Glyphosate sensitivity of *A. myosuroides*

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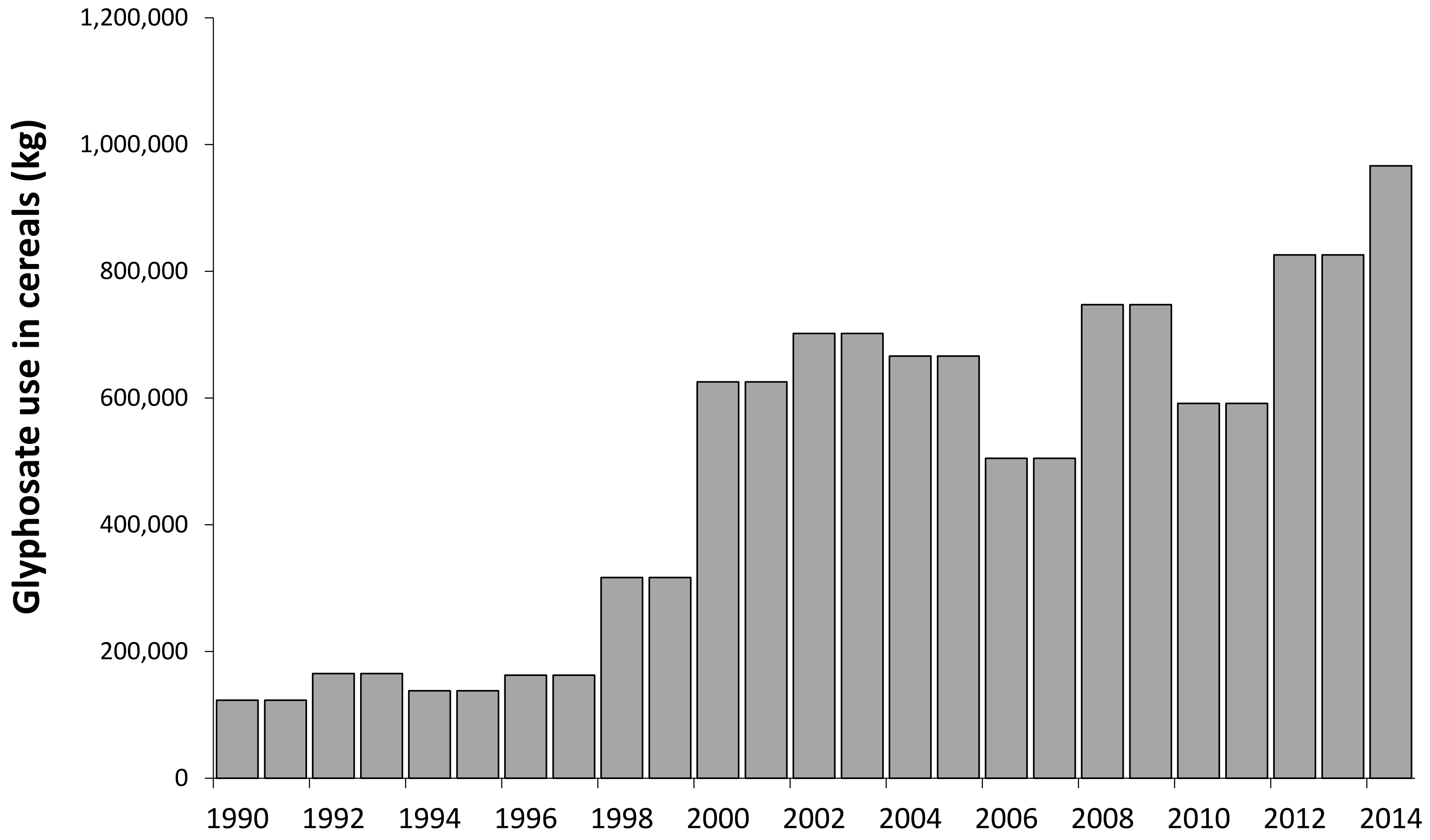
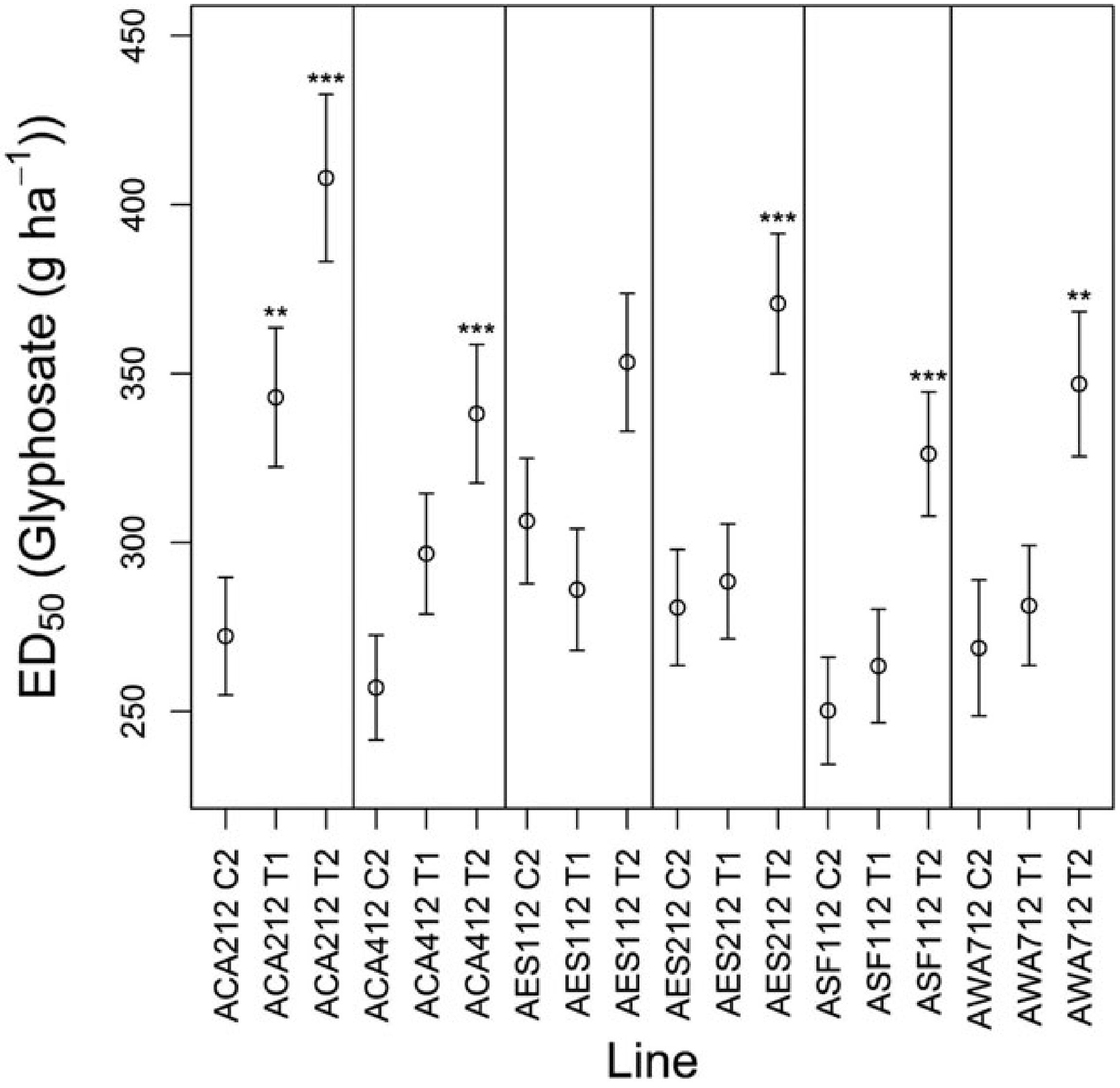
Glyphosate use has increased



