THE BOUNDARIES OF PLANT BREEDING

Report of the World Café
12 September 2019

A BIGGER CONVERSATION

In association with

IFOAM EU GROUP

This report, written by Beyond GM, summarises the discussion and conclusions of the world café, The Boundaries of Plant Breeding.

The event was co-hosted by A Bigger Conversation (Beyond GM) and IFOAM EU, and held in Brussels on 19th September 2019.

We'd like to thank all our attendees who participated so fully in a frank and open discussion.

A Bigger Conversation is an initiative of Beyond GM in the UK. While the Beyond GM campaign reaches out to citizen stakeholders, the A Bigger Conversation aims to bring together experts and forward thinkers – including scientists, academics, farmers, breeders and grassroots leaders – representing a wide range of views to establish a more in-depth dialogue around key issues around genetic engineering, food and farming. For more about A Bigger conversation see page 50.

IFOAM EU is the European umbrella organisation for organic food and farming. It fights for the adoption of ecologically, socially and economically sound systems based on the principles of organic agriculture – health, ecology, fairness and care. With more than 210 member organisations its work spans the entire organic food chain and beyond: from farmers and processors, retailers, certifiers, consultants, traders and researchers to environmental and consumer advocacy bodies.

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INTRODUCTION – PURPOSE AND GOALS

The basic question of this world café – whether there should be boundaries in plant breeding – arose in response to the seemingly unlimited applications of new genome editing techniques. But it's also rooted in the longer history of genetic engineering in plant breeding, which appears not to recognise the validity of boundaries, be they conceptual, species-based, risk-based or culturally-based.

In organic plant breeding[1], for instance, the notion of maintaining the integrity of the genome and the cell arises from a belief in the integrity of living organisms, 'naturalness' and 'respecting boundaries'. In contrast, breeding that relies on genetic engineering, and perhaps especially genome editing techniques, is more frequently portrayed as having 'limitless possibilities'[2] and scope – and by implication no boundaries, and no values-based limits that might restrain technological advances.

In truth, there is a spectrum of different approaches to breeding in agriculture and clear philosophical, epistemological and practical differences between them.

But there are also aspects of modern plant breeding where declared goals align and where there is, or ought to be, the possibility of agreement.

The clearest example is that across the board, all plant breeders and researchers make claims of pursuing 'sustainability' and 'environmental protection' whilst using similar terminology and appealing for cohesive efforts to tackle climate change and 'feeding the world'.

Having said that, the notion of boundaries and limits is foundational to the concept of sustainability – so how does that square with notions of unlimited possibilities for some types of plant breeding? And where does plant breeding actually sit in the larger spectrum of sustainability?

> **"Plant breeding serves the agricultural system, whether it is organic or an industrial monoculture. It can define what the varieties are but agriculture as a whole defines how you use the soil, the environment etc. So my question is, is plant breeding important? Is it a driving force? I am a plant breeder so this is quite an important question to me!"**

Our experience with A Bigger Conversation to date (see page 50) is that different people often mean different things when they use the same words. 'Sustainability' is one example; another is the concept of 'nature' and/or 'natural'. In the context of this discussion, the scope of the idea of 'breeding' may differ between individuals as well.

Some, for example, view genome editing as a neutral process that can be applied to specific problems. For others, plant breeding can't be disconnected from the wider agricultural system and encompasses not just downstream effects but the distribution of the material produced, its commercial and technological roll-out and the ownership of the intellectual property. As facilitators it was not our role to determine the appropriateness of differing perceptions. However, it is necessary for discourse to be aware of how these terms can be used differently according to different world views.

In questioning whether there are or should be boundaries or limits in plant breeding, the aim was to explore what these terms might mean, what the differences in approach and perception are and to see what these differences might mean in relation to underlying values and therefore perspectives – individual as well as institutional. Having identified these, the looming question is can they co-exist within the larger agricultural system or are they forever destined to conflict?

STRUCTURE OF THE DAY

The discussion around the use of genetic engineering in plant breeding has a long and difficult history.

It's a place where disagreement and conflict exist around basic questions and concerns about choice, fairness, power structures and environment and where people readily take sides and positions. Even as the science around genetic engineering and other plant breeding methods develops, those sides and positions tend to remain entrenched.

In September 2019, in Brussels, we convened a diverse group of plant breeders and those engaged in issues relating to plant breeding to discuss the boundaries of plant breeding in agriculture. Those attending were at a senior level in their professions and the meeting was characterised by curiosity and good-natured enquiry on all sides.

The meeting was organised as a day-long world café covering four broad themes. Participation was by invitation only and the meeting was held under the Chatham House Rule.

As per the world café format, there were four tables where small groups were encouraged discuss a specific theme around plant breeding in agriculture in hour-long sessions. Each session began with a short introduction from the table host outlining the theme and objectives of that table. The groups then rotated through different tables throughout the day. There were introductory and concluding remarks at either end of the day.

The themes put forward for discussion were:

Concepts and boundaries
How much do we understand each other when we talk about concepts like 'natural' and 'sustainable' in plant breeding? Are there assumptions that would benefit from challenge and/or deeper exploration?

- Are notions of naturalness and integrity valid for setting the scope and boundaries of plant breeding as we discover more about the complexity of the genome and its workings?
- Should there be any limit or boundary to plant breeding?
- How does the precautionary principle play a role in breeding?
- Do notions and aspirations of sustainability and biodiversity inherently impose limitations and boundaries to plant breeding?
- Do patents and breeder rights create barriers and limitations to sustainability and biodiversity? Are they an incentive to pursue certain innovation paths rather than others?
- How does breeding relate to the broader farming system?

Acceptable risk
Genetic engineering of food crops brings with it a level of risk. How do we decide what level of risk is acceptable?

- What are the risks of genetically engineering food – e.g. off-target effects etc?
- Are these lessened with new genome editing techniques?
- Does the picture change if you look at process rather than trait?
- Should the concept of risk be rooted in politics, science, ethics or economy?
- How far should scientists and regulators go to ensure the least possible risk?
- Who should be responsible for determining and reviewing the level of acceptable risk?

Resilient plant breeding
In a rapidly changing world, which is highly vulnerable to climate change, how can plant breeding, as a discipline and as a structured R&D and marketing system, build resilience? Can it, and if so, do the new genetic engineering techniques have a role?

- Does wider stakeholder involvement improve public trust in science and plant breeding?
- Are expectations of genome editing realistic – e.g. are we expecting plant and animal breeding to solve problems beyond their remit?
- How do we foster respectful disagreement on practice and potential of genome editing?
- Does the private sector base of plant breeding contribute to resilience?

Citizen engagement and discourse
Citizens are the 'end users' of plant breeding. Some view their engagement with and understanding of the processes involved as crucial, while others argue that citizen involvement may complicate an already complex picture.

- Should, and if so how can, citizens be informed and aware of the conceptual and values-based differences between different plant breeding approaches?
- How can transparency in R&D, policy and the market be assured?
- Is there any commitment to the above amongst plant breeders?

The initial questions posed were for guidance and as a starting point only; many discussions took a different direction, based on the interests of the participants and the insights that arose as the conversation evolved.

The focus on values and worldviews allowed a much deeper and more nuanced conversation to emerge during the course of the day. The world café format allowed each table to build on the previous group's discussion and form a more complete response to the questions that were being asked.

"I think it is fruitful to think about where we want to go with agriculture and really think about the whole food system. What was clear to me and has become clearer today is that we need a diversity of approaches."

In addition to feedback from the moderators, the entire day was audio recorded. Our aim in this report is to sum up the flow of that discussion. Further reflections from the nearly 18 hours of recordings are included in the *Final Thoughts and Next Steps* section.

Emerging Themes

The Bigger Conversation meetings and events seek to challenge entrenched views by taking the spotlight off narrow commercial or R&D agendas. Hence, the questions posed for this discussion were not meant to create a battleground over different plant breeding approaches – i.e. which is better or has more merit – but rather to provoke a more well-rounded discussion.

Amongst the themes that emerged, were:

- We currently face multiple challenges around food production and its impact on the wider environment. Participants recognised that the enormity and complexity of these challenges are likely to mean that there is no single answer but rather that a plurality of approaches is needed.

- Many expressed the view that they were not interested in rehashing discussions framed around right and wrong, or whose science is best, or whose plants are best, or any of the other controversies that are continually stirred up by the media and campaigners on all sides.

- Participants from all backgrounds felt keenly that the loss of diversity in science, not just in terms of the mindsets of individual scientists but also of scientific approaches, was detrimental to science as a whole.

- It was 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 frame it as a single answer to sustainability problems is misleading and places a heavy weight of expectation on breeders of all kinds.

- Similarly, participants highlighted that the process of breeding does not take place in a vacuum. What happens in a lab is subsequently subject to cultural, environmental and socio-economic interactions that influence potential risk, putative benefit and the impacts of the process.

- There was shared frustration at how little the public and policy discourse is engaged with even the most basic mechanics of plant breeding. This is especially important given that agricultural plants are at the centre of so many concerns around sustainability, food security, resource use and climate change. In particular, for citizens to have some meaningful influence and agency around the food they eat, some understanding of the complexities, the consequences and the trade-offs involved in plant breeding may be helpful.

- Participants also expressed frustration at how media reporting is distorted by lack of expertise and understanding amongst journalists, campaigners and politicians.

- Finally, in this frustration was also a desire to connect professionally and personally and find a more cohesive approach to agricultural plant breeding.

The complexity of language

At the start of the day we suggested that participants listen out for key words like 'sustainability' and 'natural' and take the opportunity to ask whether we all mean the same thing when using these.

Differences did emerge, especially in discussions around the concept of natural where fundamentally different perspectives surfaced over what it is and its importance in the bigger picture of agricultural plant breeding.

