Annual Project Report
01/04/2021 to 31/3/2022

Project title	**Monitoring and managing insecticide resistance in UK pests**		
Project numbers	Cross-sector: C&O 21120162; Potatoes 1120037; Horticulture 31120004		
Start date	1 April 2012	**End date**	31 May 2022

Project aim and objectives

This project monitors the sensitivity/resistance of key UK insect crop pests to insecticides. Primarily, the work uses insecticide screening bioassays on live insect samples. It provides an early indication of any reduced sensitivity in anticipation of the evolution/selection of full-blown resistance associated with pest control failures.

This approach is independent of the need to know the exact type (metabolic, target site or other) of resistance mechanism involved, as the insect samples are directly exposed to the relevant compounds at the appropriate screening doses.

Insect sampling was done through the involvement of stakeholders, including sub-contractors, agronomists and agrochemical companies.

For some established resistance mechanisms, we also use latest DNA-based diagnostic tools, which are specific to target site mutations associated with particular insecticide resistance traits. We incorporate any new diagnostic tools through other projects at Rothamsted Research.

Samples of the virus-transmitting pest peach-potato aphid (*Myzus persicae*) have been screened for their response to relevant insecticides, such as flonicamid, neonicotinoids, spirotetramat, sulfoxaflor, pyrethroids and cyantraniliprole.

We have screened other important aphid pests, including potato aphid (*Macrosiphum euphorbiae*), currant-lettuce aphid (*Nasonovia ribisnigri*), willow-carrot aphid (*Cavariella aegopodii*), grain aphid (*Sitobion avenae*), bird cherry-oat aphid (*Rhopalosiphum padi*), rose-grain aphid (*Metopolophium dirhodum*) and black bean aphid (*Aphis* fabae) in response to suspected insecticide control failures. Baseline bioassay data has been gained for relevant insecticides to allow the choice of appropriate screening doses to test for resistance in these aphid pests.

Over the years, the project has also included bioassay/resistance monitoring in other important UK insect pests, including cabbage stem flea beetle (*Psylliodes chrysocephala*), pollen beetle (*Meligethes aeneus*), diamond back moth (*Plutella xylostella*), silver Y moth (*Autographa gamma*), asparagus beetle (*Crioceris asparagi*) and onion thrips (*Thrips tabaci*).

The over-riding objective of this long-running project is to sustain effective insecticides by developing appropriate insect management strategies and providing robust scientific support to the regulatory decision-making process, via Defra/CRD.

Guidance is also made available to advisors, growers and the scientific community through the Insecticide Resistance Action Group (IRAG-UK).

Key messages emerging from the project

- Over this reporting year, COVID-19-related restrictions at Rothamsted Research stalled progress. However, bioassays on live insect samples and molecular-based assays were still achieved.
- Screening of 17 peach-potato aphid samples collected in 2021 showed no reduced sensitivity or resistance (that may compromise insecticide-based control) to a range of compounds belonging to actively-used compounds; acetamiprid, cyantraniliprole, flonicamid, spirotetramat and sulfoxaflor. Furthermore, there was no evidence of any significant shifts in sensitivity to the bioassay screening diagnostic doses of these insecticides, apart from a suggestion of a reduced sensitivity phenotype in two aphid samples (both collected from oilseed rape in November 2021) that were screened with sulfoxaflor and one sample (also collected in November 2021 from this crop) screened with imidacloprid. These apparent, subtle, shifts in response alert us

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to the need of continued monitoring. However, at present, the compounds involved should continue to be effective (unresisted).

- In contrast, we continued to find strong pyrethroid resistance in the *M.persicae* samples to esfenvalerate and lambda-cyhalothrin in the screening bioassays (primarily conferred by the super-kdr target site mechanism). There is evidence for some changes in the genetic make-up of the UK population with aphids carrying kdr alone becoming more common.
- *M.persicae* carrying MACE resistance (to pirimicarb) were also seen. This mechanism continues to be monitored in the project to assess if there are fitness costs associated with it after the reduction in selection pressure following the loss of pirimicarb as a registered spray on most UK crops.
- Our findings continue to suggest that at least some *M.persicae* collected from protected crops may have come from more genetically diverse, sexual foreign populations on imported plant material. Obtaining samples from these environments remains important as they are more likely to contain aphids with new resistance mechanisms (e.g. to neonicotinoids) coming into the UK from resistant populations abroad.
- The baseline work on other important aphid pests has continued to add data to the large database (which currently contains over 50 insecticide-susceptible aphid species baselines). These baselines will allow aphid pests linked to any future reports of insecticide control problems to be quickly screened for potential resistance.
- As in previous years, greater pyrethroid resistance than that conferred at a moderate level by kdr alone, was not found in UK samples of grain aphids (*S.avenae*) collected in 2021. In other words, moderate resistance, but not of that above, was present in some of the samples tested. This phenotype should not cause control failures for pyrethroid sprays that are applied at the full recommended rate and with good aphid contact.
- *R.padi* samples showed no evidence of either resistance or reduced sensitivity to pyrethroids.
- Pyrethroid resistance continues to be seen in UK samples of cabbage stem flea beetle, conferred primarily by a metabolic mechanism. The frequency of resistant beetles has risen consistently over the past several years and there no longer appears to be a geographical 'hotspot' in England.

