

Combating resistance to aphicides in UK aphid pests

Project number	RD-2011-3768		
Start date	01/04/12	End date	31/03/15

<p>Project aim and objectives</p> <p>The project aims to continue research on aphicide resistance management for the UK farming industries and provide up-to-date information for agronomic and regulatory procedures. The need for this work is heightened by the recent occurrence of control failures with neonicotinoids against peach-potato aphids (<i>Myzus persicae</i>) in southern mainland Europe. The appearance of these resistant aphids represents a substantial new threat to aphid control in the UK as the presence of resistant aphids is likely to have very serious repercussions for neonicotinoid treatments on a range of crops and would accentuate the risk of the evolution of resistance to alternative non-neonicotinoid compounds.</p> <p>The project is monitoring the response of field-collected live samples of <i>M. persicae</i> to a range of novel aphicides and 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 that cannot be controlled by insecticides will inevitably cause crop losses. Other important aphid pests (including grain aphids, <i>Sitobion avenae</i>) representing the interests of the project consortium will also be monitored, and baseline bioassay data established for relevant insecticides.</p> <p>The response of <i>M. persicae</i> carrying different levels of neonicotinoid resistance to seed- and foliar-treated plants will be measured in laboratory-based field simulator chambers under quarantine conditions.</p> <p>New screening tools for novel aphicides will also be developed for use in regional laboratories or by advisors and growers.</p> <p>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 will be available to advisors, growers and the scientific community through the Insecticide Resistance Action Group (IRAG-UK). Other routes of communication will include articles in the trade press, presentations to growers and agronomists, and papers in referred journals (see below for 2012 outputs).</p>

<p>Key messages emerging from the project</p> <ul style="list-style-type: none"> • Neonicotinoid target site resistance (in conjunction with metabolic resistance) in <i>M. persicae</i> confers strong resistance to topical applications of neonicotinoids in aphids that are homozygous resistant (RR), i.e. carrying two resistant alleles of the neonicotinoid binding site protein (as <i>M. persicae</i> is a diploid organism). Resistance is intermediate in heterozygote aphids (SR), i.e. lying between RR and SS (homozygous susceptible). • Neonicotinoid-SR or -RR <i>M. persicae</i> have so far not been found in the UK although a laboratory study has shown that these aphids can feed on a range of crops that are grown in this country. Interestingly, SR and RR aphids have been found recently on adjacent crops to peach (eggplant and peppers) in the Emilia-Romagna region of northern Italy confirming that neonicotinoid-resistant aphids are not restricted to peach. • No evidence of resistance to pymetrozine and flonicamid was found in the <i>M. persicae</i> samples collected in 2012 in the UK. • Strong pirimicarb resistance and pyrethroid resistance (conferred by separate mechanisms) was prevalent in the <i>M. persicae</i> samples collected in 2012 in the UK but not in other aphid pests. • Pyrethroid resistance, in the form of kdr, has recently evolved in <i>S. avenae</i> in the UK. However, so far all resistant aphids have proved to be heterozygotes. In other pest species, homozygote kdr aphids are known to carry strong resistance to pyrethroids. If these arise (through sexual reproduction) in <i>S. avenae</i>, the efficacy of pyrethroid sprays is likely to be severely compromised.

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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Summary of results from the reporting year

In 2012, Rothamsted received and successfully reared 22 field and 2 protected *M. persicae* samples (collected by Dewar Crop Protection and ADAS). The relatively low number was due to the very wet summer and high fungal pathogens present (keeping the aphid population low). Screening of these samples showed that there continues to be no evidence of significant resistance (that may compromise control) to neonicotinoids, pymetrozine or flonicamid (which belong to different chemical classes) in *M. persicae* in the UK. Furthermore, there have been no significant shifts in sensitivity suggesting selection pressures for resistance are low in the UK.

MACE resistance (to pirimicarb) continues to be very common and widespread in this species in the UK. Since 2003, there has been a continued decline in the frequency of *M. persicae* carrying *kdr* resistance (to pyrethroids). However, we have shown that there is currently a very high frequency of *M. persicae* carrying a super-*kdr* mechanism, also to pyrethroids. These are primarily MACE aphids with 'O' and 'P' micro-satellite genotypes which are now widespread in this country. In contrast, there has been a marked decline in the frequency of *M. persicae* carrying high (R_2) or extreme (R_3) esterase resistance to organophosphates (OPs) which is most likely due to the disuse of these compounds in the UK. This is in contrast to *M. persicae* in mainland European populations where R_3 aphids remain common probably because OP usage tends to be much greater.

M. persicae carrying strong resistance to neonicotinoids are now present on peach trees in several countries in southern Europe. Topical bioassays applying imidacloprid have shown that homozygote (RR) resistant aphids are effectively immune, while heterozygote (SR) resistant aphids have a Resistance Factor of several hundred (compared to susceptible baseline SS aphids). In field simulator chambers containing aphids on whole potato plants in pots, foliar neonicotinoid sprays (applied at the recommended rate) did not affect RR aphids while SR aphids were controlled to some extent. This finding suggests that the efficacy of neonicotinoid sprays will be dependent on which genotypes first arrive or evolve in the UK.