> **"I don't want to fight about if one technique is more risky than another or more natural than another. That's not important to me. It's about allowing a pluriformity of values, I encourage you to go ahead and be a responsible citizen in your work. But allow me space to find my way – and let's stay in contact."**

As the day progressed, it also became clear that other aspects of language can complicate the discussion around plant breeding. For instance, in nearly all the sessions certain words were being used interchangeably despite having different meanings.

'Citizens' and 'consumers' is one example. Members of the public can identify as, and act from, either or both positions. How plant breeders, farmers, scientists and others communicate and interact with the public can also be dependent on whether they perceive themselves as speaking to the citizen or the consumer.

Similarly, in modern sustainability discourse, the concept of

'boundaries' has become synonymous with that of 'limits'. There is, of course, a significant degree of overlap in meaning, but there are also important differences that, although they were not explored on the day, became more apparent in listening to the recordings of the world café.

A boundary can be indicative of a limit – as in an area of land or a city – but it can also reflect personal and/or communal choice, which, through inclusion and exclusion, defines identity and scope of a place, a person or a philosophy. A limit can be seen more as a restriction – a rigid line that cannot be crossed – and may arise due to regulation, but also lack of knowledge, lack of investment and/or opportunity. However, both may evolve over time and with changing circumstances.

In listening to the audio recordings of the day it seemed clear that a boundary as a principle of differentiation or a set of distinctive features of something might be worth greater consideration and could provide a way forward in discussions around different approaches to plant breeding.

Finally, although the trend in regulatory discourse is to see risk as a single absolute that can be identified, assessed and managed (and even accepted), in reality risk is linked to a host of other concepts including probability, danger, hazard, safety and vulnerability. Different risks may also have different time-horizons that can render the identify/assess/manage approach ineffective. We reflect more on all these things throughout the report and in the *Final Thoughts and Next Steps* section.

The political and policy context of genome editing

Our world café discussion took place against a volatile and rapidly changing political and policy backdrop.

It is widely held, for example, that the development of new genetic engineering techniques, known collectively as genome editing, have the potential to transform healthcare, medicines, conservation, livestock production, crop production and food processing. If so, major changes in economic structures, technology applications and production practices will follow, creating significant impacts on a wide range of societal relationships.

"To me it makes no difference whether it's ultraviolet light that makes the cut or whether it's a targeted nuclease that makes the cut. It's still the organism that is making the repair. It's repairing its DNA in the way that it normally would."

Inevitably therefore the technology is highly controversial with 'for' and 'against' lines being drawn much as they have been in the past decades over the older style GMOs.

However, although reminiscent of past battles, this controversy is different. In part this is because the technology itself is different to older style GMOs, at least in some key aspects. But it is also because, in the light of climate change and a growing population, it is easier to make a compelling case for wider and more direct societal benefits as opposed to narrow corporate interests.

Another aspect that has changed is the make-up of the opposing sides; some advocates and opponents have swapped sides and possibly crucially, there seems to be more acceptance of grey areas in between previously fixed positions, some of which were explored during this session.

The European Court of Justice ruling on genome editing

Genome editing is an umbrella term that covers the use of a variety of genetic engineering tools which can be used to manipulate DNA. CRISPR/Cas (short for clustered regularly interspaced short palindromic repeats) is the most well-known of these but others include TALENs (transcription activator-like effector nucleases) and ZFNs (zinc finger nuclease).

These new tools have been presented by many researchers, the industry, policy makers, politicians and sections of the media as being so different from 'old style' GMOs that their use should not fall under existing regulations. Some have gone further and argued that, at least some, genome editing processes are so similar to certain existing and unregulated plant breeding methods that they should be treated in the same, unregulated way.

This case is built on the fact that since the mid-20th century, conventional plant breeders have used a method called random mutagenesis (now often referred to as traditional mutagenesis) where seeds and other plant materials are treated with agents such as high-energy radiation or toxic chemicals to create genetic mutations. The resulting mutant plants are then selected for desired traits and new varieties are bred from these.

"I'm not necessarily sure we should assume that the best argument is to say if random mutagenesis is exempted then directed mutagenesis should be too. To me that's a big box to open and I wonder do two wrongs make a right?"

In the context of plant breeding, a type of genome editing known as targeted mutagenesis (or site directed mutagenesis) can alter one or more host genes of a living species, at predetermined location on the genome.

Targeted mutagenesis does not involve the insertion of foreign DNA (though in other applications of genome editing, foreign DNA, including a complete gene, can be inserted into the genome of a living organism). Instead it activates the cell's DNA repair mechanism and the mutant plants that arise from this repair are selected for their traits.

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.

It is argued by proponents of genetic engineering that SDN-1 and possibly SDN-2, are close to what could happen in nature. Governments in the US, Australia and Japan have partially accepted this argument and have deregulated SDN-1 techniques.

The counter argument is that there is rapidly mounting evidence that even a 'simple' cut and repair can produce the intended mutation at the target site (intended on-target effect), but also unintended mutations at the target site (unintended on-target effect) or at other locations (off-target effect).

In Europe the focus of the debate moved to the European Court of Justice (ECJ) in 2016. The Court was asked to consider the degree of similarity or difference in concept, mode and impact of random (traditional)

mutagenesis and modern targeted mutagenesis as presented by genome editing methods. Specifically, the ECJ was asked by the French Conseil d'Etat to clarify whether targeted mutagenesis, used in the genetic engineering of plants, falls within the scope of current European legislation on GMOs. In July 2018[3] the ECJ ruled that this was the case and therefore its use and the products of its use should be regulated as GMOs.

Furthermore, the Court affirmed that random mutagenesis is a form of genetic engineering, but that it was specifically exempt from the EU GMO regulations due a long enough record of safe use. It did acknowledge, however, that it could be regulated by Member States in accordance with overall EU law.

The judgement argues that newer techniques (many of which have yet to reach the marketplace) do not have a history of safe use and therefore, "*the risks linked to the use of those new techniques/methods of mutagenesis might prove to be similar to those which result from the production and release of a GMO through transgenesis*".

Elsewhere the judgement states "*the development of those new techniques/methods makes it possible to produce genetically modified varieties at a rate and in quantities quite unlike those resulting from the application of conventional methods of random mutagenesis.*"

Is ECJ ruling a turning point?

This ruling was, as expected, highly controversial and has been much criticised in many quarters and defended in many others. These very different views were reflected around the tables with some participants arguing that it was a "flawed judgement" since traditional and modern mutagenesis are essentially the same.

Other participants – and not just proponents of genome editing – pointed out that random mutagenesis has never been investigated or regulated for safety, and that this was an unacceptable grey area in plant breeding that merited greater scrutiny.

The ECJ ruling has certainly not ended the debate and disagreements. In fact, it has fired up more controversy. Although the ruling itself was not discussed in any detail during the session, it was a critical background influence as it represents the status quo around which all current thinking and perspectives swirl.

CONCEPTS AND BOUNDARIES

The sessions on concepts and boundaries in plant breeding led to some thoughtful discussions. It asked participants to step out of their comfort zones and consider the philosophical and values-based foundations of their work. It asked how well we understand each other when we use words like 'natural' and 'sustainable' and whether there are assumptions underpinning these concepts that would benefit from challenge and/or deeper exploration. It also sought to identify points of agreement and shared understanding.

There was general appreciation for the space and time to talk more discursively rather than focusing in on specific technologies and taking time to seek an understanding of 'where we are all coming from' was seen as helpful in clarifying why the conversation can go so badly wrong sometimes.

What sets the boundaries and limits in plant breeding?

There was recognition in all the groups that the boundaries to how we define 'plant breeding' were values-based, while also noting that values differ between social groups and change over time.

That said, there was a complete spectrum of views on how to define plant breeding, what qualified and what should be left out. At one end, several took a holistic viewpoint that plant breeding should relate only to breeding within a species, and should only be done by sexual reproduction. This would, however, still allow some laboratory techniques, such as marker assisted breeding.

This definition of plant breeding proved to be fairly challenging for some, as it was perceived as more limiting than even current plant breeding practices and would restrict the diversity of plant varieties produced. In particular, there was concern about the exclusion of some lab-based techniques from this definition, such as mutation breeding, embryo rescue, haploid doubling and also wide crosses, e.g. between wheat and rye, which produce triticale, a crop widely used on conventional and organic farms. (See the related discussion on the purpose of plant breeding in the *Resilient Plant Breeding* section).

At the other end of the spectrum, others felt there should be no boundaries to what is defined as 'plant breeding', although there was a need for transparency about the methods used.

There was discussion over whether the boundaries for plant breeding should be defined by the technology (process) or the outcome (product). Some felt that that technology *per se* was neutral, and the outcome was critical in defining limits, whilst others felt the process was the defining factor. (This was also explored in *The Question of Risk* discussion).

"I find the term 'new plant breeding techniques' (NPBT) which includes GMOs and gene-editing as well as mutation breeding, particularly misleading and problematic. This is not plant breeding as we learn the term in school. It's not just confusing for me but MEPs and academics also think that NPBT just means hybridised plants. I'm not talking about limits here; my problem is with the terminology. They are not plant breeding but something else and they should have a different name."

While the notion of boundaries proved more conceptual, the discussion around limits proved more concrete. Throughout the discussions, it became clear that existing limits on plant breeding, and calls to place further ones, particularly in the use of biotechnology, cannot simplistically be attributed to onerous regulation or 'activists' standing in the way of innovation – as it is sometimes portrayed. Limits can be, and are, set by multiple intrinsic and extrinsic factors.

In recent decades, several factors have played a part in placing limits on plant breeding and especially biotechnological plant breeding. Those identified during the day included:

- **Differing values and worldviews** – e.g. whether a scientist or regulator takes a systems-based approach to problem-solving or a more linear approach.

