

“ Without the GINs there’s some cutting-edge genetic research that simply wouldn’t be carried out in the UK. ”

AHDB

*from theory
to field*

Collaborative research has long been the backbone of a Defra-funded breeding programme that has responded to the challenges facing oilseed rape growers. CPM explores the programme’s current focus.

By Tom Allen-Stevens

Few crops will take you on the emotional rollercoaster in quite the same way as oilseed rape. There’s the dazzling display of a crop in full flower, followed by the thick mat of pods with its promise of harvest booty. And there’s the struggling seedlings mercilessly savaged by cabbage stem flea beetle as they sit in submissive surrender in a dry September soil.

Could something be done with the genetics to smoothen out the ride?

This is one of the key aims of the Oilseed Rape Genetic Improvement Network (OREGIN). Set up in 2003 as one of four Defra-funded genetic networks, it brings together researchers and breeders in a collaborative approach to pre-breeding work and resources. Priority plant characteristics being investigated include tolerance to insects, viruses and diseases, including phoma stem canker, light leaf spot and clubroot, and improved fertiliser use efficiency.

The OREGIN of resilience?

But it’s the loss of chemistry, the weather and market pressures that are commonly cited as putting increasing strain on the oilseed sector, and these factors haven’t gone unnoticed. “Everyone is acutely aware of how much of a priority cabbage stem flea beetle is,” says AHDB research and knowledge exchange manager Dhan Bhandari.

AHDB doesn’t contribute to funding, he explains, but does get involved in the many spin-off research projects that have come about through OREGIN, and sits on the stakeholder group. “We’re pleased to have the opportunity to influence the programme, although the targets OREGIN has identified and the direction taken we fully endorse. It demonstrates good industry involvement,” notes Dhan.

Alternative approaches

Broadly, the direction taken is to seek out alternative approaches to crop management, with emphasis on those that integrate genetics with seed and agronomic technologies and methods to mitigate biotic and abiotic stresses. “Previous research had implicated specific genes as being detrimental to important characteristics of rapeseed, so the current phase of OREGIN includes pre-breeding activities to test predicted impacts of the loss of these genes,” he explains.

This involves the development of new winter OSR lines with benchmarking relative to a panel of around 30 reference varieties, along with the development of molecular markers to assist future breeding.

A characteristic of all GINs, and a unique feature of the wider programme, is that information has always been made publicly available, licence-free, to guide breeders towards desired traits.

“They’re not starting from scratch — breeders have been incorporating these improvements since the programme began. What’s different now are the advances in breeding technology. Breeders target genes of interest or areas of the genome associated with a trait. Markers help them quickly identify if this gene or set of genes has come through in a new cross, and this can reduce the time it takes to bring a new variety to market. OREGIN gives the breeders not only the germplasm that has the interesting trait, but the markers to help identify it,” says Dhan.



Plant breeders and geneticists are acutely aware of how much of a priority cabbage stem flea beetle is, says Dhan Bhandari.



Hants-based Crop Management Partners agronomist Nick Wall vents the frustration felt by many over the unreliability of oilseed rape.

He points out that the nature of the programme means resources are pooled and individual partners specialise in a particular aspect for the benefit of all. "This requires considerable investment and specialist expertise. Without the GINs there's some cutting-edge genetic research that simply wouldn't be carried out in the UK, and we'd rely on importing all our novel germplasm and genetic know-how. For OSR, in relative terms, the resources spent on the crop are low, so this funding through Defra is invaluable."

The quest for a genetic solution to CSFB has its own challenges, however, as project lead Prof Ian Bancroft of the University of York explains. "Firstly, we don't have sufficient entomological research into the pest here in the UK. The second problem is that no brassica material has so far been characterised that could be resistant to CSFB."

Ian believes that could be an inherent problem with the genetic make-up of all material used within OSR lines. "The industry successfully bred double-low varieties, specifically low in glucosinolates. By doing so, we may have stripped out the very property that could give OSR a defence mechanism."

So researchers are following

two alternative avenues that show promise of delivering genetic solutions to pest tolerance. "Firstly, we're targeting glucosinolate transporters within the plant. A commercial variety must have a low content in the seed, but a high content in leaves may resist pest attack."

Progress is being made through exploring the genetics of lines produced using radiation mutagenesis — a way of inducing mutations that can then be explored for their properties. "This approach works if you know what genes you're targeting. So, for example, you look to knock out the ability of the plant to transport glucosinolates from the leaves to the seed."