A plant host preference study showed that neonicotinoid-SR and RR *M. persicae* are able to feed and reproduce on a range of crops (cabbage, tobacco, oilseed rape, potato, lettuce, cotton and broad bean), so their apparent restriction to peaches and nectarines in mainland Europe appears not to be due to lack of host suitability.

The knockdown resistance (*kdr*) mutation, seen in other pests including *M. persicae*, has been identified for the first time in UK field populations of the grain aphid, *S. avenae*. A single copy of the mutation confers ~40-fold resistance to lambda-cyhalothrin (a pyrethroid) in coated glass vial bioassays against live aphids and has been found in aphids collected from fields with reported control failures. There is no evidence of an additional metabolic resistance mechanism as total esterase levels of resistant aphids were not significantly higher than susceptible aphids. Analysis of suction trap samples has shown that the *kdr* mutation is now present at high frequency (>50%) in some areas but only as heterozygote genotypes. There does not seem to be an association between *kdr* frequency and region of collection. The *kdr* mutation was first seen at low levels in aphids in 2009 but appeared to take hold in 2011 when pyrethroid control failures were first reported.

Key issues to be addressed in the next year

We will continue to screen the UK *S. avenae* population for *kdr* and the potential appearance of *kdr*-RR (homozygote) aphids (which will probably be strongly resistant to pyrethroids) after sexual reproduction this winter.

We will continue to monitor UK *M. persicae* for the appearance of aphids with strong resistance to neonicotinoids and continue to screen aphids from the population with pymetrozine, flonicamid, pyrethroids, a diamide and spirotetramat insecticides to reveal any shifts in sensitivity which may be the first signs of resistance.

Lead partner	Rothamsted Research
Scientific partners	Rothamsted Research
Industry partners	Bayer, Belchim, DuPont, NuFarm, Sumitomo/InterFarm, Syngenta,

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	AHDB-HGCA, AHDB-Horticulture, AHDB-Potato Council, BBRO.
Government sponsor	Chemicals Regulation Directorate/Defra.

Has your project featured in any of the following in the last year?	
Events	
Press articles	
<p>Scientists identify growing threat to cereal crops (<i>Rothamsted Press Release</i>, September 2012). Growers to face BYDV threat again in 2012 (<i>Anglia Farmer</i>, August 2012). BYDV looks to be an increasing threat to crops (<i>Scottish Farmer</i>, August 2012). A seed treatment is key for BYDV (<i>Farmers Guide</i>, August 2012). Controlling aphids and virus diseases in cereals and oilseed rape (<i>HGCA Information Sheet</i>, August 2012). Grain aphids show resistance to pyrethroids (<i>Farmers Weekly</i>, July 2012). How can the threat from aphids be managed? (<i>HGCA Handout for Cereals 2012</i>, June 2012). And today's aphid forecast is... (<i>CPM Magazine</i>, April 2012, <i>HGCA Standfirst Article</i>, May 2012). Insecticide resistance in the aphid <i>Myzus persicae</i> (<i>Rothamsted Research Association Newsletter</i>, April 2012). Neonicotinoids in potatoes (<i>Potato Review</i>, May 2012). New challenges for aphid and virus control (<i>News Release</i>, April 2012). New challenges for aphid and virus control (<i>Four Seasons Potatoes Magazine</i>, April 2012). Rothamsted Research prediction for <i>M. persicae</i> (peach-potato aphid) in 2012 (<i>Syngenta Brassica Technical Bulletin</i>, April 2012).</p>	
Conference presentations, papers or posters	
<p>Presentations: A Dewar. Resistance of Grain aphids to pyrethroids. <i>Syngenta Agronomist Meetings</i>. Winchester, Newmarket, Brigg, Cirencester and Shrewsbury, December 2012. Aphid resistance in cereal and root crops. S Foster. <i>Frontier Winter Conference</i>. Warwick, December 2012. Pesticides, resistance and alternatives. L Field. <i>Hutchinson's Winter Conference</i>, Peterborough Show Ground, December 2012. Evolution of knock-down resistance to pyrethroids in grain aphids (<i>Sitobion avenae</i>) in the UK. S Foster. <i>Crop Protection in Southern Britain</i>. Peterborough Show Ground, November 2012. Dynamics of insecticide resistance in the peach-potato aphid, <i>Myzus persicae</i>. I Denholm. <i>XXIV International congress of Entomology</i>, Daegu, South Korea, August 2012. BYDV Queries Answered. M Stevens. <i>Bayer CropScience Meeting</i>. Brooms Barn, June 2012.</p>	
Scientific papers	
<p>SP Foster, D Paliwal, J Martin & MS Williamson (2012) Evolution of knock-down resistance to pyrethroids in grain aphids (<i>Sitobion avenae</i>) in the UK. <i>Aspects of Applied Biology</i> 117, 95-96.</p>	
Other	
<p>IRAG-UK Resistance Alert: kdr resistance in grain aphids (2012). Guidelines for controlling aphids in brassica crops and combating insecticide resistance in the peach-potato aphid, <i>Myzus persicae</i> (2012).</p>	

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