- **Regulation** – although that may also include the difficulty of keeping up with the speed of technological advances.

- **Environmental concerns** – e.g. climate change as a driver for new plant varieties or making other varieties redundant, and recognition of the need for biodiversity in opposition to genetically modified or other monocultures, and precaution over invasive species.

- **Biological limits** –e.g. harm to non-target organisms or loss of plant diversity; often these only become apparent slowly and over time.

- **Ethical factors** – e.g. perceived naturalness, heritability and therefore control and contamination of non-GE crops (especially with gene drives or RNAi sprays); consumer choice and therefore the need for information and labelling of food products.

- **Power concentration and monopolisation within industry** – keeps ownership of technology in the hands of a relative few; limits the number of decision-makers defining the future direction of technological development.

- **Economic factors** – including reasonable return on investment.

- **Time** – not just for R&D but for risk assessment and proof of benefits.

- **Public acceptance** – e.g. public distrust as a limit to potential markets.

- **The presence of viable non-tech or low-tech alternatives** – if something else works as well or better, then why use genome-editing?

Limits can also be self-imposed. The example of organic plant breeding is a case in point. The notion of the integrity of the organism is an important ethical starting point for organic breeders and one that precludes the use of breeding technologies (for plants and animals) that intervene directly at the cell level. Organic breeders accept this when it comes to decisions around integrating biotechnologies into their programmes.

Some participants also felt there is a wide difference between the things that actually limit us, the things that should limit us and the things that, arguably, shouldn't limit us. It was argued that we need to be clear which of these we are addressing and avoid conflation.

The notion of limits for some provoked anxiety over a potential loss, for instance of economic or environmental benefits. There was also anxiety expressed about setting the limit in an arbitrary or 'wrong' place with unknown or unpredictable future consequences. Yet it was also noted that with other types of high tech innovations (artificial intelligence, driverless cars, smokeless cigarettes) limits are accepted as a necessary and rational part of the package.

While limitations can shift, change and even disappear over time, participants recognised that we can only ever work with where we are now. In addition, it was noted that the idea of limits should not necessarily be

perceived as limiting innovation. Limits, worked with consciously, can provide a clear starting point and open up space and drive for innovative thinking, research, development and practice.

Is precaution a boundary or a limit?

There was general agreement that safety and potential risk to humans and the environment could legitimately set limits on plant breeding. However, there were differences in how concepts of 'safety' and 'risk' were viewed. Some considered risk assessment to have clear and precise definition, whilst others considered it to be a value-laden and contested field.

Much of this debate centred on the Precautionary Principle, which provides a pathway for regulators to take action the face of a possible threat to health or the environment, particularly where scientific data is not able to provide a complete evaluation of the risk. This principle is a fundamental of European environmental law including regulations around environment, human, animal and plant health. It is, therefore, directly relevant to the regulation of genetically modified organisms.

The Precautionary Principle, which can be applied to a phenomenon, product or process, is not a risk analysis tool but can be invoked as part of a formal decision-making process. It acknowledges that we don't know everything and provides guidance for assessment in the face of scientific uncertainty, ambiguity or ignorance.

> **"What does safe mean? Safe for human consumption? Safe for animal feed? Safe for the environment? Safe for the farmer's health? Safe for future generations i.e. that it doesn't irreparably harm the soil and other plant varieties?"**

The European Commission's approach to the Precautionary Principle[4], which was laid down in 2000 and has not changed since then, says that "*the precautionary principle is neither a politicisation of science or the acceptance of zero-risk but that it provides a basis for action when science is unable to give a clear answer*."

Participants discussed the relevance of this widely-known, but also widely debated, principle to setting limits and boundaries to plant breeding.

Some identified it as limiting to both research and various fields of application because, they argued, it is a values-based notion, and therefore an unreliable basis on which to judge risk. Others felt there was an ethical justification to precaution when it came to genome editing and that, far from being derogatory, the values-base of the Precautionary Principle provided a constructive added dimension to the standard risk assessment approach.

This was not convincing to those who were concerned at the way the application or perceived application of the Precautionary Principle placed limits on plant breeding. They took the view that it was not possible to say that a technology, such as genome editing, was inherently 'unsafe' because advances in DNA sequencing are leading to a more detailed understanding of the changes induced by gene editing and thus facilitating more effective safety assessment.

But several felt that even though the science had advanced, genetic engineering and genome editing are still 'young sciences' where there is a lack of knowledge of how to identify the risks. Because of this the products of these technologies should not be considered safe until the science is more mature.

In truth neither view is incompatible with the Precautionary Principle or the EU's stated approach to its application, which provides that: "*Measures should be periodically reviewed in the light of scientific progress, and amended as necessary.*"[5]

'Nature' and 'natural' as loaded terms

All those present recognised that the terms 'nature' and 'natural' have a range of meanings to different people in different contexts including consumers, regulators, organic farmers and conventional breeders.

For this reason, many (including those on different 'sides') considered the discussion around nature and 'what is natural?' to be frustrating or unhelpful. It was widely agreed that what we understand as agriculture is not natural but rather the result of a long series of interventions in natural processes by humankind. That said, since the term is pivotal to the EU's legal definition of a GMO, it is highly significant even if there is no consensus about its clarity as a concept: "*an organism…in which the genetic material has been altered in a way that does not occur naturally by mating and/or natural recombination*".[6]

Some suggested that the debate over GMOs has energised the question over the definition of natural and where the boundary to plant breeding is:

"*If the word 'natural' is going to occur in a policy context then we need to explain it but we don't need to define it. We can take the plurality of understandings – this is what nature and natural is – without locking it in to a definition*."

In order to help deepen the understanding of differing worldviews in this discussion, our moderator introduced an idea, which evolved out of early research the Dutch government conducted on the ethics of biotechnology[7]. It proposed four "worldviews" based on different notional relationships between humans and nature, and thus also plant breeding:

- **humans as rulers over nature** (nature has been given to humans to use).
- **humans as stewards of nature** (humans can use nature's resources but without compromising future generations' use of resources).
- **humans as partners of nature** (humans can use nature's resources but nature has an intrinsic value).
- **humans as participants in nature** (eco-centric position).

It was not clear, however, whether all those on the table found this framing useful or clear cut. For example, with greater analysis it is clear that these roles are not mutually exclusive and may also share similar goals.

The example was given of a steward who takes the position that patents are wrong, not because they are intrinsically wrong (as would be the 'human as partner' or 'human as participant' stance) but because they block innovation and don't achieve what they are supposed to. In this theory of worldviews, the steward's concerns are framed as functional rather than ethical and yet the overall goal is compatible with that of the partner or participant whose concerns are framed as ethical.

It is also not a given that certain individuals or sectors align precisely with only one view. In the organic sector, for example, there is concern for agro-biodiversity (a partner/participant view) but also for future generations (a stewardship view). Similarly, plant breeders using genetic engineering might have a ruler perspective but equally may also come more from a stewardship perspective.

"I am trying to find out, where do people come from? Which concepts do they think and speak of? My take-home message here is that I want to continue on this line of rulers, stewards, partners and participants because it explains a hell of a lot about the inability of all of us to come to a clear conclusion or even to talk to each other."

It's fair to say that the mental gymnastics of this concept are not a normal part of the day-to-day plant breeding discussion and they were not easy for everyone to grasp. But some found them enlightening.

Does imitating nature equal natural?

From a scientific perspective, plant breeding may not be natural but, on the other hand, agriculture and plant breeding are closely linked to natural practices – learning from nature or manipulating it to produce something of benefit to humans. Cultivated plants also interact with nature and natural cycles.

> "The plants that we grow for our food would never survive in nature. They would all die."

There was a spectrum of views expressed. From one perspective, all human activity, including gene-editing plants is 'natural', thus the discussion on whether plant breeding itself was 'natural' was irrelevant.

Similarly, another participant said: "*In agriculture, by definition, we are not dealing with nature but 'culture'. It is agri 'culture' – that is man-made. Nothing that we eat from this earth is natural*."

There were differences in opinions on the extent to which mutational breeding (using chemicals or radiation to induce mutations in plants), and ultimately genome editing, are simply the result of observing and learning from nature, and therefore part of the natural continuum.

Some felt that what we consider natural or unnatural – and thus acceptable or unacceptable – is a purely human construct. This may well be so but, as one participant pointed out, "*this does not mean that the term is not useful in terms of guiding human actions and thinking around boundaries and limits*".

Other participants expressed concern that the GMO debate had resulted in scientists being accused of creating 'unnatural food', without acknowledging that lab-based plant breeding has almost a 100-year history and has provided many of the varieties commonly used in agriculture and horticulture.

The difficulties around the concept of 'natural' in plant breeding is exemplified by the relationship between wild brassica and cauliflower – the question being whether a modern cauliflower is still 'natural', and whether that even mattered. While some felt it is, the majority of participants felt that as it has been bred solely for human consumption and is now so different in characteristics from a wild brassica that it cannot be considered 'natural'.

> "With the cauliflower, breeders have used a natural wild plant as raw material to create a mutant that is deformed in every aspect, just so that we have something to eat. From a plant perspective, it's a very poor plant. Left on its own in the wild it would die out. This is a prime example of where we have used nature to produce something. It may be naturally produced but it's still unnatural."

'Natural' as an important value for consumers

Most participants felt the term 'natural' was important primarily because it has become widely used in food marketing where it is often equated with organic foods although it is widely used in promoting conventionally grown products too. A 'natural' label or imagery can also significantly increase trust in and therefore the value of a product as well as imply food safety.

It was noted, however, that the term 'natural' is sometimes used in misleading ways.

For example, a flavouring produced using micro-organisms and synthetic biology is described as 'natural vanillin' to distinguish it from chemically-produced vanillin. This may be technically valid, but it implies that it is derived from a plant, which it is not.

