

Alternative insecticides to control grain aphids, *Sitobion avenae*, that are resistant to pyrethroids

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Start date	Oct 2012	End date	Dec 2013
HGCA funding	£15,000	Total cost	£15,000

<p>What was the challenge/demand for the work?</p> <p>Control of the grain aphid, <i>Sitobion avenae</i>, has relied heavily upon the use of pyrethroids in recent years, largely because they are cheap, and readily mixable with fungicides in disease control programmes. As a consequence, according to surveys funded by Defra, the majority (>70%) of winter sown cereals in the UK are treated every year with insecticides, either in the autumn to control aphids carrying barley yellow dwarf virus, and sometimes also in the summer to control grain aphids or blossom midges. These insecticides are almost all pyrethroids.</p> <p>Not surprisingly, this usage has resulted in selection for <i>S. avenae</i> that are resistant to pyrethroids. Their occurrence was first described in 2012, but they have since been recorded in many sites across the UK following a survey funded by Syngenta UK Ltd, backed up by further tests using a DNA-based diagnostic assay developed at Rothamsted. In 2012 and 2013, samples collected from across east and central England, and tested using a vial bioassay test, 35% and 38% respectively were classified as resistant, after less than 60% of the individuals in the vials were killed by a discriminatory dose of insecticide. Further tests of these and other samples in 2013 using the DNA diagnostic test, showed that 50% contained some individuals that carried the <i>kdr</i> mutation conferring resistance to pyrethroids. These results correlate well with similar testing of dead <i>S. avenae</i> caught in Rothamsted Insect Survey suction traps operating in the same areas, namely the Broom's Barn, Rothamsted and Kirton traps in east and central England.</p> <p>There is some circumstantial evidence that the mini-epidemic of BYDV seen in England in the spring of 2012, following a mild winter that would have allowed overwintering aphids to survive quite well, may have been exacerbated by resistant <i>S. avenae</i> that survived the traditional autumn sprays of pyrethroids used to control another aphid species, the bird cherry–oat aphid, <i>Rhopalosiphum padi</i>, which is regarded as the main vector of BYDV. Many of the samples collected in 2012 came from BYDV-infected fields.</p> <p>In response to this situation, field experiments were set up a) to investigate the efficacy of three commonly used pyrethroids against susceptible and resistant <i>S. avenae</i> in winter sown barley, and b) to test alternative insecticides that might be useful for controlling resistant aphids if they become a serious problem in the future.</p>

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How did the project address this?

Surveys funded by Syngenta UK Ltd. In 2012 and 2013, allowed the collection of 33 samples of grain aphids, *S. avenae*, from across mid and southern England, and tested using glass vials that were coated with different doses of the pyrethroid, lambda-cyhalothrin. These classified 35 and 38 % of samples as resistant in 2012 and 2013 respectively (when more than 60% of individuals survived the discriminatory dose). Further DNA diagnostic tests done at Rothamsted on these and other 2013 samples showed that 50% of 30 samples tested contained the *kdr* gene that confers resistance in this species.

Field trials

A field trial was set up at Broom's Barn in autumn 2012, in which winter barley plots were inoculated with both susceptible and resistant clones of *S. avenae*, along with a susceptible clone of the main BYDV vector, *Rhopalosiphum padi*. Plots were subsequently sprayed with field rates of three pyrethroids, lambda-cyhalothrin (Hallmark Zeon), deltamethrin (Decis Protech and cypermethrin (Toppel 10), and the organophosphorus insecticide, chlorpyrifos (Dursban WG).

A further two field trials were set up at Broom's Barn and Stetchworth in Suffolk with the resistant clone of *S. avenae* only, which was inoculated at marked locations into plots that had already been seeded with small numbers of *R. padi* carrying BYDV. Plots were subsequently sprayed a few days later with lambda-cyhalothrin and cypermethrin, chlorpyrifos, the carbamate, pirimicarb (Aphox), the neonicotinoids, thiacloprid (Biscaya) and acetamiprid (Insyst), and, at Stetchworth only pymetrozine (Plenum) mixed with an adjuvant oil, Toil. The rates applied were either recommended for use in cereals for aphids or other pests (cypermethrin, deltamethrin, chlorpyrifos and pirimicarb), or rates that were recommended for other crops if they were not approved for use in cereals (thiacloprid, acetamiprid and pymetrozine). The rate of lambda-cyhalothrin used was that recommended for use in oilseed rape (7.5 g a.i./ha), which was higher than that recommended for use in cereals (5 g a.i./ha).

Aphid numbers in all trials were counted 3, 6-8 and 13-15 days after application. In the latter two larger trials the incidence of barley yellow dwarf virus (BYDV) was assessed in May 2013, and the effects of treatments on yield were measured at harvest in August 2013.

