Project promise on resistance conundrum

HGCA

from theory to field

> *"This research is of relevance to every grower in the UK who uses a herbicide."*

With an unprecedented programme of genomics, field monitoring, evolutionary biology and modelling, the BBSRC-HGCA blackgrass project is set to lift the lid on the problem and empower growers struggling to manage it. *CPM* explores what it hopes to deliver.

By Tom Allen-Stevens

It's the biggest publicly funded weed research project ever undertaken in the UK, and is set to bring to light more information about blackgrass resistance than growers have ever had. The £2.8M BBSRC-HGCA Blackgrass Resistance Initiative (BGRI) is now underway, and researchers have spent the past month gathering samples of blackgrass from farms across a swathe of the UK arable area.

"One of the reasons this research is so important is that it'll bring a good assessment of the problem at the moment," notes Dr Susannah Bolton of HGCA.

"We wouldn't have been able to get anywhere near the level of understanding on genetics and population dynamics this project should deliver had it not been for the BBSRC funding."

While a priority for growers, however, projects like these very rarely attract such public spending. Blackgrass had been earmarked as an area for grower-funded research following an HGCA strategic review in 2010, reveals Susannah Bolton. "Growers had highlighted resistant grassweed management as one of the biggest technical challenges they faced. It was an area at the time where there was relatively little research, so HGCA put out a call for bids.

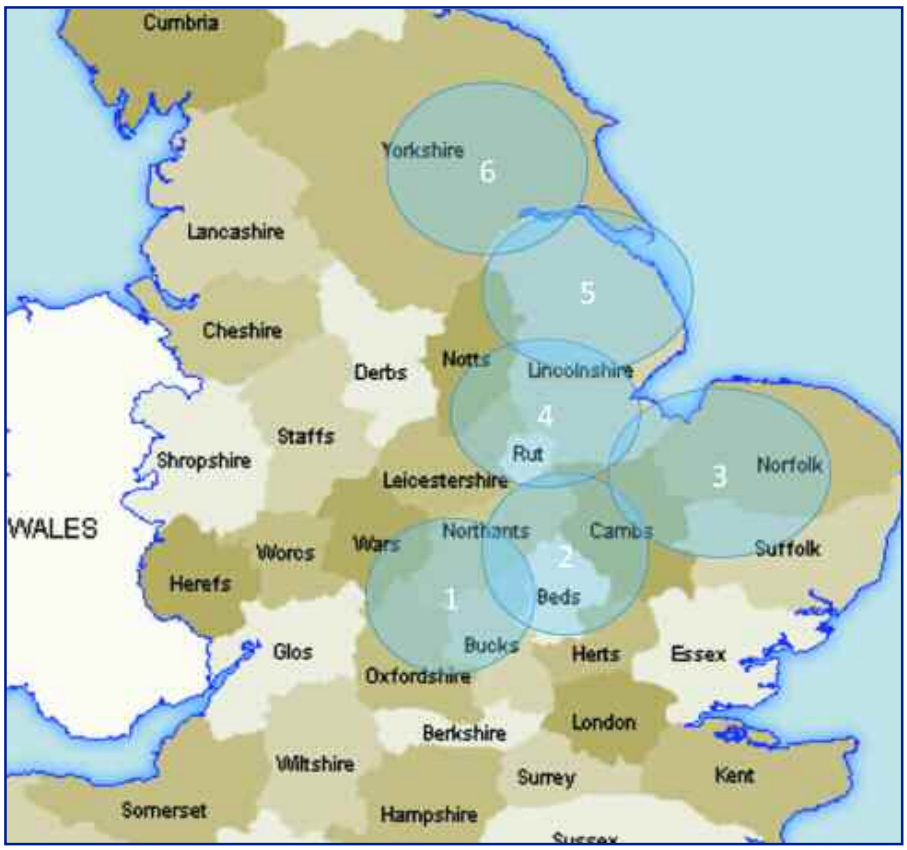
"It just happened that an expression of interest came from a consortium of researchers that was putting together a bid for BBSRC funding. They needed 10% industry funding, and it meant we could tap into a far more ambitious project than the HGCA could have funded on its own."