"The term 'natural' not only conveys safety for consumers, it has a longing in it – a longing for something that is whole, authentic and wholesome. Something that says 'it's all right'."

It was also pointed out that organic plant breeders try to avoid the term 'natural' except when referring to natural cycles, preferring the terms 'whole' and 'whole organisms'.

Although 'whole' and 'natural' have different meanings, nonetheless in common parlance they have, to a significant degree, become synonymous.

Consumer acceptance was acknowledged as a significant limit to some plant breeding strategies. For example, some participants thought the public debate on GMOs in the late 1990s/early 2000s was detrimental to consumer acceptance of GMOs resulting in restrictions and even bans on the cultivation of these crops in some EU countries. This led to a wider discussion on how to communicate the complexities of plant breeding to a lay public. See the *Citizen Engagement* section for more discussion.

Nevertheless, it was recognised that many members of the public have a perception of, and desire to eat, 'natural' food and consider GMO ingredients to be 'unnatural'. However, because perception of 'natural' varies from person to person, it can be difficult to know how to incorporate it into the wider debate on genome-edited foods.

Do plants have 'integrity'?

Another way of looking at the concept of natural is from the perspective of plant integrity. The notion that plants have integrity and dignity is an important ethical concept for the organic movement and for many indigenous peoples around the world and is consistent with concepts such as whole and 'whole organisms'.

It was noted also that the notion of integrity was central to the discussion around human genome editing and has also emerged in relation to farm animal genome editing, but it is usually ignored or dismissed when it came to plants. Some argued that because we had been altering plant genomes for so long in order solely to serve human purposes that plant integrity no longer seems to be an ethical issue in our society whereas it remains important to many indigenous peoples.

One participant proposed that the concept of the integrity of plants should be divided into:

- **Genotypic integrity** The integrity that is shared among all plants. Genotypic integrity means not overcoming natural crossing barriers in plant breeding;

- **Phenotypic integrity** Plant breeders produce a large diversity of offspring. Phenotypic integrity entails not selecting a plant during breeding that e.g. potentially has a high yield but requires chemical support to achieve that yield. This stresses the importance of balanced crop growth and is consistent with organic farming principles.

The concept of plant integrity was challenging for many participants. Although the discussion was respectful of differences, there was a significant gulf between worldviews and beliefs about where humans and human ingenuity fits into the 'grander scheme of things'.

'People consider 'natural' as a morally important concept when it comes to food, without even having to define what it means. Even if it hasn't got a precise meaning, we can't exclude that fact.'

There was no general agreement on the notion of plant integrity – except in recognising that individual beliefs were

founded in differing values and worldviews. There was agreement, however, that a practical way forward that recognised both approaches was becoming necessary, both in agriculture and the wider ecosystem.

Are sustainability and biodiversity inherently limiting?

Like the term 'natural', 'sustainability' has different meanings in different contexts. However, it was repeatedly stressed throughout the day that "the goal was sustainability". Everyone professed this to be their overarching aim, whether they promoted organic agriculture or genetic engineering or something in between.

> "Plant diversity depends on breeder diversity."

Questions – but few answers – arose regarding how corporate sustainability agendas might affect plant breeding. For example, whether the requirement to reduce a company's carbon footprint might pose a limit to plant breeding. Would it define research agendas, leading researchers to focus on developing plants that absorbed carbon more quickly? How should the carbon footprint of plant breeding be accounted for, including the transportation of seeds and other products, machinery and greenhouses?

The discussion on biodiversity focused, in part, on concerns regarding genetically engineered varieties contaminating biodiversity, particularly landraces in centres of origin and diversity. Several participants raised concerns regarding GM contamination of organic farming systems, particularly where neighbouring farms were cultivating GM varieties.

On the other hand, fears were expressed that limitations – either regulatory or economic – placed on the use of genome editing techniques would thwart the incorporation of traits found in wild crops and, ultimately, limit the diversity of traits available for all breeders. This so-called 'rewilding' approach is seen by some as a way of enhancing biodiversity and therefore sustainability.

Corporate and regulatory limits to breeding

Some participants argued that the current limits to plant breeding are predominantly set by large private sector companies since the most concrete limit is the cost of developing new technologies. Larger companies have the legal and financial capacity to engage with regulatory processes that set limits on plant breeding. As such, it was felt that both legislation and market forces posed a danger to the survival of small breeding companies.

This concern is shared across the plant breeding sector although, the relative cheapness and accessibility of genome editing is seen by some as a potential benefit to small breeding companies serving niche markets, if accompanied by "light touch" regulation.

> "How do we get a diversity of breeders to co-exist? We need to keep the markets open. There is a tremendous diversity in farmers' needs, farming systems, diversity in varieties that are needed, niche markets, seed supply systems that are needed."

Another related limit to plant breeding is access to germplasm. Concentration in the sector has resulted in seeds and germplasm being increasingly controlled by a few large companies and, in some cases, by national governments, as is the case in China.

Most participants expressed concern that this could restrict access to these plant breeding resources, although many thought it was possible to design a regulatory framework to solve the problem.

A number of participants also raised concerns regarding the close relationship of some large companies with universities and how these can both direct and limit the scope of plant breeding research.

This led to debate on whether public sector breeding programmes were preferable over private sector. There was agreement that public sector breeding could be more consumer oriented, less profit motivated and more participatory and responsive to farmer needs.

That said, public sector breeding programmes could also be shaped by the aspirations of national governments that may not support such an approach, or in partnership with the private sector, blurring the boundaries of public and private sector plant breeding.

In general, it was agreed that a diversity of plant breeders, large and small is necessary since they catered for different markets. Small breeding companies, for example, are essential for niche markets.

Are patents and breeders' rights barriers to sustainability and biodiversity?

There was a clear consensus that the work of plant breeders had to be recompensed in some way and that this constituted a "right". That is not to say there was agreement on whether such rights actually function as a limit or a spur to innovation, either in the form of traditional breeders' rights/royalty payments or as patents.

Some participants regarded patents on plant material as necessary, given the costs of producing new plant varieties, and considered patents gave them a market advantage over other companies working on similar products.

> "Who do you trust? Is the real issue the label or is the real issue the distance between the crop and the consumer - the system, the chain, if you like, between those two things?"

However, others felt that the patent system pushed development down certain pathways at the expense of others, and that it limited access to plant material, hindering or slowing plant breeding efforts. There was a feeling that the difference in regulatory systems for patents in the USA and Europe are a limit to plant breeding since certain patents in the USA may not apply in Europe.

The predominant view is that markets and commercial roll-out structures are greater limits and spurs since they determine where the resources are focused. Although there is an interaction, it is these that determine the extent of diversity and sustainability rather than rights and patents *per se*.

Mixed views were expressed about 'open access' systems and how they might develop. One suggestion was that establishing 'values chains' (a common concept in biodynamic agriculture, which encompasses non-economic values and goals) rather than 'value chains' (which are purely economic), and describing, labelling and promoting these would facilitate greater community and consumer engagement in plant breeding in general and in specific approaches and characteristics.

Although not explicitly discussed as a limiting factor, both those who used genome editing and those who used organic breeding methods expressed the idea that their method suffered from lack of consumer trust and uptake. A 'values chain' approach, it was thought by some, might help overcome this.

The complexities of this issue were acknowledged by all but there was not enough time to explore them in any depth, though the issue of privatisation of public sector research is discussed further in the *Resilient Plant Breeding* section.

THE QUESTION OF RISK

The default discussion about genetic engineering in food and farming is always about risk – how to identify it, how to assess it, how to manage it and whether or not we accept it.

While most participants believed that an over-focus on risk was unhelpful, their reasons for this varied considerably. Some felt newer genome editing techniques in particular posed no extra risk above and beyond conventional plant breeding. Others felt that the risk discussion was too focussed on the process of genome editing itself and not enough on the end product. Still others felt that the regulatory focus on health and environment overshadowed other legitimate concerns such as economic, societal and cultural risks.

There was also a strong strand of feeling that any consideration of potential risk had to be balanced by a consideration of potential benefit. In addition, there was a view that this consideration is not a matter of absolutes and that context must also be considered.

Looking at the bigger picture of risks linked to food and farming, some argued that plant breeding in general, and genome editing in particular, is only a relatively small part. It was argued that the evidence suggests the risks related to food and farming are primarily linked to how food is farmed and, in particular, the dominant industrial model rather than how a plant is bred.

If this is the case, the question was posed, does a faulty food and farming system absolve plant breeders of a responsibility for risk assessment and, by the same token, remove any justification for arguing the case of putative benefits? Or should plant breeders nevertheless be encouraged to claim their place as responsible actors in this bigger picture?

"We are focussing on the process side because many of us think that there might be more to be investigating as to the boundary there between the conventional techniques and GM techniques."

In the *Concepts and Boundaries* discussion there was a general shared understanding that safety and potential risk were among the essential elements that define the boundaries of plant breeding.

There was also general agreement that regulation, either at government level or through third party certifiers such as the organic movement, can be seen as a way of formalising concerns around safety and risk into policy. This discussion was an invitation to explore more deeply not just the concept of risk but how notions of 'risk' and 'safety' might effectively be approached in the regulatory sphere.

In this context, there was a wide range of opinion, with some minimal consensus. For example, some considered risk assessment to have clear and precise definitions, while to others it is too heavily value-laden and therefore open to interpretation.

A view expressed both here and in the session on *Concepts and Boundaries*, is that genetic engineering and genome editing are relatively new advances and we do not know enough about them to identify accurately or predict what is risky and what is safe. For this reason, the Precautionary Principle, which gives regulators a mandate to act even in the face of uncertain risks, is seen by some as crucial. Others believed it to be both vague and restrictive.