~ 8-fold increase in glyphosate usage since 1990

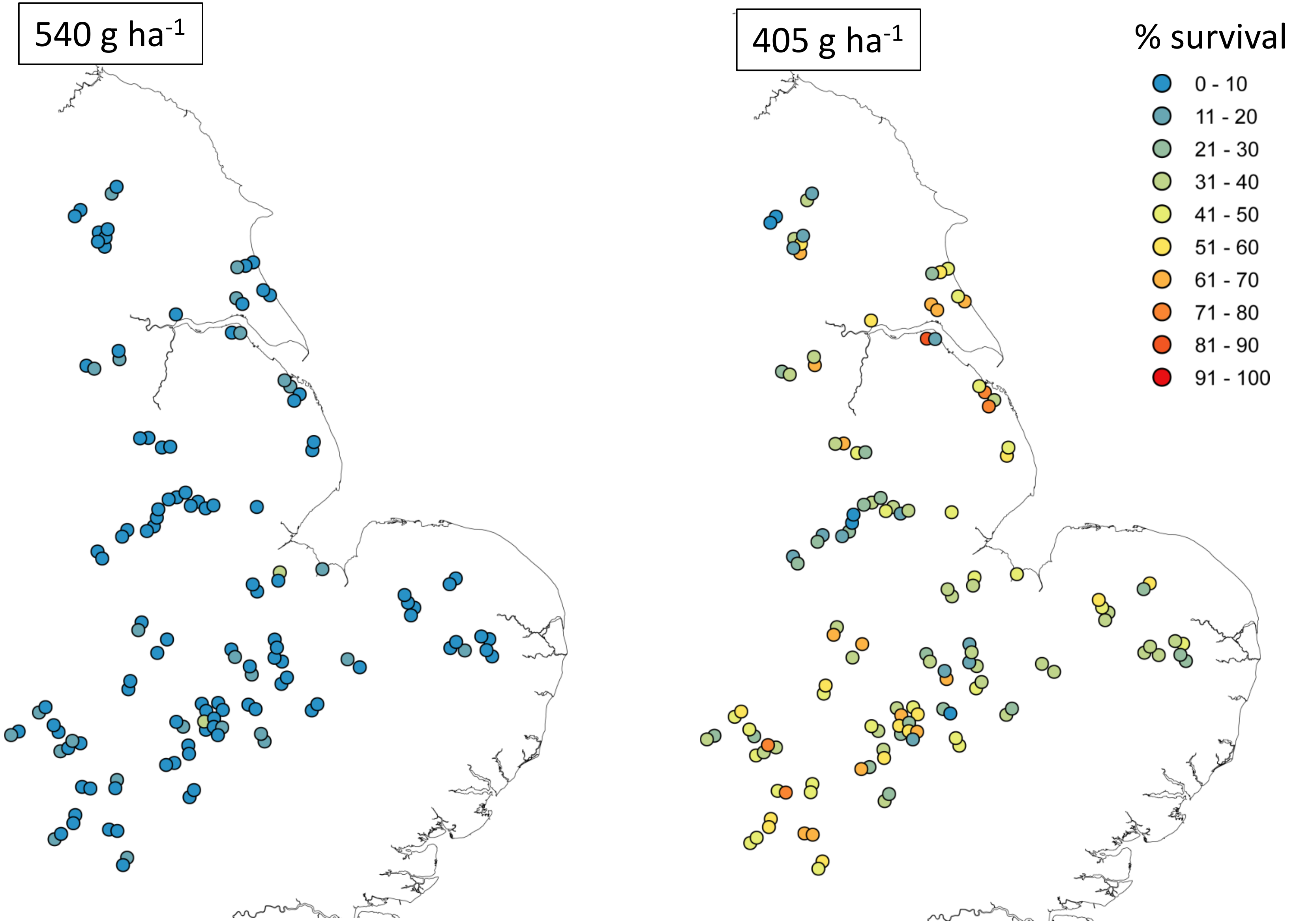
Glyphosate sensitivity is heritable



Reduced glyphosate sensitivity in blackgrass is heritable, and responds to selection:

Davies and Neve (2017) Inter-population variability and adaptive potential for reduced glyphosate sensitivity in *Alopecurus myosuroides*.

Populations have variable sensitivity



Variable % survival at lower dose

High survival is not clustered in any one geographic location

LD_{50} values ranging from 230 – 470 g ha^{-1}

Mixed model regression

Management factor	Effect	P value
Population size and cultivation		
Blackgrass abundance	-0.007	0.188 ns
Proportion autumn sown	0.408	0.512 ns
Blackgrass emergence	0.270	0.029 *
Cultivation score	0.150	0.649 ns
Herbicide usage		
Glyphosate use	**0.452**	**0.007 ****
HRAC turnover	0.164	0.147 ns
HRAC diversity	-0.126	0.462 ns
HRAC mixing	-0.092	0.765 ns
Herbicide resistance		
Atl Survival PC	0.277	0.088 ns
Cyc Survival PC	-0.330	0.084 ns
Fen Survival PC	0.170	0.209 ns

R^2 marginal: 0.240 **R^2 conditional**: 0.565

Glyphosate use is the strongest predictor of the LD_{50}.