The other route is to explore the genetics of vigour. "When you cross two varieties, this results in vigour, but in OSR it's very difficult to know how much vigour a cross will bring and at what growth stages this will take place. We want to make this more predictable."

Cotyledon stage

The main focus of the work is the period just beyond cotyledon stage, aiming to identify genetic markers for areas of the genome that appear to encourage a quick accumulation of biomass.





"Another potential route is to look at the radiation-mutagenesis lines to see whether there are genes responsible for inhibiting growth that have been knocked out. But equally we don't want to encourage excessive growth in the canopy later on that then results in a poor seed yield," notes Ian.

Much of the work of OREGIN has revolved around harnessing and characterising Diversity Fixed Foundation Sets (DFFS) within the brassica species. 188 fixed lines have been identified for Brassica napus, for example, which includes OSR, swede, forage rape, Siberian kale and some synthesised lines. As more information is unravelled about the genetics and traits of these lines, it's been made publicly available to aid ►



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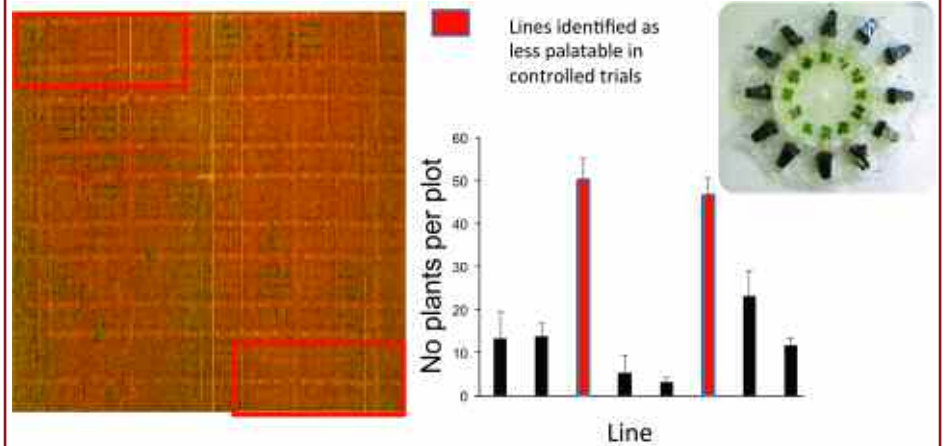


Ian Bancroft believes targeting glucosinolate transporters and exploring the genetics of vigour may help OSR build its own defences against CSFB.

► genetic improvement.

This has helped scientists at John Innes Centre, for example, who are currently using the lines in an AHDB-funded project studying the feeding behaviour of CSFB (see *CPM* March extra issue p23 for more details). They've found the degree of

Palatability of OSR lines tested in field and controlled trials



A drone flyover of the JIC trial plots in early Oct 2019 found significant differences in the establishment of the DFFS lines tested, which correlated with results from the controlled palatability tests.

Source: JIC, 2020.

damage to seedlings varies from 2-20% across 100 of the DFFS lines studied, notes JIC's Dr Rachel Wells.

"It's resources like this that OREGIN has produced that make these programmes so important. Producing diversity sets and

sequencing data, then making them available to the community is so expensive. The network is also invaluable for keeping us linked up with each other," she adds.

Improving the sustainability of OSR has been a key priority for Defra, and Ian

Collaborative effort brings a rich diversity of genetics

Lincs-based oilseed rape breeder at Elsoms Mark Nightingale has been involved with OREGIN almost since it first began. "For us, it's been like a breath of fresh air — the work the programme carries out is excellent," he says.

He recalls the LINK projects that preceded OREGIN in which research and commercial partners would work together on a public-funded project. "This way of funding of pre-breeding work has always been essential for the industry as it would be prohibitively expensive for individual breeders to invest the kind of resources it requires," he notes.

"But it was clear to us in the LINK programmes that there were competing research teams doing very similar work, and it made more sense for them to collaborate more closely. We now have a situation where different parties, rather than competing, use their core skills across the pre-breeding programme wherever they're needed."

Elsoms gains primarily through a greater understanding of the genetics and access to a very wide range of germplasm the company can develop to bring interesting traits to market. "The work carried out at John Innes Centre on CSFB is among some of the most interesting at the moment. Researchers have already screened a vast array of genetics and identified varietal differences and are in the process of taking that forward. In time, this will bring to growers elite varieties with greater tolerance or

even resistance to CSFB," explains Mark.