Many participants expressed the view that the world is full of risks. There was frustration that individuals seem all too willing to take risks with other aspects of their lives, including with other forms of technology –

mobile phones and 5G technology were oft-quoted examples – but seem less willing to take risks when it comes to food. Does that mean that these other technologies have a higher or lower personal value than the food they eat? The answers suggested a difference between the citizen and consumer, which is discussed in the *Citizen Engagement* section.

There was a feeling amongst many participants that the discussion around risk was unproductive. This raises the question: what would make it more productive?

Is the risk/benefit equation too binary and too inclined to frame specific issues or challenges in food and farming as isolated from the wider system? Would a consideration of what an equitable approach to risk looks like give more scope to include societal values? On the other hand, several argued that risk assessment should focus only on the likelihood of health and environmental harm; taking the view that anything further clouds the issue.

> "For me this focus on health and environmental risks is too narrow. It's not the whole picture. There may be other risks such as social or economic. How do we talk about those?"

The agricultural sector is subject to many different types of challenges and risks; added to those faced by most businesses there are also the risks associated with working in a deeply interconnected system, working with organic and living material, such as seeds, livestock and fresh produce and their biological processes.

An efficient and effective approach to risk management in agriculture should take into account the interactions and trade-offs between different risks, on-farm strategies and government policies. Over emphasis of one aspect – whether it be technological innovation or open pollinated seeds, neither of which is appropriate in every circumstance – can lead to unsustainable practices.

There was some measure of agreement that there is a need for the agricultural sector as a whole to become more resilient and consequently a more holistic approach to risk is needed. While the concept of risk versus benefit proved provocative, the need for resilience was a concept most could get behind. What was left unresolved at this table particularly with regards to where to draw 'clear red lines' did, however, provide a foundation for, and find some resolution in, the *Resilient Plant Breeding* discussion.

Where to draw the line?

The discussion around how risk perception impacts regulation was a source of real tension around all the tables. Significantly, given the current political and policy debate, no-one at this meeting felt that genome-edited foods should not be regulated in some way. However, several felt the current regulations unfairly penalised the products of genetic engineering and that, in particular, European 'process-based' regulation, where the process as well as the end product is regulated, is flawed.

Instead a product-based system, which focuses solely on the end product, was thought to be more appropriate. In such a system an apple would be an apple, no matter how it was bred.

This is a key question and appears to be a pivotal demarcation line between supporters and opponents of GM technology. Are the risks primarily linked to the technology or to the products of that technology? Or is it a mixture of both? There was no resolution to that question in this meeting. There were hints, however, that the line could be less solid than it sometimes appears.

For some, genome editing belongs to a suite of so-called disruptive technologies (such as artificial Intelligence and driverless cars) where apparently 'limitless' applications are making democratic control and oversight

difficult, and pushing a vision of the world that few citizens understand and may not want.

In food and farming, for instance, genome editing in plants and animals is now being proposed for a variety of uses including:

- Conservation and rewilding.
- New areas of environmental enrichment such as bioengineered soil microbes and biological pest control.
- Gene drives, which can spread traits through entire wild populations in the field.
- RNAi sprays, also used in the field, which can shut off certain traits in plants without altering their DNA.
- Genome-edited farm animals.
- Factory produced foods via synthetic biology and so-called 'precision fermentation'.

It is not clear if or when such future technologies might become realities, but because the regulation of risk involves some level of speculation, they loom over the discussion of whether, where and how we draw any 'clear red lines' around genome editing in food production.

Other participants, while recognising the potentially disruptive power of genome editing in food and farming, felt – in the case of plant breeding – that its use within the existing framework of trials and selection would ensure a positive balance of benefit versus risk.

As shown above, the discussions acknowledged that the concept of risk is often subjective, which makes discussions difficult and sometimes unproductive. It was also acknowledged that as science and technology develop some risks dissipate (although new ones can emerge) and this, too, makes drawing of conclusions and 'clear red lines' difficult.

Risk identification, risk analysis, risk management – and risk acceptance

Regulators may strive for ever-more simplicity and a one-size-fits all approach to risk, however, the identification, assessment and management of risk can look very different in different spheres of life. Thus, in health, environment and social care, risk may be different than it is in in law, business, politics, sports or even personal relationships.

The emergence of so-called disruptive technologies in food and farming has added another layer of complexity to the risk discussion. It is widely agreed that disruptive technologies, which cut across several regulatory areas, require a careful approach.

Genome editing, of course, is a spectrum of technologies. At one end, arguably, it is not all that disruptive. But at the other extreme, where synthetic biology or gene drives are predicted to diminish or replace the role of farmers – and therefore traditional breeders – its impact is likely to be huge and discussions around risk are only just beginning.

Given this complexity, the question was posed: How far should scientists and regulators go to ensure the least possible risk? This

"Once a gene edit is called a GMO then the regulatory framework means the marketplace doesn't exist. I think that's why there is a drive to separate genome editing technology from GMOs and not get bogged down again with the baggage of fear and regulations."

raised several discussions around the identification, assessment, management and acceptance of risk.

This exchange was typical of discussions during the day: "*At the moment GMO is very high on the public radar and so everybody has an opinion on that and it is in any case very difficult to come to a common understanding of risk. But maybe in 10 years' time when it's not so much on the public radar, everybody will be much more relaxed and tolerant about risks. Because there are so many high-risk technologies we use every day, but they're not in the public focus.*"

To which the response was: "*Yes, but by then the risks may actually have happened. That's why we've got the Precautionary Principle, which is not so much about the probability of risk but more about the severity of risks, meaning that if some of the risks are irreparable, legislators are not supposed to let this happen. That makes it mandatory for the legislators to ensure a thorough risk analysis before we put a technology on the market.*"

Breeders supportive of the use of genome editing argued that they did not warrant regulatory intervention since the risk of off-target effects could be managed within the breeding and selection process by back-crossing until those effects disappear. Others felt the management of risks could not simply be left *ad hoc* to breeders and that regulatory intervention was warranted.

Still others felt that risk analysis made no sense unless there was a corresponding benefits analysis. The point was made, however, that the benefits of genome editing are too often discussed in terms of potential rather than actual benefit and that there is no requirement of proof of benefit necessary for regulatory approval.

"I think plant breeding, the way the world is today, is demanding bigger creativeness than just 'fixing' things."

One participant argued: "*I don't see it's acceptable to take any risk unless there's a corresponding benefit. So, if the plant is a soybean with blue leaves just for the fun of it, then you can't take any risks to get to that point. But if you have a crop that requires half the nitrogen inputs, for the same yield and maintains good soil structure then maybe you can argue for taking a small risk to get to that point.*"

Bringing benefit into the analysis of risk, however, means a higher level of regulatory oversight, which many felt was counterproductive. The question was also raised of who decides what a meaningful benefit is and whether genome editing was the only way to, for example, create a plant that uses less nitrogen and maintains soil structure. Conventional breeders felt that this is not the case, and that conventional breeding could – and did – produce plants with these qualities.

Here, as at the *Concepts and Boundaries* table, some felt that the increasing complexity of regulations worked in favour of large corporate monopolies that had the resources to deal with them and to "work the system". From this perspective some argued that heavy regulation could be seen as a societal risk because it creates a nexus of diversity loss in business, in plant breeding facilities and in the supply chain ecosystem.

In addition, like risk, the analysis of benefits is not always clear cut. For example, in cases where there is an economic benefit, but less benefit or even a negative impact on the environment or the farmer, corporate monopolies might have both the resources and the motivation to downplay or ignore that risk. Interestingly, no one questioned whether a 'benefit' was the only or best counterbalance to risk. If a genuine risk is identified, for instance, do potential benefits matter?

Perspectives on consistency of regulation

There was also discussion around what some saw as the inconsistencies in the European approach to risk. On the one hand, the EU allows the import of GM animal feed and GM foods for human consumption after a

safety assessment by the European Food Safety Authority (EFSA), as long as they are labelled. In such cases EFSA, some argued, have found no health risk to consuming these foods. Several varieties of GM crops have also been approved in the EU but planting of these crops and commercialisation of additional GM foods has stalled.

This, some felt, was because even though Member States might have 'signed off' on the approval process, they are also mindful of a range of citizen concerns. These include the cultivation of currently approved genetically engineered plants, and specifically the risk posed by their associated pesticides. It also includes concern that such technologies encourage large monocultures that not only pose a risk to biodiversity but also to the dietary diversity that humans require to be healthy.

"Who decides what sustainability is? Risk-benefit analysis is all about weighing the risk against the benefit which is, of course, a political decision. The problem with your criteria – ethics, ecology, economy, society, good governance – is that they are all tradeable."

Although some saw risk assessment as a scientific methodology, others expressed general concerns with the concept, asking: who is taking the risk and who is benefiting from putting the risk out there? If risk management is about trade-offs between risk and benefit, who defines risk and benefit and on what basis? Who decides what is tradeable in society?

All this moved one participant to describe the current EU regulatory framework as "*an ill-sorted combination of more or less 'scientific' risk assessment along with justifiable socio-political, policy and cultural perspectives*."

Who – or what – should determine 'acceptable risk'?

Without defining or describing the term, it was stated that risk assessment is generally "science-based" and narrowly focussed on health and environment. A significant number of participants agreed that consideration of other types of risk – societal, economic, cultural – should also inform the discussion on genome editing and that excluding these concerns from risk analysis reduces its credibility and legitimacy in the eyes of the public.

That said, government advisers tend to be specialists in a narrow field of genetics and therefore may not be sufficiently cognisant and/or credible representatives for wider concerns about social, economic or cultural risks. Bringing these concerns to the fore thus requires input from a wider group of stakeholders, especially citizen stakeholders.

It was acknowledged, however, that involving larger groups of stakeholders in the identification and assessment of risk was not without its challenges and some even felt it complicated the issue. See also the *Citizen Engagement* section.

