden, September 2019 M Williamson, S Foster & L Field New Method for detecting BYDV in cereal aphids. *Cereals*, Lincoln, June 2019 S Foster, M Williamson & L Field Monitoring insecticide resistance in peach-potato aphids. *Cereals*, Lincoln, June 2019	

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Resistance Management Guidelines and Resistance Alerts

Revision to *IRAG-UK Guidelines*: insecticide resistance and its management (2019)

Revision to *IRAG-UK Guidelines*: insecticide resistance status in UK cereal crops (2019)

Revision to *IRAG-UK Guidelines*: insecticide resistance status in UK oilseed rape crops (2019)

Revision to *IRAG-UK Guidelines*: Insecticide resistance status in UK brassica crops (2019)

Revision to *IRAG-UK Guidelines*: insecticide resistance status in UK potato crops (2019)