Annual Project Report 01/04/2018 to 31/3/2019

Project title	**Monitoring and managing insecticide resistance in UK pests**		
Project numbers	AHDB Cereals & Oilseeds 21510015 AHDB Potatoes 1120037 AHDB Horticulture 31120004		
Start date	1 April 2012	**End date**	ongoing

Project aim and objectives

The sensitivity of key pest species to insecticides is monitored by this long-term project. The results show which active ingredients are affected by insecticide resistance. The information can be used to inform management strategies and minimise the risk of control failures. The project helps to retain the availability of effective pesticides and provides robust scientific support to the regulatory decision-making process.

Live insect sampling, across Great Britain, relies on the continued involvement of stakeholders, including agronomy and agrochemical companies and sub-contractors.

Bioassays, conducted on the live insect samples, are used primarily for the monitoring. This approach is most effective because it provides an early indication of any reduced sensitivity to previously un-resisted insecticides. It is also independent of the need to know the exact mechanism of resistance.

For some established resistance mechanisms, DNA-based diagnostics, which are specific for the mutations associated with particular resistance traits, are also used. Developments in diagnostics are incorporated within the work, as they become available (e.g. through other projects at Rothamsted Research).

Samples of peach–potato aphid (*Myzus persicae*) are screened for their response to cyantraniliprole, esfenvalerate, flonicamid, lambda-cyhalothrin, neonicotinoids, pymetrozine, spirotetramat and sulfoxaflor. Screens are also conducted on other important aphid pests: potato aphids (*Macrosiphum euphorbiae*), currant–lettuce aphids (*Nasonovia ribisnigri*),willow–carrot aphids (*Cavariella aegopodii*), grain aphids (*Sitobion avenae*), bird cherry–oat aphids (*Rhopalosiphum padi*), and rose–grain aphids (*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. These include cabbage stem flea beetles (*Psylliodes chrysocephala*), pea and bean weevils (*Sitona lineatus*), pollen beetles (*Meligethes aeneus*), diamond-back moths (*Plutella xylostella*), silver Y moths (*Autographa gamma*) and onion thrips (*Thrips tabaci*).

Guidance is 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 refereed journals and conference proceedings.

More information on insecticide resistance is available from the [Insecticide Resistance Action Committee website.]

Key messages emerging from the project

- Screens of peach–potato aphid (*M. persicae*) samples, taken from the field and protected crops in 2018, showed that there continues to be no significant resistance (that may compromise control) to a range of compounds. These belong to different chemical classes (cyantraniliprole, flonicamid, pymetrozine, spirotetramat and sulfoxaflor). Furthermore, there have been no significant shifts in response to diagnostic doses of these insecticides that are currently effective (un-resisted) in GB.

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- Strong pirimicarb resistance and pyrethroid resistance (conferred by MACE and super-kdr target site mechanisms, respectively), remain prevalent in the *M. persicae* samples. Hwoever, there is evidence for some changes in the genetic make-up of the GB population, with aphids carrying kdr alone becoming more common.
- Microsatelitte analysis of *M. persicae* populations (an 'in-kind' contribution to the project) shows that the 'O' and 'P' super-clones seem to be on the wain with new genotypes, particularly 'W' (which also carries MACE and super-kdr), becoming prevalent.
- Findings 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 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 information to a large database (which now contains over 50 separate insecticide-susceptible baselines). These baselines allow aphid pests linked to future reports of insecticide control problems to be quickly screened for potential resistance.
- Greater pyrethroid resistance than that conferred by kdr has not been found in grain aphid (*S. avenae*) samples collected in 2018.
- Pyrethroid resistance has been found in willow–carrot aphids (*C. aegopodii*).
- Pyrethroid resistance continues to be seen in cabbage stem flea beetles (*P. chrysocephala*), pollen beetles (*M. aeneus*), pea and been weevils (*S. lineatus*) and diamond-back moths (*P. xylostella*).
- Pyrethroid resistance was not found in silver Y moth (*A. gamma*) samples.
- Spinosad resistance, along with known pyrethroid resistance, was found for the first time in onion thrips (*T. tabaci*). This explains reports of reduced efficacy of this compound against this pest on salad onions and leeks. Growers, advisors and CRD have been made aware of these findings.