Paradoxically, as noted in the European Environment Agency (EEA) report[8] *Late Lessons from Early Warnings*, the inclusion of 'non-scientific' factors does not necessarily make risk analysis less scientific. On the contrary, it can make the science more sound by giving it a firmer foundation in real world concerns and conditions. The EEA report also noted that another benefit of lay knowledge is "*independence from the narrow professional perspectives that can be a downside of specialist expertise*".

"If a new tech can be used to solve big problems – is it ethical NOT to allow it. There should be very good arguments against usage."

Organic advocates added that GM crops are not permitted in organic farming systems and, whilst this is a limitation, it was felt that it nevertheless stimulated innovation – including around biodiversity – in the organic sector. But some participants argued that there is no logical reason why agricultural diversity and technology should compete with each other – including in the organic sector. As a wider point, the group was

also asked to consider what the risk for agriculture is if we fail to develop, by whatever means, sustainable varieties of, for example, staple crops such as perennial grains in the face of climate change.

Should the concept of risk be rooted in politics, science, ethics or economy?

What does an equitable approach to risk look like? It was generally accepted that the discussion of risks posed by genome editing needs to happen in a much broader and more substantial space than the narrow 'high tech-low tech-no tech' echo chamber in which it currently takes place.

> "Basically farmers – organic as well as conventional – are thinking in an economic way and if they see a good variety which serves their economic success they use it and this has nothing to do with the breeding methods."

Some, spanning both sides of the technology divide, argued it should be discussed within the bigger question of what kind of farming system we want and need and what tools will help us realise that goal.

It was generally agreed that the dominant farming system was not working on several levels and that a change toward a more sustainable, fair, ethical system was needed. But even here the language was tricky. People's concepts of sustainability and fairness, and of what constitutes a reasonable, ethical pathway to sustainability varied a great deal.

There is no doubt that, currently, politics, policy and economic drivers have the greatest influence on the future direction of farming and therefore agricultural plant breeding. Many European governments believe that investment in innovation is crucial to making farming more sustainable. But there was concern around the table that innovation, like risk, can be too narrowly defined.

Investment in technological innovation usually greatly outpaces, for example, investment in organic breeding programmes. Many of the true costs of the current farming system are externalised, making the system appear more cost effective, efficient and sustainable than it actually is. A dispassionate assessment of risk needs to take these kinds of economics into account.

> "Maybe there could never be an economic argument that could outweigh sustainability principles."

It was also said, although not completely accepted by everyone, that the mantle of innovation rests largely in the private sector. This sector, therefore, exerts an overly large influence on the direction of travel for food and farming. Placing more responsibility for innovation into the public sector, with a mandate to focus on public goods rather than private profit, some believed, might produce an entirely different kind of farming.

Others felt that this solution was too simplistic. Plant breeders are influenced by their customers' (i.e. farmers and growers) wishes in both the public and private sector. Farmers and growers, in turn, are influenced by their own customers and this is generally expressed through the marketplace. That said, it could be possible to create a civil society forum for 'non-market aspirations' that could then influence the direction of public sector-based plant breeding.

Thus, while it is fashionable to believe that change must begin from the ground up, in the case of designing a new and truly sustainable agricultural sector that is not trumped by economic factors, top down change is also needed. Politicians and policymakers have a crucial role and some participants argued a responsibility, to assess all the evidence – scientific, economic, ethical, societal and cultural – in creating a vision for a sustainable agricultural sector and a plant breeding system appropriate to it.

RESILIENT PLANT BREEDING

In a rapidly changing world highly vulnerable to climate change and other environmental threats, how can plant breeding, as a discipline and as a structured R&D and marketing system, build resilience? Can it, and if so, do the new genetic engineering techniques have a role to play?

The discussion around resilient plant breeding was very wide ranging and produced some notable areas of agreement even amongst those from different specialities and with seemingly opposing points of view.

It was agreed that while there is a lot of information on potential applications of genome editing in agriculture, much of the research is still at an early (laboratory) stage and does not yet reflect the reality of the breeding process in the field. There was unanimous agreement that genome editing has been over-hyped in public communications and in efforts to attract funding. Participants from the organic plant breeding sector, however, acknowledged that they also hype organic breeding methods in order to obtain funding.

There was general concern that the over-focus on technological solutions to address problems of hunger is based on narrow and sloppy analysis, for instance, focussing on higher yield as the solution to hunger and not placing hunger in the wider context of socio-political, agricultural and management systems.

> "The private sector model by its nature, does not develop resilience. The whole model is based on short-term gains. It's about how much seed you sell. That is not to say that it doesn't contribute to resilience."

Several participants emphasised that resilience could be achieved by breeding for broader genetic diversity, rather than resistance to a single, specific disease. Although it was generally agreed that genome editing is not a magic bullet, several considered it to be a useful tool in the plant breeding 'toolbox', although this also depends on the overall goals of breeding and the agricultural system. In this respect resilience is, for some, a more important focus than risk.

It was agreed that the decline of public interest and public owned plant breeding institutions is regrettable. Some participants felt that in some cases the private sector has led plant breeding technology in an inappropriate direction, particularly with regard to the focus on the tolerance of crops to specific proprietary pesticides as well as in the search for increasingly higher yields. In the case of yield increases, however, it was acknowledged that this was not solely driven by the private sector.

Some participants felt that respectful disagreement between plant breeders had been hindered by intense lobbying from both the pro- and anti-GM movements in the past and this is now being repeated with genome editing and by unequal representation at public events.

Organic plant breeders expressed concern that, without proper regulation and transparency around genome-edited crops, their livelihood and the whole organic system could be compromised.

Finally, all participants agreed that it is important to improve public communication around plant breeding. There was agreement that there is a lack of public understanding that has led to confusion and mistrust around food and plant breeding in general.

Beyond Green Revolution thinking

There was some consensus that 'green revolution' thinking, which has led to the near exclusive focus on yield and thus a handful of high yielding crops, as well as on intensive crop production systems, has not worked. Under this system, higher-yielding cereals have displaced pulses and other lower-yielding crops such as

landrace varieties. Farm mechanisation has displaced labour. The use of toxic chemicals in agriculture has also increased exponentially. Thus, in many respects, the singular focus on yield presents its own set of risks to agriculture – even though it is rarely spoken about in those terms.

Seen in the context of the politics, beliefs and practices of its time, the Green Revolution, had a coherence and logic which, although narrow and partial, was generally accepted. However, most of our participants now believe such thinking to be a relic of a bygone age.

But this prompts the question: what kind of farming do we want now and what role will plant breeders have in realising that vision?

This session asked, in the broadest terms, whether the concept of 'resilience' was a better goal than yield. It is, of course, important to 'feed the world' but feeding a growing population is not a single-dimensional problem. Future crop production will need to meet several targets including food security, safety and quality; food and seed sovereignty; social justice; agro-biodiversity; ecosystem services; and climate robustness.

Participants accepted that no single approach will get the job done. In the broadest sense there was a belief that a plurality of approaches is needed. This was not, as might be expected, the exclusive view of those who advocated for genome editing. Most of those attending accepted that this is the case – and that proponents of all approaches had the potential to learn something from each other.

This sharing of knowledge between those employing different methods has all but disappeared from plant breeding, and yet if biodiversity is the goal, it may be time to resurrect this practice.

These tentative beginnings allowed more in-depth discussion of other key questions such as:

- Are expectations of genome editing realistic – e.g. are we expecting plant and animal breeding to solve problems beyond their remit?
- How do we foster respectful disagreement on the practice and potential of genome editing?
- Does the private sector involvement in plant breeding contribute to resilience?

The purpose of plant breeding

The question arose about whether the expectations placed on genome editing are realistic and whether it could ever live up to the 'hype' around its benefits.

The purpose of plant breeding – any type of plant breeding – is to generate new genetic diversity and select from those plants with the desired improved characteristics. Most, but not all, plant breeding is concentrated on food crops.

No matter what method or technology is used, the creation of any new variety is complex, costly and time-consuming. It requires skill and forethought – today's breeders are trying to anticipate the needs of farmers, consumers and the environment a decade or more from now.

The characteristics of plants are determined by genes, therefore, whatever method or technology is used all plant breeders' work with genetic material, or germplasm. Each plant contains many thousands of genes and the breeder is seeking to combine a range of traits in one plant such as high yield, quality and resistance to disease. For this reason, developing a successful variety has been compared to playing a slot machine – not with three reels but with several hundred.

From a plant breeding perspective, the drive to constantly improve yields has also contributed to the marginalisation and possible loss of varieties – at least in terms of mainstream accessibility – of other useful characteristics.

In a world before soil degradation and climate change this may not have seemed so important. Today we know that preserving the diversity of germplasm is vital to both traditional plant breeders and those working with genome editing technologies – and both types of breeders are already selecting for things like resilience in the face of climate resilience.

> "Over the last few years, the summers in Europe are getting hotter and arriving earlier – my trials are now ready a week to 10 days earlier. So, by nature, you choose material that is better adapted to extreme conditions. You want those that have a stable performance. That is what the farmers want as well. Something trustworthy."

The promise of genome editing

It is against this complicated background that genetic engineering (and most recently, genome editing) techniques have emerged as a possible solution. Breeders using this technology spoke of the potential for higher yields and disease resistance, for repairing breeding-induced mutations in plants and increasing diversity through re-domestication of traditional varieties. However, for the most part, these referred to future potential since, as yet, few such crops are near a point of distribution or market.

Exaggerated claims for the benefits of genome-edited crops, it was agreed, was often done to attract funding. But this also happens in organic breeding and there was near unanimous agreement that whatever type of breeding is being pursued, this need for hype was problematic and had at least some roots in a toxic cultural context where rewards are given not for merit but for spin.