This consortium is led by Prof Rob Edwards, now at Newcastle University. "There were a number of us working in the same field, including Rob Freckleton and colleagues at Sheffield University and Paul Neve, now at Rothamsted Research. We realised that by joining together we could bring a new multidisciplinary approach to study and combat herbicide resistance in blackgrass using the latest research approaches, in a study that spans from molecular events to field-scale outcomes."

The consortium was awarded one of only nine BBSRC strategic Longer and Larger grants approved in 2013/14. These projects must be over £2M, can be up to five years long and are highly competitive, ▸

The BBSRC funding meant a much more ambitious project could be undertaken than had been originally planned, says Susannah Bolton.

A herbicide isn't a natural stress trigger, points out Rob Edwards — MHR has evolved from the plant utilising a combination of related stress mechanisms.



Monitoring and assessments will focus on 70 collaborating farms located from Oxon to Yorks.

▸ so are only awarded to consortia who can demonstrate the highest degree of scientific excellence and strong alignment with UK strategic research priorities.

"Because of its applied nature, we also looked to obtain joint support from HGCA, which is funding 10% of the total £2.8M cost over the project's four-year lifetime."

The core BGRI project comprises five work packages:

1. Molecular mechanisms underpinning the evolution of metabolic herbicide resistance (MHR) in blackgrass. This peers into the genetics of blackgrass, ▸

New project holds hope in blackgrass battle

The blackgrass has been getting steadily worse at Hollygate Farm, Stragglethorpe, for Notts grower Peter Gadd. With 100ha of combinable crops on Keuper marl red clay and medium loams, there are areas of the farm where he's now struggling to keep it in check.

"There's a band of heavier, blacker soil through the farm, and that's where the worst of the problem tends to be. Previously we'd controlled it with Atlantis (iodosulfuron+ mesosulfuron) applied in early spring. But since 2009, I've noticed a drop-off in efficacy," he notes.

In addition to herbicides, cultivations and rotation are currently his primary tools against grassweeds. Land coming out of oilseed rape is ploughed and then worked down to encourage a flush of blackgrass which is then sprayed off with glyphosate before drilling. Pre and early post-emergence herbicides are then relied on to take out most of the survivors.

"We can't put the drilling date back too late — this is a small farm and we need to aim for maximum output and make every acre count," he explains.

In the second cereal slot, hybrid winter barley is proving highly competitive against blackgrass, says Peter Gadd. "It's working really well for us, and this year yielded 8.7t/ha, drilled in the last week of Sept."

The OSR crop is established with a subsoiler, ensuring minimal soil-surface disturbance and that subsequent additional control is achieved with propyzamide, which followed clethodim last autumn. "We had good results with this, although with OSR, crop competition is again key — we had a lot of blackgrass come through the poor crop we had the previous year."

The farm is now one of the collaborating farms taking part in the BGRI project. The blackgrass has been mapped and sampled and Peter Gadd has provided the research team with a detailed history of how it's been managed.

"What I'm looking forward to most are the results from the sampling — if we can identify what type of resistance we have, we can target herbicide use and other forms of control more effectively. That'll give us a fighting chance of staying on top of the problem."

Other information built into the project he reckons will help growers build a better anti-blackgrass strategy over time. "It'll tell us more about resistance, and how this is developing on a regional basis. You can extrapolate that information to identify crop-specific and cultural techniques to adopt more locally."

Peter Gadd hopes to extrapolate the information gathered by the project to identify crop-specific and cultural techniques to adopt on a more local basis. Picture: NFU

But he believes more radical solutions should also be researched. "We know that burning is a very effective form of control. We're in a Catch-22 where we can't lobby to re-introduce it because we don't have any updated research to test whether it can be done safely and with minimal environmental impact, and there's a reluctance to spend research funds on a practice that may never be allowed. But properly licensed, limited and controlled, it has potential."

The five work packages contain a mix of cutting-edge science and practical, on-farm application.

▸ studying the plant's stress responses, with the aim of developing a molecular diagnostic kit that can spot resistance in the field.

2. Blackgrass population monitoring and resistance audit. This'll produce a detailed dataset on weed abundance, MHR and target-site resistance (TSR) status, linked to historical farm management.