Summary of results from the reporting year

- In 2021, we successfully reared and screened peach-potato aphid samples.
- Screening bioassays applying diagnostic insecticide doses to live aphids from the *M.persicae* samples continued to show no resistance to neonicotinoids, cyantraniliprole, flonicamid, spirotetramat or sulfoxaflor. Although there was evidence of reduced sensitivity to neonicotinoids and sulfoxaflor, which may be a pre-cursor to resistance.
- In contrast, continued strong resistance to pyrethroids was seen in many of the *M.persicae* samples.
- These findings were backed up by DNA tests showing that *M.persicae* carrying the new form (north European: *Ne*) of super-kdr (conferring resistance to pyrethroids) continue to be common and widespread in the UK, being found in 71% in the 2021 samples. kdr conferring moderate resistance, was also found only in the heterozygous form and was present 24% of the samples. Both resistance frequencies are similar to that seen in 2020.
- 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). Specifically, resistance to esfenvalerate may be caused by a new, as yet undisclosed, mechanism.
- In the 2021 *M.persicae* field samples, there were none with high (R_2) or extreme (R_3) esterase-based resistance. This has not been seen before in the course of the project and suggests that the esterase-based mechanism is now being selected against. The selection benefits of exposure to OPs no longer exist as these compounds are no longer used in the UK.
- Comparison of the *M.persicae* insecticide resistance profiles found that over the course of the project shows that aphids with rarer combinations of resistance mechanisms/genotypes are found significantly more often at

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the protected crop sites rather than in UK fields. This is probably due to at least 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 on sugar beet) have so far not been seen in either the protected or GB field samples. However, one sample collected from oilseed rape in November 2021 showed a Nic-R^{+} phenotype associated with metabolic-based resistance which has not been seen before in the UK. The continued monitoring for the Nic-R+ and Nic-R^{++} forms remains important, particularly as the latter are strongly resistant to the remaining neonicotinoid products approved for use in the 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.
- As in previous years, and in many 1,000s of aphids tested, no *S.avenae* kdr-RR (homozygote) genotypes were found. This may relate to a fitness cost associated with this genoype, as postulated in other insect pests, or the inability of kdr-SR (heterozygotes) to produce both males and females to mate and produce RRs.
- 17 cabbage stem flea beetle samples (from OSR in England) were screened for pyrethroid resistance in 2021. The greater majority of these samples contained resistant adults. Resistance was equally spread across the counties sampled. It is worth noting that in 2020, a Scottish sample was fully susceptible to pyrethroids. Future monitoring will aim to assess this potential geographical diversity.

Key issues to be addressed in the next year

- There will be another one-year extension to the project with altered aims and objectives reflecting a focus on insect pests of cereals and oilseeds. All of the other 14 project participants (including Certis Belchim, recently merged) have agreed to continue their participation for another year (from June 1 2022).

Lead partner	Rothamsted Research
Scientific partners	James Hutton Institute ('in kind' contribution for Micro-satellite testing on relevant *M. persicae* samples)
Industry partners (for reporting year)	Agrii, AICC, AHDB, BASF, Bayer, BBRO, Belchim, Certis, Corteva, FMC Agro, Frontier, Hutchinsons, NuFarm, Procam, Sumitomo and Syngenta.
Government sponsor	Defra/CRD cash and 'in kind' contributions

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

Events	***Press articles***
S Foster. Monitoring and Managing Insecticide Resistance in UK Pests. *AIC Meeting*. Peterborough, April 2022 S Foster. Update on Aphids and Resistance. *ADAS Aphid Workshop*, Virtual Meeting, March 2022. S Foster. Insecticide Resistance. *Lecture to Agronomist Students*, Cranfield University, December 2021.	..

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S Foster. Update on insecticide resistance work. *IRAG-UK Meeting*. Virtual Meeting, November, 2021. S Foster. Update on insecticide resistance work. *IRAG-UK Meeting*. Virtual Meeting, April 2021. S Foster. Monitoring and managing insecticide resistance in UK pests. *Croprotect Webinar.* Virtual Webinar. February 2021.	
Conference presentations, papers or posters	***Scientific papers***
See Above	LE Walsh, O Schmidt, **SP Foster**, C Varis, J Grant, GL Malloch & MT Gaffney. Evaluating the impact of pyrethroid insecticide resistance on fitness in *Sitobion avenae*. *Annals of Applied Biology.* Open Access Article.
Other	

Resistance Management Guidelines and Resistance Alerts (in last year)

Revision to *IRAG-UK Guidelines*: insecticide resistance status in UK cereal crops (2021)
Revision to *IRAG-UK Guidelines*: insecticide resistance and its management (2020)
Revision to *IRAG-UK Guidelines*: insecticide resistance status in UK cereal crops (2020)
Revision to *IRAG-UK Guidelines*: insecticide resistance status in UK oilseed rape crops (2020)
Revision to *IRAG-UK Guidelines*: Insecticide resistance status in UK brassica crops (2020)
Revision to *IRAG-UK Guidelines*: insecticide resistance status in UK potato crops (2020)

Articles in Farming and Popular Press

Pinpointing pesticide-resistant pests (*Arable Farming Magazine*, September 2021)
What does the aphid threat mean for TuYV control? (*Arable Farming*, September 2021)

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