

Where GM meets GE

“It’s an order of magnitude more expensive to run GM trials.”

Innovation GM research

With the future unclear for field-based research for gene-editing across Europe, *CPM* visits the GM research plots at Rothamsted Research to see the first ever UK field trials of a gene-edited crop.

By Tom Allen-Stevens

There’s a clunk and a whine as the bolt is drawn back and the heavy steel gates swing open. You enter the inner enclosure of two high security fences, and it feels a little as if you’ve stepped into the recreation area of one of Her Majesty’s prisons.

But the fences aren’t there just to prevent the escape of what lies within this 0.4ha plot. This is the GM trials enclosure at Rothamsted Research in Herts, which now contains the UK’s first ever trial of gene-edited (GE) crops, alongside the GM camelina — the true subject of this field trial. The whole plot, tucked to one side of

the 0.4ha enclosure, occupies a modest 400m². This includes the pollen barrier — a wild-type camelina that enshrouds the trial plots and keeps any GM pollen from escaping.

Dr Lihua Han, one of the Rothamsted GM camelina team, has come to inspect the plots. The fences are there to keep all types of mammals from damaging the plots — both small and large, she explains. “But I’ve been here since 2015 and we’ve had no trouble from protestors. I think people can see the benefits from the technology now.”

Unique nature

The crop has podded up and looks well for harvest. She’s expecting a yield of 1.2-1.8t/ha — hardly an output that will make a UK combinable crop grower burst with excitement. But it’s the unique nature of the oil this crop produces that makes it so important.

The GM crop has been genetically engineered to ensure the seed is high in omega-3 long chain polyunsaturated fatty acids (LC-PUFAs), specifically EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid). These are the ones said to confer health benefits in areas of coronary heart disease and

neurodevelopment — so-called fish oils. And with the commodity price of fish oil at over \$2000/t, that might be something that catches the eye of a farmer looking for a good return.

Farmed fish, which accounts for one quarter of the EU’s production of fish, molluscs and crustaceans, currently relies on what it’s fed to provide this valuable and healthy oil, and this is generally sourced from fish captured from the oceans. Fish farms consumed around 80% of all fish oil harvested from the ▶

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If the CJEU ruling is perceived as a barrier, scientists in the UK may abandon GE research, despite the investment and advances already made in this area.

- ▶ oceans in 2011 (as fish).
With EU aquaculture valued at €3.2 billion (£2.8 billion), Prof Johnathan Napier,

who leads the BBSRC-funded research into GM camelina, believes it makes sense to look to a more sustainable source for this fish oil. "Current plant sources of omega-3 PUFAs, such as flax seed, do not produce the long chain varieties, EPA and DHA," he explains.

Global requirement

"We chose camelina because it's very easy to work with from a GM point of view. But you don't need a commodity crop — just 750,000ha would provide the world's global requirement and replace what's currently fished from the oceans."

The genes have been successfully transferred over from photosynthetic marine organisms, such as phytoplankton. In a separate experiment (but the same

field trials) plants have also been engineered to produce bigger leaves and thicker stems, and these genes come from the bacterium *Escherichia coli*.

The research reached the stage in 2014 at which the team needed to conduct field trials. Since this is GM material, releases to the environment are covered by the EU's strict GMO regulations, so Rothamsted applied to Defra for a licence to conduct the trials.

"We knew we could grow the plants in the lab, but if you want any meaningful data about how it performs as a crop, you have to conduct field trials — this is a critical stage in developing a new crop trait," explains Johnathan.

But when it comes to GM trials, complying with the regulations is costly and time-consuming, he confirms. "It's an order of magnitude more expensive to run GM trials. Just making the submission to Defra for a field trial costs £5000. You then have to ensure no material leaves the site and must be accounted for. For flowering crops that means a pollen barrier, but you also have to take care with cultivation and harvesting equipment that it's thoroughly cleaned. The main job for the fencing is to prevent mammals coming onto the site and transferring material away, while all the crops have to be destroyed after harvest and the site monitored for volunteers."

This year there are 16 GM plots, each 5m by 1.8m, which are replicated and there's a conventional control plot. "The trials are really an iteration of what we've learned in previous years — we're testing types with higher yields and oil content. It's also valuable to see how the changes to plant stem and leaf size play out in the field," says Johnathan.

For the first time this year, there are also



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Yielding just 1.2-1.8t/ha, the high health fish oil the crop produces has a current commodity value of \$2000/t.

two GE plots. This is material that's been developed by a French colleague, Prof Jean-Denis Faure from INRA-Versailles, using CRISPR-Cas9. Camelina is a hexaploid variety, like wheat, so often changes must be made to specific genes in all three sub-genomes before any significant phenotypical change is expressed, he explains. In this case, scientists targeted three delta-12-desaturase (FAD2) genes which affect the accumulation of oleic acid in the oil.

"In the GE plots, we're actually testing the polar opposite of what's on trial on the GM side, looking for a high oleic acid oil and reduced polyunsaturate content. While different fatty acid profiles have been achieved with the mutant plants, the lab work has found the absence of the gene also leads to a loss of function in the plants that we're testing in the field."

No transgenic material

The key difference with GE is that there's no transgenic material brought into the host plant — it just has specific mutations or edits to its genome. "But whereas you can target just the seed in GM plants, GE changes to the genome take place throughout the plant. It's why it's so important to take this work out into the field."

The Rothamsted GE trial is a one-off, he says. "It's more about gaining a better basic understanding of the biology of GE plants than developing a useful trait. If we carry on with GE material in this project, it's likely to be used in conjunction, or stacked, with the GM plants."

But he's keen that work in this area continues in the UK, even if the final GM camelina crops that result are not grown here, and is worried about the impact of the ruling on GE crops made by the Court of Justice of the EU, that brings them within GMO regulations.

Before the trial was established, Rothamsted sought the advice of the Advisory Committee on Releases to the Environment (ACRE) which concluded the plants contained no transgenes and could have been produced through traditional breeding techniques. "Consequently, it would not be possible to determine whether these lines had been produced by genome-editing or by traditional mutagenesis because they would be genetically indistinguishable," was the advice, indicating GMO restrictions for the trial were not necessary.

"We're still waiting for Defra to advise specifically following the ruling, although the whole site is managed as a GM site,

so it may not make a significant difference to this specific trial — it likely means just additional monitoring for the GE plots," says Johnathan.

"My main concern is the impact this will have on related research. BBSRC has been enormously supportive and indeed the taxpayer has already made a big investment in gene-editing. There's a wealth of talent in this field in the UK, not just at Rothamsted and John Innes Centre, where we have experience with GM trials, but throughout the universities and research institutes. The CJEU ruling may be perceived as a barrier and scientists will abandon GE research. It's imperative this doesn't happen, because it has such great prospects for farming and for society in general." ■



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