Annual Project Report
01/04/2020 to 31/3/2021

Project title	Monitoring and managing insecticide resistance in UK pests		
Project number	21510015 / 91120162		
Start date	1/4/2012	End date	ongoing

Project aim and objectives

The project extension is continuing to monitor the sensitivity of key UK insect crop pests to insecticides in order to know which of these will work and which will not. The monitoring is being done primarily using insecticide screening bioassays on live insect samples. This is the best approach as it provides an early indication of any reduced sensitivity to the currently un-resisted insecticides in anticipation of the evolution/selection of full-blown resistance that would lead to pest control failures. It is also independent of the need to know the exact type (metabolic, target site or other) of resistance mechamanisms involved.

Insect sampling has been done through the continued involvement of stakeholders, including sub-contractors and agronomy companies. For several established resistance mechanisms, we have also used DNA-based diagnostics, which are specific for the target site mutations associated with particular resistance traits, and we aim to incorporate any new diagnostics as they become available (through other projects at Rothamsted). Samples of peach-potato aphids (*Myzus persicae*) have been screened for their response to relevant insecticides for their control, i.e., esfenvalerate, flonicamid, lambda-cyhalothrin, neonicotinoids, spirotetramat and sulfoxaflor. Cyantraniliprole is also included in the screening as it is considered that aphids may be exposed to the active ingredient on some crops, such as brassicas, where it is applied to control other pests, e.g. thrips or lepidopteran larvae.

We have also studied 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*), rose-grain aphid (*Metopolophium dirhodum*) and black bean aphid (*Aphis* fabae). Baseline bioassay data has also been gained for relevant insecticides, for a wide range of aphid pests, to allow the choice of appropriate screening doses to test for resistance in the future.

The over-riding objective of the project is to retain the availability of 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 being 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

- Covid-19-related restrictions at Rothamsted Research, imposed by the Lockdowns affected progress over the past year. However, bioassays on live insect samples and molecular-based assays were still achieved.
- Screening of 27 peach-potato aphid (*M. persicae*) samples collected from open fields and protected crops in 2020 showed that there continues to be no reduced sensitivity or resistance (that may compromise control) to a range of compounds belonging to relevant chemical classes: acetamiprid, cyantraniliprole, flonicamid, imidacloprid, spirotetramat and sulfoxaflor. Furthermore, there was no evidence of any significant shifts in sensitivity to our diagnostic doses of these insecticides. Therefore, these compounds should continue to be effective (un-resisted) when used against this pest in this country.
- 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 kdr and super-kdr target site mechanisms), although 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.
- 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 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 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 was not found in UK samples of grain aphids (*S. avenae*) collected in 2020; i.e., moderate resistance was present in some of the samples tested but this should not cause control failures for pyrethroid sprays that are applied at the full recommended rate and with good aphid contact.
- Pyrethroid resistance continues to be seen in UK samples of cabbage stem flea beetle (*P. chrysocephala*), conferred primarily by a metabolic mechanism. The frequency of resistant beetles has risen consistently over the past several years but there no longer appears to be a geographical 'hotspot' in England.

Summary of results from the reporting year

- In 2020, we received, successfully reared and screened 25 open field and 2 protected crop peach-potato aphid (*M. persicae*) samples (sent primarily by the sub-contractors, Dewar Crop Protection and ADAS).
- 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.
- In contrast, continued strong resistance to pyrethroids was seen in many of the samples.
- This was backed up by DNA tests showing that *M. persicae* carrying the new form (north European: *Ne*) of super-kdr (conferring strong resistance to pyrethroids) continue to be common and widespread in the GB with them being found in 60% of the samples. This mechanism was found only in the heterozygous form. Kdr, also in the heterozygous form, conferring moderate resistance, was found in just over 20% 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 2020 *M. persicae* field samples, there were some (22%) *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.
- Comparison of the *M. persicae* insecticide resistance profiles found in UK field versus protected crop samples shows 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 on sugar beet, 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.
- 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.
- 30 cabbage stem flea beetle (*P. chrysocephala*) samples (collected from oilseed rape in England) were screened for pyrethroid resistance in 2020. The majority of these samples contained resistant adults.

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Resistance was equally spread across the counties sampled although the one Scottish sample collected was fully susceptible to pyrethroids.

Lead partner	Rothamsted Research
Scientific partners	Rothamsted Research
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 (Cash) and Defra/CRD ('In Kind')

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. *Croprotect Webinar.* Virtual Webinar. February 2021. S Foster. Update on Resistance Monitoring. I*RAG* Virtual Meeting, November, 2020. S Foster. Insecticide resistance monitoring and managem *AHDB 'Aphids Day'*. Virtual Conference. Novemb 2020. S Foster. Winter oilseed rape without neonicotinoids. *Th Economy and Agricultural Societies Conference.* Linköping**.** Sweden. February, 2020. C Willis.Investigating insecticide resistance in UK popula of oilseed rape pests *AICC Annual Conference*, Towcester, January, 2020. S Foster. Aphid and BYDV control after Neonicotinoids. *CAFRE/UAS/UFU 8th Annual Conference.* Belfas Northern Ireland, January, 2020.	..
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. Resubmitted* LE Walsh, E Ferrari, **SP Foster** & MT Gaffney. Evidence of pyrethroid resistance in the bird

	cherry-oat aphid *Rhopalosiphum padi* (L.) in Ireland. *Outlooks on Pest Management*. **31**, 5-9.

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 oilseed rape crops (2020)
Revision to *IRAG-UK Guidelines*: Insecticide resistance status in UK brassica crops (2020)
Revision to *IRAG-UK Guidelines***: I**nsecticide resistance status in UK potato crops (2020)

Articles in Farming and Popular Press

What does the aphid threat mean for TuYV control? (*Arable Farming*, September 2020)
Fending for the natural foe (*Crop Production Magazine*, August 2020)
Breeding "built in" resistance (*Crop Production Magazine*, May 2020)
How the potato industry must flush virus out of the system (*Potato Review*, March/April 2020)