Genome Editing In Brief

What is ‘gene-editing’?

The term gene-editing refers to a suite of new genetic engineering techniques that can be used in plant breeding. The most well-known of these techniques is CRISPR/Cas-9 a type of genetic engineering that is relatively cheap and quick to use. Other gene-editing (or more properly genome--editing) techniques include zinc finger nucleases (ZFN) and transcription activator-like effector nucleases (TALENs), as well as oligonucleotide-directed mutagenesis (ODM) and directed mutagenesis.

They are called 'new' techniques, CRISPR and these other techniques have been around a long time. Several make use of older genetic engineering processes (e.g. ZFN, oligonucleotides). Even so, biotech companies argue that gene-editing is different and should not be regulated under existing EU (or UK) regulations.

In agriculture, terms like ‘Precision Breeding’ and ‘New Plant Breeding Techniques’ are used – primarily by lobbying interests – to describe all genome editing techniques, including gene editing, synthetic biology and gene drives, even though significant difference between them.

Is the name important?

Yes. In the 1990s ‘genetically modified organism’ replaced the more accurate description, ‘genetic engineering’, in common use as a way of making the technology seem less invasive and extreme.

The current name change is an extension of this and aims to separate genome editing from GMOs and set it on an equal footing with traditional plant breeding. It therefore forms a key part of the argument for deregulation.

If new genetic engineering technologies are partly or fully deregulated their products would not be subject to meaningful risk assessment and foods containing them would likely be unlabelled. This would reduce consumer choice, undermine consumer confidence and leave us open to unpredictable and unmonitored risks to the environment and public health.

What was the European Court of Justice case about?

Very broadly, the ECJ case was about how we define and, therefore, regulate GMOs.

The case began as an action brought by several French NGOs, which argued that herbicide tolerant varieties of rapeseed and sunflower, produced using new directed mutagenesis processes, were ‘new hidden GMOs’ and should be regulated as such under European law. The case was referred to the European Court of Justice in 2016 and in July 2018 after reviewing copious scientific evidence the Court’s unequivocal judgement was that organisms obtained by directed mutagenesis are GMOs and are, therefore, subject to the obligations – e.g. risk assessment and labelling – laid down by the GMO Directive. Since directed mutagenesis is a step in many of the new gene editing techniques, these too fall under existing regulations. The court upheld the notion that plants created by random mutagenesis had a history of ‘safe use’.

But if one type of random mutagenesis is unregulated shouldn't all types be

No plant is unregulated. To register a new variety, for instance, the plant needs to undergo a series of official tests including the Distinctiveness, Uniformity and Stability (DUS) test. For arable crops you also need a Value of Cultivation and Use (VCU) test. In most countries, the VCU test requires breeders to select for highest yield otherwise they wouldn't be able to bring their crops to market.

There are multiple examples in our food system of crops that were originally created using some form of mutagenesis. The practice, now waning, was once so widespread that it is impossible to keep track of which crops were or were not subjected to this technology. Older style mutagenesis was simply accepted as, rather than proved to be, safe. There is an argument that older style mutagenesis, as used in conventional breeding, alters the whole plant in a way that could happen in nature, and has a long history of safe use. But most plant breeders agree that it probably wasn't safe and did result in multiple off-target effects.

The idea that targeted mutagenesis should have parity with an undetermined number of untested plants and that it should enter the food system without testing or regulation is essentially claiming that two wrongs would make a right. We possess more knowledge about genetics now than we did 60 years ago, we should apply it.

But CRISPR is a fast way to create new crop varieties

Technologies like CRISPR do not, in themselves, create new organisms. In most instances, these genome editing tools, which are sometimes described as 'genetic scissors', are used to cut both strands of the DNA helix at a pre-determined location. This cut then activates the cell's DNA repair mechanism. This combination of events allows genetic engineers to introduce a genetic modification at a specific location on the genome.

Currently there are three types of procedures that can be used following the 'cut'. In the simplest possible terms these are:

- SDN-1 the cut is made and the organism's normal cellular repair mechanisms are left to make the repair;
- SDN-2 the cut is made and a template is provided to instruct the organism how to repair itself;
- SDN-3 the cut – and sometimes multiple cuts – are made and both a template for repair and the simultaneous insertion of transgenes are applied.

Beyond CRISPR the process of creating a new organism is more or less genetic modifications it has always been practised. Further, whatever type of 'breeding' is used a time frame of anywhere from 5-15 years is normal for any kind of new plant variety – something which challenges promises of genome editing as a form of 'speed breeding'.

Even so, gene editing is more precise than traditional plant breeding, right?

Gene editing is promoted as being a more precise type of genetic engineering because the location of the intended 'cut' in the DNA can be 'precisely' targeted. However, precision is not the same as predictability, accuracy – or control.

A single gene can have multiple functions, thus a single DNA change can have multiple and profound results throughout the organism. These effects cannot be predicted or controlled because we simply don't know enough about the genome. Numerous recent studies are showing that 'precise' CRISPR technology can produce massive and unpredictable disruption in the genome.

How we breed plants is key to how productive and ecologically sound a crop is

It is widely recognised that there are limits to what can be achieved solely through plant breeding in terms of improvement in plant/variety performance *per se* and in terms of the bigger picture of 'feeding the world'.

Since plant breeding is both a slow process and also only one piece in the bigger puzzle of creating a sustainable food system, by itself it possesses no immediate or magical answers to food security and sustainability. To frame it as a single answer to sustainability problems is misleading and places a heavy weight of expectation on breeders of all kinds. An understanding of genetics can greatly assist with varietal selection but more important than how a plant is bred is how it is farmed, the condition of the soil in grows in, the geographical/regional appropriateness of the crop and the skillset/knowledge of the farmer.

Innovation does not always mean high-tech

Part of the argument for deregulating agricultural GMOs is that farmers are in urgent need of innovations to help them farm sustainably. This may be so, but it is wrong to conflate technology – particularly hi-tech solutions like genetic engineering – with innovation.

Some of the most innovative solutions involve low tech, open source and affordable methods that all farmers and growers can use right now. These include agroecological approaches such as crop rotation, intercropping, soil enrichment, and integrated crop and livestock systems.

Hi-tech solutions, when they are used in plant breeding, should be both purposeful and responsible. Many breeders, for instance, now use 'molecular markers' to track genes of interest through the breeding process using marker assisted selection (MAS).

MAS is an example of responsible and effective technology that results in a conventionally-bred plant by using our knowledge of genes and genomes to select varieties with desirable traits. Examples of MAS-bred varieties include flood tolerant rice, cassava that is resistant to mosaic disease, and wheat resistant to stripe rust fungus. Although MAS varieties are subject to patents, the approach to development is 'bottom up' e.g. farmers and growers bring their knowledge to the table and work with scientists to breed new varieties that work for them wherever they farm.

But don't we need strong science-based regulation?

We need evidence-based regulation. Genetic engineering in farming and the food system is a disruptive technology. Like all 'disruptive technologies' – driverless cars, social media & e-cigarettes – it cuts across multiple sociological, environmental, economic, scientific and regulatory areas. Rational regulation is only possible when evidence from all disciplines/stakeholders is included.

Importantly, the call for science-based regulation does not insulate us from intractable ideology. We applaud scientists who want to 'feed the world' and 'fight climate change', but the belief that hi-tech-fixes are the best or only solutions is ideologically-driven. Moreover, this ideology, however well-meaning, addresses only a small piece of these complex puzzles. Progress, rational regulation and depolarisation of the GMO debate can only evolve from a wider, more systemic view of the problems agriculture faces and an honest look at all the evidence around proposed solutions.