3. Genetic architecture and inheritance of MHR. This work package will develop an understanding of how resistance is inherited, the patterns of cross-resistance in a population and the fitness costs associated with the evolution of herbicide resistance.

4. Eco-evolutionary modelling of blackgrass populations. Starting in the second year of the project, this work package will begin to integrate knowledge from the first three work packages into computer models. These will be used to simulate how resistance evolves under certain regimes or selection pressures.

5. Assessing wider impacts of resistance and management. Undertaken in years three and four of the project, this looks at the impact of resistance on the environment and farm economics.

For Susannah Bolton, there's the right mix of cutting-edge science and practical, on-farm application. "The really nice aspect of this project is that it'll provide genuinely new scientific evidence that'll spin off into strategic and management practices. It'll give growers a better understanding of the risk of resistance through their crop management and those with resistant grassweeds will get a better understanding of how a particular strategy will play out.

"But for growers who want a quick fix or miracle cure, this project is unlikely to provide that. It'll give us a better understanding of plant physiology, and perhaps as a spin-off, that may lead to a new herbicide development. But the core aim of the project is to equip growers with a long term strategy to deal with resistance, not a quick fix from a can."

She points to the close involvement the project will have with at least 70 collaborating farms — these will form the basis of case studies to explore how to manage resistant blackgrass. So will this be of no relevance at all to growers for whom it's not an issue?

"There's an emphasis within the project on exploring what happens in fields where resistance is just developing, and a key output is to help growers who don't have herbicide resistance, prevent it occurring. So this research is of relevance to every grower in the UK who uses a herbicide."

Researchers are hoping to find a chink in the armour a grower could exploit, either through chemistry or management practices.

Rob Freckleton has built up a seven-year history of blackgrass population density related to management history on farms.

And it's this very element that lies at the heart of work package one and its aim to explore the molecular mechanisms influenced in a blackgrass plant. Rob Edwards has studied herbicide resistance at a molecular level, identifying a genetic 'switch' that can turn resistance on and off. He points out that herbicide resistance isn't a natural response.

"Plants have evolved natural defences to extreme weather conditions and attack by pests and diseases. They've acquired this through becoming stressed and then adapting to that stress. But a herbicide isn't a natural stress trigger — MHR has evolved from the plant utilising a combination of related stress mechanisms. We need to unravel the molecular basis of herbicide resistance so we can understand what the plant thinks it's responding to."

TSR is different, he notes, and not a core focus of the work package. "We're familiar now with the gene mutations that confer TSR, but we know less about the genomics of MHR."

What's new in the project is the wide diversity of samples from which to test. "The nature of MHR, and probably why it's so difficult to manage, is that it's evolving differently, depending on the specific field conditions. We'll be able to unravel the different populations of resistant blackgrass and study them at a biochemical and genetic level — we know there's not a universal trigger for MHR, but we're hoping to hone in on the genetic fingerprint."

Diagnostic test

The aim is to develop an in-field diagnostic test, and a greater understanding of the molecular basis of resistance may even bring to light a new form of control, suggests Rob Edwards. "We could find a chink in the armour you could exploit, either through chemistry or management practices. At the very least it would give you a good understanding of exactly how your blackgrass is developing resistance that could form the basis of a new approach to tackle it."

The in-field monitoring in work package two is led by Prof Rob Freckleton of Sheffield University, who for the past 6-7 years has monitored the development of resistant weeds across a network of 50 farms. Around 10 fields on each farm have been mapped and split up into 20m-by-20m grids, with blackgrass density measured. What's built up from this work is a seven-year history of population density related to management history.

"That work has so far focused on three areas in Beds, Lincs and Norfolk," notes Paul Neve. "We've extended it to 70 farms across six areas, going west into Oxon and Warwicks and further north into N Lincs and Yorks. "We're interested in particular in the more marginal areas, on farms where resistance may just be developing, as this will give us the biggest insight into population dynamics."

Earlier this year, the call went out to growers to get involved, and there was a terrific response, reports Paul Neve. "We've not only established a good network of 70 representative farms, but have an additional 15 farms from whom we've requested ▸

▸ additional samples, and we've asked them to carry out and report their own mapping.

"The response from growers has been very encouraging generally and we've a database of interested farms with which we'll be keeping regular contact and involving them in aspects of the project."