> "Every week I talk to a journalist asking, 'Can organic food feed the world?' It is such a stupid question. But we also need the hype to sell ourselves. If you are not interesting, you get no funding. You have to tell a story. It's the same for GMOs."

Questions arose also about the boundary of genome editing; is it limited to targeted mutagenesis or does it also include gene insertion (transgenesis). Additional confusion over terms arose from the fact that, under the EU GMO Directive and the European Court of Justice ruling, plants created by traditional mutagenesis (see page 10) are also defined as GMOs but exempted from the regulations due to a long history of use. This was accepted by most as a factor that makes the public debate less clear cut.

Some viewed genome editing as contributing towards a land-sparing approach to land use, where high-yielding agriculture requires less land for the same yields and leaves greater areas of habitat for conservation. However, there is no reason why land sharing, e.g. farming which includes biodiversity and landscape enhancement within the production system and which encompasses lower yied, extensive systems, should exclude genome edited plant varieties

Others questioned whether the changes in technology, from first generation genetic engineering techniques to genome editing, might be increasingly persuasive to governments and the public, especially given the challenge of climate change. There was also discussion, which remained open-ended, of whether genome editing could be viewed as a driver of university research and economic growth.

The question of speed

It was generally agreed that genome editing technology offered similar potential benefits as conventional

breeding and, that under certain circumstances, it could be faster, cheaper and more precise. However, it was also acknowledged that sometimes, especially for complex traits, the same results or even better could be achieved through conventional plant breeding.

There was also agreement that how genome editing is presented in the public sphere – as a 'magic bullet' – was inaccurate. A gene-edited plant does not appear perfectly formed from the lab. After its *in vitro* creation there is much laborious *in vivo* conventional breeding involved in order to develop the plant.

"Genome editing doesn't have to solve all the world's problems to be valid or valuable. It can be a tool in the toolbox. It's been over-hyped but that is not a reason not to have it. It's a reason to say 'let's calm down a bit'."

As one participant said: "*If you are using genome editing, you still need to do the basics of crossing and selecting under different environmental conditions. Only if the variety with all its characteristics performs, can it be brought to the market. Genome editing is one aspect, but a new variety is selected in the field*."

Because of this there were several challenges to the idea that genome editing using CRISPR made breeding faster than conventional breeding. But one participant noted: "*Crossbreeding and selecting takes time. But in one year, I can select for lots of traits whereas with CRISPR I can only select for a few. So, I think that I'm just faster.*"

Some breeders using genome editing also felt that off-target effects are fewer in genome editing than they are in conventional breeding due to its greater facility to focus on a target within the genome.

But, it was pointed out, changing a 'single gene' rarely changes only a single gene and while off-target effects can be present in the early stages of any type of plant breeding, information about the potential unintended DNA changes arising in genome-edited products has rapidly emerged as the technology has advanced.

Serious efforts to document the spectrum of these off-target effects would go a long way to improving the transparency, and therefore trust, around the technology. At the same time, as discussed at T*he Question of Risk* table, a certain degree of risk is embedded in many of the products of technology that we use every day. The question of where to draw the line for that trade-off remained largely unanswered in our discussions.

"The blending of the knowledge economy, high-tech and biology is seen by some as the 'Fourth Industrial Revolution'. It's part of a vision for how we are going to revolutionise our economy and that vision has filtered to the universities – their funding depends on it. Politicians have also bought into the 'miracle' of this approach.'

The tool in the toolbox

Although it was generally agreed that genome editing is a not a magic bullet, several participants considered it to be an extremely useful tool in the plant breeding toolbox. A commonly cited example was breeding resistance to disease where only a single gene would need to be changed. Not everyone accepted this.

Some also felt that the usefulness of genome editing as a tool was context specific and depended on the overall goals of breeding and the agricultural system. For example, genome editing might be a less useful tool in an agro-ecological land management system based on the use of landraces, old varieties and possibly evolutionary breeding of populations of plant materials.

It was noted that the major problems farmers face are usually system-wide and breeding is only one aspect. From this perspective how one manages the whole system matters more than any one aspect of it. The

phrase 'tool in the toolbox' doesn't really fit the vision of those who think and work in a more systems-oriented way. Likewise, the problems conventional farmers are not necessarily the same as the problems that, for example, organic farmers face. Therefore, the tools needed to address those problems are different.

> "Ending hunger is not just about breeding plants or developing techniques. It has a relationship with social justice."

As one participant said: "*If you are going down the intensification route, then genome editing fits that model. Within that narrow definition of efficiency it makes sense as a tool in that particular toolbox. But whether it makes sense in a broader more extensive agro-ecological land management system toolbox is another question. There, the important issues are ecological, agricultural and functional diversity. So, we need to ask: whose tool? Whose toolbox? And who is deciding what tools we are using? You wouldn't use a carpenter's tool to make a cup.*"

There was general concern, however, that an over focus on technological 'tools' to address problems of hunger was reductionist, 'Green Revolution' thinking, i.e. focussing on yield as a single factor separate from wider socio-economic and cultural dimensions. It was noted that societal resilience was – or should be – integral to the concept of plant breeding resilience.

Does the private sector base of plant breeding contribute to – or detract from – resilience?

Many participants raised the issue of privatisation of public sector research, including plant breeding, in the latter half of the 20th century. It was agreed that this was regrettable and that a revival in public plant breeding would be welcomed. All groups highlighted that the goal of a private company is to make a return on investment for the company. One participant noted: "*The private sector model by its nature, does not develop resilience. The whole model is based on short-term gains. It's about how much seed you sell. That is not to say that it doesn't contribute to resilience*."

Some participants felt that, on occasions, the private sector had led plant breeding technology in an inappropriate direction. A key example of this was the decision to focus genetic engineering technology on tolerance to pesticides, or pesticides being bred into crops, instead of focusing on breeding crops that aren't reliant on chemicals at all.

There was also discussion as to what extent the private sector had led to an over emphasis on yield rather than resilience in plant breeding. Some participants pointed out that a focus on increased yields was not solely driven by the private sector. Government funded research globally has often focussed directly on yield and used it as a proxy indicator of overall improvement.

> "The decision to focus on a narrow innovation is a political decision. It is a political decision to spend taxpayer money to work with a private company to develop a GM purple tomato that is only useful for highly processed sauce on pre-prepared pizzas and puts farmers in Sicily, who grow real purple tomatoes, out of business."

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, to pass the VCU test, breeders have to select for highest yield otherwise they wouldn't be able to bring their crops to market.

This means there is a trade-off between yield and resilience in those countries with a regulatory system focused on yield. This is not so pronounced in other countries, in some cases due to the existence of more broadly focussed public sector breeding programmes. One participant noted:

"*In Switzerland there is public breeding and different plant registration thresholds to those in Germany. We use these cultivars from Swiss plant breeding that would never get released in Germany because the yield is too low. However, our bread wheat can be grown without fungicide because it has a very high resistance level and a very high baking quality*."

Some argued that the focus could shift from yield to resilience through legislation that is better attuned to farmer demand or through government incentives. Simply put, if we want private breeders to produce resilient crops, greater resource priority must be given to resistance traits and quality traits.

It was noted that, of course, organic plant breeding research was also mostly privately funded – through charitable foundations or other means. One UK participant, using modern genomic methods, also noted that he was a recipient of long-term public sector funding to increase the genetic diversity of wheat. Examples of continued public funding of conventional plant breeding and new models of private sector breeding overseen by farming organisations are also emerging.

There was unity around the idea of a need for more equitable investment in a variety of different breeding approaches and that levelling the playing field in this way had a role in improving relationships and communication as well as cooperation across the board.

Limits to what breeding can achieve

There was agreement that plant breeders need to continually breed for resilience to pests and, increasingly, for resilience to a changing climate. However, several participants pointed out that increasing within-crop genetic diversity through, for example, breeding populations rather than single resistance traits in single varieties could also improve resilience.

But plant breeding alone is not the answer to the world's most pressing social and environmental problems. Genetically identical monocultures (e.g. the Cavendish banana, propagated through cloning) can, for example, still be vulnerable to disease as a result of external factors such as climate stress.

One participant stated that plant breeders were already selecting for climate resilience by choosing plant material that gives stable performance under the current variable climate and that genome editing was not part of this.

However, another noted that plant resilience alone would not guarantee resilience in a changing climate: "*Resilience is needed on the scale of society, at plant scale and at farm system level. To try and pack all that into the breeding system alone is not the right way*."

"We can't solve huge problems with only breeding and it's not just about yield increase. We need societal resilience."

Several participants highlighted some agricultural GMOs under development that they felt would not contribute to a resilient food system, for example those made for the processed food industry, or those subject to ownership (patenting) of genetic material.

Acknowledging values clashes

Participants recognised that understanding the context in which disagreements were taking place was important to foster respectful disagreement. There was recognition that disrespectful disagreement was often a clash of vested interests. For example, scientists speaking in favour of genome editing in agriculture might have public or corporate funding interests. Likewise, those speaking against genome editing in agriculture might also have a vested interest in resisting the technology or promoting alternatives.

In order to address this issue, there was a call for greater transparency and honesty in public discourse. For example, speakers should openly declare their backgrounds and position on genome editing. Most felt that a lack of expertise should also be declared. One participant stated that establishment scientists sometimes make statements in favour of technologies such as genome editing, even though it is outside their professional expertise.

Clashes can also arise when professional boundaries are not respected. Several participants expressed concern that some supporters of genome editing technology were trying to persuade the organic sector to accept genome-edited crops. Some felt that pressure to accept genome editing in organic was less about resilience than it was about enhancing public acceptance of genome editing by capitalising on the high level of public trust the organic sector has build up over the years.

