Final Project Summary

Project title	Preventing a wide scale increase in ALS resistant broad-leaved weeds through effective management in cereal/oilseed rape rotation in the UK		
Project number	RD-2012-3788	**Final Project Report**	PR564
Start date	01 October 2012	**End date**	30 September 2016
AHDB Cereals & Oilseeds funding	£120,000	**Total cost**	£187,500

What was the challenge/demand for the work?

Recent reductions in available herbicides (including Approvals legislation 1107/2009/EC (replaced 91/414/EEC), Sustainable Use Directive 2009/128/EC, MRL requirements, Water Framework Directive 2000/60/EC and commercial pressures) has led to very limited herbicide choice across arable rotations, with many growers now relying heavily on acetolactate-synthase (ALS) inhibitor herbicides, which are a high risk resistance group (HRAC group B). New herbicide modes of action are extremely rare and have not been seen for at least the last 20 years. Although most ALS-inhibitor herbicides are not highly active on common poppy (*Papaver rhoeas*) their risk to resistance developing is important to determine and manage. Where resistance occurs, growers face costly control (often with increased cultural control), major inconvenience and difficulties balancing long-term planning strategies and short-term financial constraints. World-wide the ALS-inhibiting herbicide class has the greatest incidence of resistance as reported by 'The International survey of herbicide-resistant weeds' website (www.weedscience.com). The number of ALS-resistant broad-leaved weeds in 1997 was reported as 26; by 2011 this had risen to 133 and it currently stands as 159 species, so is slowly increasing. Of these species 109 are broad-leaved weeds and 50 are grasses. Biotypes of common poppy were first reported as showing resistance to ALS inhibiting sulfonylurea herbicides in the UK in 2001 and have now been identified in nine counties of England and greater than 70 populations.

How did the project address this?

The project aims were to (1) identify and quantify the risks of ALS resistance in broad-leaved weeds, (2) develop the optimum management practices to manage or reduce developing resistance, (3) raise awareness of the issue and provide information about the early warning signs and how to manage the situation in the UK. The focus weed was common poppy (*Papaver rhoeas*) which was used as an indicator species for broad leaved weeds in general.

The experimental work was divided up into glasshouse pot screens (year one and four), container experiments (years one to three) and field experiments (Cambridgeshire years one to three and Yorkshire year two only). Seed from one of the field experiments (CAMB-M) were used in the container and glasshouse pot screens for consistency and further validation of results. This population was known to have a high level of ALS-resistance.

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Year one of the CAMB-M field experiment included winter wheat and four herbicide treatments, 1) Untreated, 2) ALS alone, 3) Non-ALS + ALS, 4) Non-ALS only, which were repeated in the same plots annually. Details of the specific herbicides are shown in the table below.

Treatments	Wheat	Oilseed rape
Untreated	-	-
ALS alone	Metsulfuron-methyl (20% ww) (Jubilee SX)	Imazamox (17.5 g/l)
Non-ALS + ALS	Flufencet (60g/l) + pendimethalin (300g/l) (Crystal) fb. Metsulfuron-methyl (20% ww) (Jubilee SX)	Imazamox (17.5 g/l) + metazachlor (375g/l) (Cleranda)
Non-ALS	Flufencet (60g/l) + pendimethalin (300g/l) (Crystal) fb. MCPA (500g/l)	Metazachlor (500g/l) (Butisan) fb. Propyzamide (500 g/l) + aminopyralid (5.3 g/l) (Astrokerb)

These four treatments were repeated in two field years (including wheat and oilseed rape crops, so the herbicide product changed, but the four basic treatment principles remained) and three container trial years (with seed collected from survivors then re-sown and treatments repeated). Results from year one of the field experiments proved that no control of this already resistant population could be achieved by using an ALS alone, however, treatments containing a non-ALS + ALS and a non-ALS alone both provided a significant ($p < 0.001$) level of poppy control of 96% and 98% respectively, compared to the untreated. There was no significant difference between these latter two treatments in year one.

Year two of the CAMB-M field experiment included winter wheat and oilseed rape sown within the same field trial location as year one. There was very good establishment of both crops and field conditions were very favourable for the autumn pre-emergence herbicides, and autumn post-emergence herbicides in oilseed rape and spring post-emergence herbicides in winter wheat. The results for the mean number of poppy heads per m^2 for all herbicide treatments in year two are presented in Figure 1. The mean number of poppy heads was always lower in the oilseed rape cropped areas (mean untreated, 252 heads per m^2) compared to the wheat (mean untreated, 537 heads per m^2) due to plant competition. The ALS-alone herbicide treatment achieved no control compared to the untreated for both wheat and oilseed rape, with significantly ($p>0.001$) more poppy heads per m^2 in wheat and a non-significant increase, compared to the untreated control, in oilseed rape.