Summary of results from the reporting year

- In 2018, we received, successfully reared and screened 28 open field and 5 protected crop peach–potato aphid (*M. persicae*) samples in England and Scotland (collected primarily by the sub-contractors and agronomy companies). The number of field samples was lower than in 2017 due to extreme climatic conditions (the 'Beast from the East' and the long, hot, dry summer).
- Screening bioassays, which applied diagnostic doses to live aphids from these samples, continued to show no resistance to neonicotinoids, cyantraniliprole, flonicamid, pymetrozine, spirotetramat. Testing with sulfoxaflor, a compound added to the work in 2017, also showed no evidence of resistance.
- In contrast, continued strong resistance to pirimicarb and pyrethroids was seen in most (> 70%) 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 2018 *M. persicae* field samples, there were a few (11%) *M. persicae* with extreme (R_3) esterase-based resistance to organophosphates (OPs). 40% of the protected samples contained R_3 aphids.
- A comparison of the *M. persicae* insecticide resistance profiles found in the 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.
- Micro-satellite testing (done in collaboration with the James Hutton Institute) showed that the *M. persicae* 'O' super-clone was no longer found in Scotland or England in 2018. This clone has been replaced by new super-

clones; ‘S’ and ‘V’ (which carry kdr alone) and ‘W’ (which has the same resistance profile of MACE and super-kdr, both in the heterozygous form, as ‘O’ and ‘P’). The ‘P’ super-clone, which also has the same resistance genotype as ‘O’, has become rarer.The GB *M. persicae* population appears, therefore, to be undergoing a change in its make-up.

- *M. persicae* carrying strong (Nic-R^{++}) neonicotinoid resistance, found in southern mainland Europe and north Africa, have, so far, not been seen in either the protected or field GB samples. However, there are recent unpublished reports of these aphids being found in Belgium. This highlights the importance of continued monitoring for these forms, as they are strongly resistant to acetamiprid and thiacloprid sprays and to neonicotinoid seed treatments (the latter are available in protected environments).
- We have continued to develop and validate the best bioassay method for various aphid species. This has procuded 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.
- Three grain aphid (*S. avenae*) samples (collected from winter wheat in Northamptonshire and Bedfordshire), in response to reports of pyrethroid control failures, contained aphids with pyrethroid resistance but this remained at the expected level for aphids carrying kdr (in the heterozygous form).
- No *S. avenae* kdr-RRs (homozygote) genotypes have been found to date. This may relate to a fitness cost associated with this genoype.
- Four *C. aegopodii* samples, collected from Nottinghamshire, Suffolk and Yorkshire, contained aphids that were resistant to lambda-cyhalothrin applied at the 100% field rate.
- Over 40 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. The hot spot of higher frequencies of resistant beetles in the south east of England was seen again, with levels of resistance similar to 2017.
- Two samples of pollen beetle (*M. aeneus*), collected from Essex and Leicestershire, contained adults carrying pyrethroid resistance. The response of these pollen beetles to lambda-cyhalothrin and tau-fluvalinate (pyrethroids) was similar. Bioassays applying a synergist prior to a pyrethroid gave good control demonstrating a metabolic-based mechanism is responsible for resistance in this pest.
- Samples of striped flea beetle (*Phyllotreta striolata*), collected from Suffolk, turnip beetle (*Phyllotreta cruciferae*), collected from Suffolk, and three samples of bruchid beetle (*Bruchus rufimanus*), collected from Hertfordshire and Hampshire, were tested using lambda-cyhalothin. There is evidence for reduced sensitivity to the active in all three species but, because of the small sample sizes used, more testing is required before conclusions about pyrethroid resistance can be drawn.
- Six diamond-back moth (*P. xylostella*) samples (collected from England and 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.
- This resistance profile was the same as seen in *P. xylostella* samples in 2016 and 2017 (also collected from England and Scotland) and supports reports from growers and agronomists that this pest is now overwintering in the UK, probably under netted brassicas.
- Reports of reduced control of onion thrips (*T. tabaci*) with spinosad were followed up by tests on a sample (collected from salad onions in Worcestershire). Unlike in 2017, bioassays showed that none of the adults was resistant to either this insecticide or deltamethrin, when applied at the recommended field rates. This may relate to the sample being collected further West than the previous samples
- Two samples of silver Y moth (*Autographa gamma*), collected from Warwickshire in response to concerns of pyrethroid resistance, showed no evidence of resistance to lambda-cyhalothrin, spinosad or diamides.

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Key issues to be addressed in the next year
• Pymetrozine will be unavailable for use in the UK in the near future. As a result, monitoring with this compound will stop for the 2019 samples. • A one-year project extension (with the same aims and approach) has been agreed with the funders. Three new partners (Certis, BASF and Procam) have joined the project consortium. Financial support is provided by all three AHDB crop sectors.