The company also benefits from spin-off projects. Turnip Yellows Virus (TuYV) resistance has been a great success story for the industry, he notes, with all the major breeders now having commercial varieties coming through that have the trait built in. But all resistant varieties can be traced back to just one source. "We're one of a number of breeders involved in a BBSRC-funded project led by the University of Warwick that's identified new genetic sources of resistance," he notes.

"On the pathology side, we get access to spores and races of major diseases and an insight into the genetics of these we'd never be able to generate ourselves. Going forward, as chemistry continues to lose its approval, it will be up to breeders to develop the traits and escape mechanisms that will provide growers with the crop protection they need."

This in itself provides a challenge he's hoping collaborative research will help address in future. "Growers are working more with biostimulants and biologicals. One aspect we've noticed is that the increased root growth these stimulate can expose the crop to more soil-borne threats — the fast-growing roots don't have the opportunity to build their own resilience. This is an area where genetics can help, but will require considerable R&D resources," notes Mark.

Although Elsoms has no new OSR lines on



Mark Nightingale considers it will be up to breeders to develop the traits and escape mechanisms that will provide growers with the crop protection they need.

the current AHDB Recommended List, it has both hybrids and conventional varieties coming through National List trials showing real promise, he says. These include "extremely vigorous" varieties that can cope with a high larval load of CSFB in the spring. Lines with verticillium wilt resistance, identified through OREGIN, are also making their way into NL trials, he adds.

"We don't currently do any work in gene-editing in the UK. It's an area we'd like to utilise sooner rather than later, however — if the OREGIN programme was to identify true genetic resistance to CSFB, it could still take 10-20 years to bring that to market. With GE, we could do that in as little as three years," Mark points out.



Next steps for OREGIN include a focus on the oil itself to improve its thermal stability and produce a more healthy oil.

highlights the work to increase nitrogen use efficiency as a key outcome. This is now beginning to be introduced in commercial lines, such as Limagrain's N-Flex trait. Next steps include a focus on the oil itself to improve its thermal stability and produce a more healthy oil.

"It's possible to go much further than the HOLL varieties commercially available — we're looking to increase vitamin E content and alter phytosterols, which are related to cholesterol content."

Ian points out that the OREGIN work is of global significance, with specific projects published in highly respected peer-reviewed journals. "The UK has an outstanding environment for OSR, both climatically and scientifically, and OREGIN responds directly to the priorities of breeders and other stakeholders."

Diversity panel

But none of the research involves GM or gene-edited (GE) material. "Our focus is on making available the large diversity panel and undertaking work that expands that and helps breeders understand the genetics behind it. This is resource-intensive work and there isn't the need for GE, which is a relatively low-cost technology, although there's nothing stopping breeders using GE to alter specific genes."

While plant breeders are very much involved in the OREGIN programme, Ian believes the opportunity for growers to explore some of the novel lines coming through the programme is more limited — specific release agreements and measures to limit cross-pollination are required for non-listed material, while some are HEAR lines that could result in contamination issues with commercial crops. "We welcome growers who want to look round the trial plots, however, or participate in the Stakeholder Forum," he notes.

Dhan is hoping for greater involvement through AHDB's Monitor Farm network, however. "Especially with some of the CSFB

Research roundup

The **Oilseed Rape Genetic Improvement Network (OREGIN)** is one of four projects supported by Defra as part of a long-term research platform for the genetic improvement of arable crops and fresh produce. OREGIN aims to generate pre-breeding material that carries novel, profitable and sustainable traits, while collaborative research ensures efforts are placed on key traits and the material produced (genetic and knowledge) is accessible to breeders. The project started in 2003 and is now in its fifth stage, which runs from 5 March 2018 to 31 March 2023 at a cost of £1.2M.

OREGIN is led by the University of York, with the Universities of Hertfordshire, Nottingham, Reading and Warwick, ADAS, JIC, NIAB, Rothamsted Research and SRUC, while Elsoms and Limagrain are also involved. <http://www.herts.ac.uk/oregin>

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work, we've received interest from Monitor farmers keen to help develop the resilient varieties of the future.

I think there's potential for growers with the right knowledge and resources to make a significant contribution," he maintains. ■

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