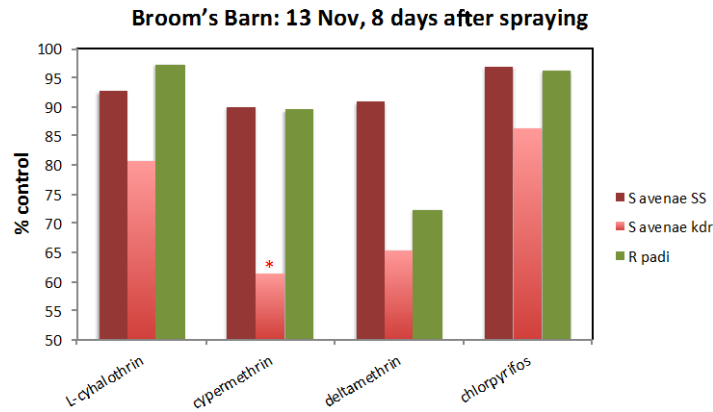
What outputs has the project delivered?**Comparison of pyrethroids**

Lambda-cyhalothrin, cypermethrin and chlorpyrifos all gave good (>85%) control of the susceptible clones of *S. avenae* and *R.padi*; deltamethrin gave good control of the susceptible clone of *S. avenae* (>88%), but not as good control of *R. padi* initially (75%), rising to 99% after 8 days (Fig. 1). However, cypermethrin and deltamethrin gave significantly poorer control of resistant *S. avenae* than chlorpyrifos, but not lambda-cyhalothrin. The rate of lambda-cyhalothrin used was higher than recommended rate (7.5 rather than 5 g a.i./ha), which might explain why it gave better control.

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Fig.1 Efficacy of pyrethroids against cereal aphids

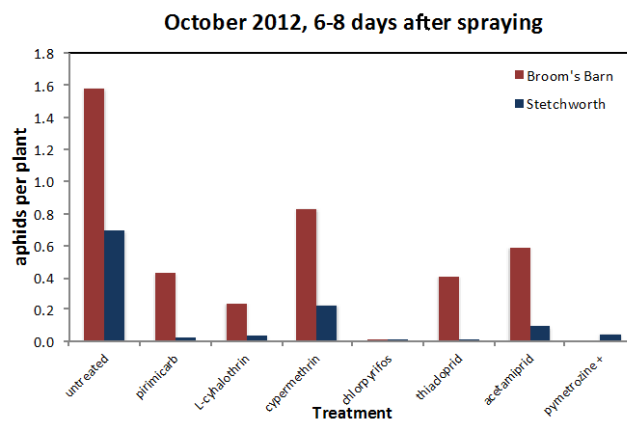


* Significantly less than chlorpyrifos at P<0.05

Alternatives to pyrethroids

In the two larger field trials to test alternative products against the resistant clone of *S. avenae*, and the consequent spread of BYDV, the pyrethroid lambda-cyhalothrin again gave good control, but cypermethrin performed poorly. The rate of lambda-cyhalothrin was again higher than recommended for cereals, using the oilseed rape recommended rate (Fig. 2). Of the alternatives to pyrethroids tested, pirimicarb gave moderate control at one site, Broom's Barn, but good control at another at Stetchworth (Fig. 2). The neonicotoid, thiacloprid gave good control at both sites, while acetamiprid was relatively poor at Broom's Barn. Pymetrozine plus oil gave good control at Stetchworth, the one site it was tested. Chlorpyrifos gave best control at both sites.

Fig. 2 Efficacy of aphicides against grain aphids, *S. avenae*, in winter barley



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Effect of treatments on BYDV infection and yield

Secondary spread of barley yellow dwarf virus (BYDV) was low in untreated plots at both sites (<2%) in the winter of 2012-13, due to very low temperatures after spray applications, which prevented further primary colonisation by ‘wild’ aphids, and multiplication of those that survived the treatments. However, significant reductions in virus infections were still recorded the following spring, although not enough to affect yield at harvest. There were no significant differences between treatments at either site, but their comparative performance did reflect their efficacy against aphids.

Who will benefit from this project and why?

None of the alternative non-pyrethroids mentioned above is currently approved for use against aphids in cereals in the autumn, but these results will give regulators some evidence for their activity against resistant grain aphids, should alternatives be required.

The likely higher price of alternative insecticides compared to pyrethroids will discourage ‘insurance’ use of insecticides in the autumn, which is practiced in many fields at the moment, with consequent benefits to the environment. It will also encourage uptake of integrated pest management techniques and use of forecasting and monitoring schemes such as the Rothamsted Insect Survey, and their aphid alerts issued by HGCA.

HGCA return on investment: The project confirmed the presence of widespread resistance to pyrethroids in grain aphids, and offered solutions to overcome this. With a little further investment, good alternative strategies can be developed to control a potentially serious disease that can cause significant damage to cereal yields in mild winters. A range of scientific messages were also produced, which underpin BYDV control and future developments.

If the challenge has not been specifically met, state why and how this could be overcome

1. The performance of lambda-cyhalothrin was better than expected, which may have been due to a higher rate used than is currently recommended for use against aphids in cereals. The rate used was that recommended for use in oilseed rape. Thus, it may be possible to overcome resistant aphids by using higher rates of pyrethroids, at least in the short term until alternatives with different modes of action can be registered. This needs to be examined in further trials.
2. The consequent effects of poor control seen with cypermethrin did not manifest itself in much greater spread of BYDV than the other treatments, largely due to the adverse effects of severe cold weather shortly after sprays were applied on the survival of the inoculated aphids. In a milder winter this poor control may have demonstrated greater spread of BYDV, as was suggested following the winter of 2011. Further experiments need to be done in mild winters to confirm this.

Lead partner	Dr Alan M. Dewar, Dewar Crop Protection Ltd
Scientific partners	None
Industry partners	Syngenta UK Ltd (surveys)
Government sponsor	None

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