Lead partner	Rothamsted Research
Scientific partners	Rothamsted Research
Industry partners (for reporting year)	Adama, Agrii, AICC, AHDB-Cereals & Oilseeds, AHDB-Horticulture, AHDB-Potatoes, Bayer, BBRO, Belchim, Dow (Corteva), DuPont, Frontier, Hutchinsons, NuFarm, 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***
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 R Harrington Monitoring of aphid populations as a basis for effective control. *IIRB (International Institute of Sugar Beet Research) Workshop: Growing sugar beet without neonicotinoid seed treatments*, Leuven, Belgium, March 2019 S White IPM of cabbage stem flea beetle. *Agtech Seminar*, Dunmow, March 2019 A Dewar The consequences of a total ban on neonicotinoid seed treatments for pest control in cereals and oilseed rape in the UK *Crop Management Partners*, Petersfield, March 2019 A Dewar The consequences of a total ban on neonicotinoid seed treatments for pest control in cereals and oilseed rapein the UK *Wessex Agronomy* Market Lavington, February 2019 A Dewar Consequences of the neonicotinoid ban in oilseed rape, cereals and sugar beet for pest control. *Boston and North Wash Training Group*, Old Leake, February 2019	Cabbage stem flea beetles, *NIAB-TAG Agronomy Update*, September 2018 Virus looms in OSR, *Crop Production Magazine*, September 2018 Farming without neonicotinoid seed treatments, *Bayer Crop Focus Magazine*, August 2018 How will the neonic seed treatment ban affect beet? *Farmers Weekly*, June 2018 Tips to manage BYDV in cereals without neonics, *Farmers Weekly*, June 2018 Overcoming resistance in a post-neonic world, *Bayer Website*, June 2018 Resistance is far from futile, *The Grower Magazine*, June 2018 New insights into insecticide resistance, *Crop Production Magazine*, April 2018

Conference presentations, papers or posters	Scientific papers
S White Integrated pest management of cabbage stem flea beetle. *Syngenta iOSR Conference*, Northamptonshire, February 201. L Field Monitoring and managing insecticide resistance in the UK. *Velcourt Annual Farmers Event*, Oxford, January 2019 S White: Managing OSR pests. *Farmers Weekly OSR Masters Live*. Kensworth, December 2018 S Foster: Update on insecticide resistance in UK pests, including willow-carrot aphids. *British Carrot Growers Association R & D Committee Meeting*, Newark, November 2018 M Williamson & S Foster: Pyrethroid resistance in UK crop pests *Pyrethrum Meeting*, Cambridge, September 2018 S Foster: Pest control strategies, resistance issues, new actives. *Insect Pest Control Review Meeting*, NIAB, Cambridge, September 2018 S Cook: Ecologically-based Integrated Pest Management in oilseed rape: a need not an option! *Rothamsted Research Lecture*, Harpenden, June 2018 S Foster: Full ban on neonicotinoid seed treatments in open field crops: where do we go from here? *Bayer Stand at Cereals*, June 2018 M Stevens: *CIBE Technical Meeting*, Ghent, May 2018 S Foster: Monitoring and managing insecticide resistance in UK pests. *IRAG-UK Meeting*, Dunmow, April 2018 R Collier: Aphid control in leafy salads: trials in SCEPTREplus. *British Leafy Salad Association - Annual General Meeting*, Stoneleigh, April 2018	
Conference presentations, papers or posters	***Scientific papers***
S Foster Winter oilseed rape without neonicotinoids. *NORBARAG*, Malmo, Sweden, March 2019. S Foster Control of the cabbage flea beetles and peach-potato aphids in the UK: development of insecticide resistance and alternative methods to control these pests. *Danish Crop Production Congress,* Denmark, January 2019 S Foster Update on insecticide resistance in UK pests. *AICC Conference*, Towcester, January 2019 S Foster: Organiser of Session and introductory talk at AAB Meeting: Pest control after the loss of	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*

the neonicotinoid seed dressings. *Crop Protection in Southern Britain*, Brighton, November 2018 S Foster: Insecticide resistance in UK pests: the good, the bad and the ugly *European Congress of Entomology*, Naples, July 2018 M Stevens: *IIRB Summer Congress*, France, June 2018	
Other	

Guidelines and Alerts

IRAG-UK: Insecticide resistance status in UK potato crops, *Guideline*
IRAG-UK: Insecticide resistance status in UK cereal crops, *Guideline*
IRAG-UK: Insecticide resistance status in UK oilseed rape crops, *Guideline*
IRAG-UK: Insecticide resistance and its management, *Guideline*
Rothamsted News Release: Thrips know their onions, *Alert*
AHDB News: Pyrethroid resistance in willow-carrot aphid, *Alert*
AHDB News: Spinosad resistance found in onion thrips, *Alert*
AHDB SCEPTREplus Blog: Targeting onion thrips, *Alert*

Radio

Farming Today: *BBC Radio 4*: Pyrethroid resistance in Cabbage Stem Flea Beetles, September 2018