Also included will be 300 farms used as part of FERA's annual pest and disease survey. This collects data on pest and disease incidence, relating it to on-farm management practice. The farmers involved have been asked to supply additional blackgrass seed samples.

Tests on the samples will look for up to four modes of action, continues Paul Neve. ACCase and ALS TSR will be assessed through standard tests using 'fop' and 'dim' chemistry and sulphonylureas respectively. A better insight into the level of MHR will come from using residual herbicides, such as pendimethalin, and samples may also be tested for glyphosate resistance. "Hopefully we won't find any, but that's a good reason to start looking now," he points out.

Details of the farms themselves will remain undisclosed, but the work package will result in a fairly comprehensive picture of the current state of blackgrass resistance across the main arable area of the UK, he says. It'll also provide the basis for studies undertaken in the third work package.

"This aims to bring a better understanding of the genetics of MHR. While the first work package is concerned with the links between MHR and plant stress responses, we'll be adopting quantitative genetic approaches to help understand the inheritance of resistance."

Cross-resistance

The work will focus on studying how resistance is passed from one generation to the next, and the pattern of cross-resistance — how a population with metabolism-based ACCase resistance acquires ALS resistance, for example. "We want to investigate at a genetic level how plants evolve resistance, and how its response to other stresses develops. Importantly we want to look at any fitness cost that may result — is there a dormancy difference in resistance blackgrass, for example? We're hoping to expose an Achilles heel that growers can exploit."

While the first three work packages have already started, work package four and five won't begin until the second and third years of the project, says Paul Neve. "One of the important features of this project is the interaction between farmers and other stakeholders. In addition to newsletters and a regularly updated website *(www.bgri.info)*, we're running farmer focus groups and holding stakeholder meetings.

"The aim within the project is to understand better the problem of blackgrass resistance. There's

Regular stakeholder meetings will relay findings from the project back to growers.

Research round-up

HGCA project 3807, Multiple herbicide resistance in grassweeds: from genes to agro-ecosystems, runs from April 2014 to March 2018. It aims to examine the evolution and management of herbicide resistance in blackgrass from the genetic to the level, focusing on metabolic herbicide resistance (MHR), which is underpinned by enhanced herbicide metabolism. Led by Newcastle University, scientific partners include Rothamsted Research and Universities of Sheffield, Reading, Oxford and York. Its total cost is £2.8M, funded by BBSRC and HGCA (contributing £280,000).

To join the database and receive updates and news on the project, email bgri@rothamsted.ac.uk. For more information, see *www.bgri.info.*

HGCA Information 30, Blackgrass: solutions to the problem, has been updated for summer 2014 and is available to download at *www.hgca.com*

Paul Neve will be adopting quantitative genetic approaches to help understand the inheritance of resistance.

already good work carried out on farm and through trials, by the agricultural supply industry. Our plan is to feed knowledge into those trials, and learn from the feedback, rather than carrying out the fieldwork ourselves."

He suggests the modelling studies in work packages four and five will be instrumental in helping stakeholders and growers focus their efforts against blackgrass. "One of the first jobs will be to create 'hindcasts' for the collaborating farms that links their current blackgrass situation with past management."

With a background of working with resistance in Australia, Paul Neve also plans to collaborate with a worldwide network of resistance projects. "The great thing about a big new initiative like this is that it attracts other interested parties. Within the project, there are spin-off and side projects, and more and more students and under graduates are getting involved.

"We're maintaining strong links with the Australian Herbicide Resistance Initiative, that's the biggest of its type in the world — they were at the same stage in 2000 with ryegrass resistance as we are now. Blackgrass resistance is a very different beast and particular to the UK, but there may be valuable lessons we can learn about how Australian growers have adapted."

One example is the Harrington seed destructor, a combine-mounted cage mill, developed by a West Australian farmer, which grinds weed seed into flour before it leaves the harvester via the chaff-spreader. "A lot of innovation is farmer-driven, and it would be wonderful if similar devices were to surface through the BGRI project — necessity is the mother of invention, after all." ■

Project partner

CPM will be following progress of this project closely over the next four years, with unrivalled access to researchers and other stakeholders. Look out for regular updates and further features that we hope will help when deciding an effective grassweed strategy.