Glyphosate resistance in the UK? An epidemiological assessment of glyphosate sensitivity in UK *Alopecurus myosuroides*

ROTHAMSTED RESEARCH

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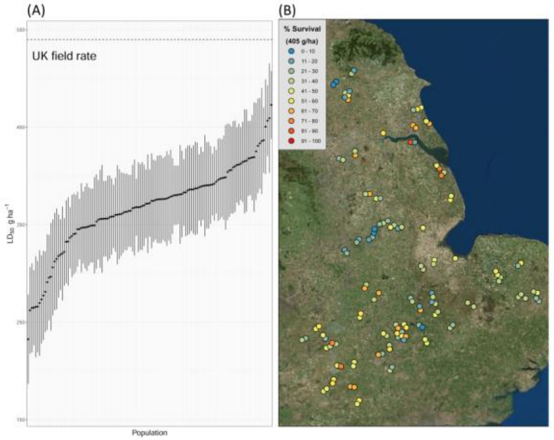

Figure 1: Variation in glyphosate sensitivity in UK *A. myosuroides*. (A), LD_{50} values from dose-response analysis relative to the current UK field rate (Mean ±95% confidence interval). (B), Map of population locations coloured according to percentage survival at 405 g ha^{-1} glyphosate (75% of the current UK field rate of 540 g ha^{-1}).

INTRODUCTION

Alopecurus myosuroides (Blackgrass) is the predominant weed species affecting arable cropping in the UK. A low diversity of available herbicides and high frequency of herbicide resistance has led to an increasing reliance on glyphosate for control of this species. To date, there are no confirmed cases of glyphosate resistance in *A. myosuroides*, though there is precedence for glyphosate use in comparable systems to result in the evolution of resistance.

This study is novel in taking a proactive approach to glyphosate resistance management, testing the hypothesis that UK *A. myosuroides* will show significant variation in glyphosate sensitivity, caused by selection from increasing glyphosate usage in the field.

METHODS

- 132 UK *A. myosuroides* populations were collected from the field.
- An average of seven years field management data (herbicide use, crop type, cultivation etc.) was collected for 89 of these populations.
- Population-level variation in glyphosate sensitivity was assessed using a glasshouse dose-response experiment.
- Key agronomic drivers of reduced glyphosate sensitivity were identified using mixed-model analysis.
- Annual change in the frequency of glyphosate applications was assessed to highlight temporal trends in glyphosate usage.

RESULTS

- Field rate of glyphosate (540 g ha^{-1}) controlled on average 95.4% (± 0.6) of individuals.
- Considerable variability in glyphosate sensitivity was seen below field rate (405 g ha^{-1}), with survival varying between 6% – 85% (Figure 1).
- Dose-response analysis identified LD_{50} values ranging from 230 – 470 g ha^{-1} (Figure 1).
- The strongest predictor of the glyphosate LD_{50} was the frequency of glyphosate use, with greater glyphosate usage corresponding with higher LD_{50} values (Table 1).
- The proportion of the blackgrass cohort emerging before crop drilling (which can therefore be treated with glyphosate) was also positively associated with the LD_{50} (Table 1).
- There has been a significant increase in annual glyphosate usage within our surveyed fields, and an increase in the area sprayed with glyphosate at a national scale.

Table 1: Mixed-model analysis of predictors of glyphosate LD_{50}

Fixed effects	Estimate	Mean-Sq	F-value	P-value
Population size and cultivation				
Blackgrass abundance	-0.006	0.798	1.619	0.208 ns
Proportion Autumn sown	0.415	0.415	0.841	0.505 ns
Blackgrass emergence pre-crop	0.275	3.111	6.309	0.023 *
Intensity of cultivation	0.150	0.140	0.284	0.631 ns
Herbicide usage				
Glyphosate use frequency	0.452	3.378	6.852	0.006 **
Herbicide turnover	0.166	1.161	2.355	0.134 ns
Herbicide diversity	-0.127	0.406	0.824	0.398 ns
Herbicide mixing	-0.100	0.084	0.171	0.745 ns
Herbicide resistance				
Sulfonylurea resistance	0.276	1.616	3.279	0.105 ns
Cycloxydim resistance	-0.333	1.653	3.353	0.100 ns
Fenoxaprop resistance	0.171	0.871	1.766	0.177 ns

Example blackgrass infestation in a UK wheat field.

CONCLUSIONS

We present a novel proactive, epidemiological approach to assessing future risks of glyphosate resistance in black-grass. We have demonstrated that significant variability in glyphosate LD_{50} is present amongst *A. myosuroides* populations, and there is a concomitant reduced sensitivity to glyphosate where glyphosate is being used more often for herbicidal control. Future work will monitor changes in glyphosate sensitivity in UK black-grass populations to determine the predictive value of this approach.

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AHDB CEREALS & OILSEEDS

The University Of Sheffield.

The Black-grass Resistance Initiative (BGRI)

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