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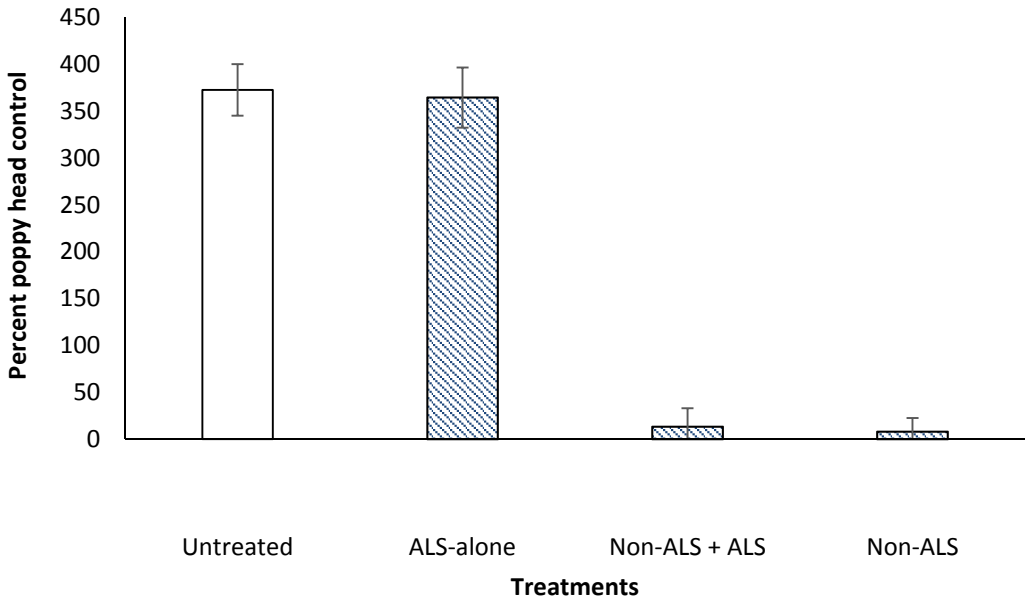

Figure 1 The mean number of poppy heads per m^2 in the CAMB-M field trial in 2014, after two years of herbicide treatments and varied crop rotation.

The oilseed rape non-ALS + ALS herbicide treatment achieved no control of the CAMB-M field population, with a mean of 340 poppy heads per m^2, which was more than the ALS-alone treatment of 320 poppy head per m^2. The Non-ALS treatment in oilseed rape gave a significant ($p>0.001$) reduction in poppy heads (105 per m^2 remaining) compared to the untreated control, however this is still a large amount of poppy heads remaining in the crop that would set seed. The wheat non-ALS + ALS treatment and the non-ALS treatment both achieved a significant ($p>0.001$) reduction in poppy heads per m^2 compared to the untreated of 81.4% and 89.4% control respectively.

Results from the container experiments support the field experiment findings and provide further evidence that poppy populations resistant to ALS-inhibitor herbicides can be controlled using other herbicide modes of action.

What outputs has the project delivered?

The key results from both the field and container experiments showed that a non-ALS herbicide programme consistently provided the highest control across all experimental years and poppy populations (ALS-resistant and susceptible). A mixture or sequence of non-ALS + ALS herbicides also provided good control. The use of a post-emergent ALS inhibitor herbicide alone was always the weakest treatment with the poorest control of known resistant poppy populations. These results provide

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further evidence that common poppy populations resistant to ALS inhibitors can be controlled using well-timed applications of other herbicide modes of action.
The number of confirmed herbicide resistant broad-leaved weed populations in the UK is still relatively low compared with grass weeds. This project shows that ALS-resistant broad-leaved weeds are currently controllable with alternative modes of action and a robust herbicide-resistance management strategy is essential. Unlike many grass weeds, the biology of broad-leaved species are less impacted by cultural control. Therefore, it is crucial that a wide range of effective herbicide alternative modes of action are maintained to enable control of resistant populations and prevent further cases of resistance. Early detection, monitoring and removal of patches of problem broad-leaved weed will also limit and potentially prevent resistance spread.

Who will benefit from this project and why?

Practical guidelines for resistance management strategies for broad-leaved weeds have been provided for agronomists, farmers and regulators, in an AHDB leaflet (Information sheet 54),published Summer 2016, and through the wide dissemination of results via agronomic events, workshops, national and international scientific conference papers and presentations. The project results provide vital evidence of the importance of retaining the availability of effective herbicides, by demonstrating the importance of alternative modes of action in resistance management strategies for farmers and growers.

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

The challenge of the specific project aims have been met. This project has raised awareness of the risk of broad-leaved weed resistance in the UK and this message should be continued to be communicated providing a proactive approach to managing broad-leaved weeds in the future.

Lead partner	ADAS UK Ltd
Scientific partners	Stephen Moss Consulting
Industry partners	BASF, Dow AgroSciences, DuPont
Government sponsor	n/a