> "Even if you think that you are independent, you probably won't be seen as independent by anyone else. It's easy to shoot down your argument using 'Yes but look who is funding you'."

For several participants, respectful disagreement was connected to acceptance that a diversity of values translated into a diversity of breeding and farming systems.

There was discussion on whether genome editing technologies could truly be neutral as they were closely associated with patents and large companies. One participant suggested that genome editing could be part of a different type of plant breeding framework, e.g. genome-editing service providers for small breeders or farmers. Although this idea suggests that genome editing can be applied outside of the context of patents and large companies.

Others dismissed this idea, taking the view that genome editing, rather than being applicable to small breeders or farmers, was more likely to be used to produce a volume commodity product tailored to a global market – and therefore only of benefit to large agricultural businesses.

A threat to organic?

The discussion of genome editing in relation to organic encompassed more than just a concern for professional or philosophical boundaries. Organic plant breeders were concerned that, without proper regulation and transparency of crops developed by new GM techniques, their livelihood and the whole organic system of farming could be compromised.

There was also some discussion on the new ethical guidelines on so-called new plant breeding techniques (NPBTs), recently published by the Danish Government.[9] These have shifted official policy from an anti-GM position to one more open to the idea that new genome editing technologies had moved on and may help address the challenge of climate change. There was concern that if such a shift is possible in a country that has traditionally been opposed to agricultural genetic engineering, this could sway some in the organic sector to press for organic standards to include some genome editing technologies.

IFOAM – the international body that represents the interests of the global organic agriculture movement – says that genome editing is not acceptable in organic breeding. Not only could it cause problems in countries where there might be cross-pollination between gene-edited plants and organic plants, but there are also issues in countries that do not label gene-edited varieties.

European breeders, for example, run into problems that mean they can't use germplasm from colleagues in the USA because they don't know whether it is from GM/gene-edited varieties.

As one participant noted, the fast-moving pace of the technology means greater uncertainty: "*We know there*

are no genome-edited cereals – yet. Maybe in 3-4 years we will have to be very careful because they cross easily – and extension workers don't know the pedigree or if it came into contact with gene-edited varieties."

The notion of 'pluriformity'

One organic proponent was keen to clarify that organic agriculture is not against technology as such. On the one hand, some within the organic sector do not completely reject the idea that gene-technology research could provide new opportunities that may be consistent with the organic standpoint.

There are, however, inevitable ethical and practical questions that would arise around such a shift. Others said they did not oppose other groups in society developing new technologies, under certain conditions:

"*If other groups in society want to develop new crops with new technologies, no problem. It's Greenpeace that wants to eliminate all those technologies for the world. We say we want to do it in an alternative way. So, give us space to do that. And I think it's good for science, it's good for society because of pluriformity and because we can learn from each other because there is no blueprint to heaven.*"

"When we can see the differences in values, we can create a beautifully respectful discussion. As soon as breeders say 'we are going to save the world' or activists say 'this is wrong and you shouldn't use it', it is not helpful. A diversity of outcomes is possible when we accept that there are a diversity of values and approaches."

"Pluriformity" inevitably means "co-existence", a practical and philosophical sticking point between genetically engineered and non-genetically engineered crops that has not found any resolution in decades of discussion.

Most participants agreed that a need for a diverse set of approaches is necessary to meet future challenges in agriculture. But there was frustration at the lack commitment – in government, in the regulatory sphere and among breeders and farmers – to putting the necessary policies, budgets and structures in place to make that happen. In part this is because our regulations are focussed almost entirely on risk – on limits and what should be kept out – and do not address resilience – where the boundaries are and how those boundaries help define the kind of agricultural system we desire.

For "pluriformity" to work it requires transparency, which requires labelling, which requires some form of regulation – by government or third-party markets, which requires inspection, all of which means infrastructures and costs.

Furthermore, as we are referring to biological materials, which are active in the environment and cannot readily be constrained, issues of spread and "contamination" can and do arise. These take the discussion back to a consideration of boundaries and restraint and to questions of how to enforce limits – and apportion liabilities should things go wrong.

CITIZEN ENGAGEMENT

There is no question now that in politics, in brand marketing and across many different disciplines including the science of plant breeding, there is an increasing emphasis on citizen engagement. It's a laudable goal but also a complex one.

Most political institutions don't have much – if any – infrastructure that allows them to engage positively with members of the public. Many marketeers desire to know what the public thinks but prefer the techno engagement of passive listening on social media to actual human contact.

Meaningful citizen engagement is fraught with difficulties. Even knowing where to start poses problems. Is the starting place a 'deficit' model – telling people what we think they don't know or what we think they should know? Or do we dive fully into a relational model that prioritises listening, responding and engaging? And when we do engage, what is the type and amount of information that best serves the majority of citizens? Is it through bumper stickers and slogans or lengthy technical papers or some middle ground?

For plant breeders, citizen engagement could be useful. Citizen science programmes can help evaluate the products of plant breeding in real world conditions. Seed savers can help protect and preserve germplasm for future use. Most plant breeding innovations are aimed at making the farmer's life easier but citizen engagement can provide clues about what is important to the ultimate end users.

Perhaps the most crucial starting point is to determine whether we are seeking to engage the public as consumers or as citizens. Certainly participants recognised that there is a wide-ranging spectrum of interest amongst citizens/consumers. Some seek as much information as possible from labels, specialists and the internet while there are others for whom the origin of their food is simply not a priority issue. Some favour local or regional foods and farming while others see access to the global larder as integral to their quality of life.

> **"Local is an important values-based decision, but it is dismissed a lot of the time as being kind of niche, hair shirt or greenie."**

Some behave differently in different situations. A person can believe passionately in sustainability and still end up eating a day-old sandwich made from unidentifiable (and probably unsustainable) ingredients on a train station platform. A person can believe in the importance of provenance but still decide not to spoil a night out with friends by asking the restaurant how it sources its meat or fish. Nearly all of us have the experience of walking through a supermarket and putting something, unexamined, in our baskets because it was cheap, convenient or easy in that moment.

In addition, this spectrum is not constant; the depth or intensity of interest waxes and wanes and individuals may act as a concerned citizen on one issue and a uninterested consumer on another.

Engaging with citizens, most participants agreed, adds another layer of complexity to already complex work. People coming to this table, even if they were generally supportive of the idea of citizen engagement, were deeply divided about whether it was, in the end, worth the effort.

Citizen, consumer – or both?

There were lengthy discussions about defining citizens versus consumers. It was noted by many how easy it is to conflate these two, but at the same time it was acknowledged that whilst consumers don't always act as citizens, citizens are always consumers.

For the most part, there was agreement that the two categories could be divided along the lines of what underpins their choices and actions, i.e. values and world views but also along the lines of how they relate to food, i.e. transactional or relational.

The consumer, most felt, is more concerned about self – my health, my convenience – whereas the citizen is oriented more toward systems and society – ourselves, our health, our environment, our future.

Consumers appreciate choice but citizens may be more aware of the trade-offs and dilemmas involved in choice and more adept at weighing these up. In this respect, citizens have concerns that are rather more complex than those of consumers. Or as one attendee said, "*consumers are more easy going*".

"At the citizen level we also talk about citizen lawmaker, because while the consumer votes through his wallet the citizen votes in elections. For the most part genetic engineering has never been communicated to the consumer because its benefits were for the farmers and not for the consumers. But what we are seeing now is that gene editing is being communicated to the consumer in order to influence the citizen."

But while it may benefit food companies and supermarkets to encourage easy going consumers, who are easily pleased and who don't ask too many questions, it effectively shuts down communication especially around complex issues.

But there are also places of crossover. Pesticide use on conventional crops is a citizen concern because of the way it degrades the environment and presents a widespread threat to health. But it is also an individual threat to 'my health' that may make it a topic of interest for someone who otherwise would be just a consumer. In this case messaging and reliable sources of information are crucial.

The desire for influence and agency

It was noted that citizens want their consumer choices to influence the direction of travel of the food system. Citizens are interested in a) readily accessing information and, b) weighing up alternatives before making their choices, and the idea of a choice or an alternative is fundamental for a feeling of involvement.

That notion of alternatives is important when it comes to issues like genome editing. From the earliest days of what is termed 'consumer research', the most important question in some cases was not "is it safe?" or "is it ethical?", but "is there an alternative?"

"You want that agency in the supermarket where you can actually choose something that gives you a feeling you have a part to play."

Behind that question certainly lies questions of sustainability, environmental protection and safety. But deeper than that is a desire not to be pushed down a particular pathway or to lose the power of choice either now or in some future time.

Choice, of course, is a slippery slope. There are many technologies we use where we never ask the question "what is the alternative?". It was further pointed out that choice in the supermarket is largely an illusion. We may, for instance, have a 'choice' of eight different shampoos – but they are all made by one company.

Issues around food choices, however, are more 'alive' for many, in part because of the sheer number of civil society groups campaigning around it. There is a growing recognition of how deeply connected food is to so many areas of life and of nature. Food is also something we take directly into our bodies and, as the saying goes, you are what you eat; thus many people believe that the food we eat reflects and becomes a part of us.

The who, what and how of messaging

In the introduction to the day it was proposed that slogans and bumper sticker messaging was not adequate to relay the complexities of plant breeding. But a few participants took exception to this.

This view, it was suggested, was essentially saying one form of communication is better or more desirable than another; and in saying this you are also making a very big decision about which messages are legitimate and which ones are not. Some felt the complexity of the message depends on what you are trying to communicate and that bumper stickers and simple slogans can also express a more global view, for or against, that may inspire people to want to learn more.

It was, however, acknowledged that the genome editing discussion is complex and that simple slogans are a poor way to communicate complexity. This led to discussion about sources of information, experts versus specialists and the concern about information overload.

> "We depend so much on experts, but being someone who has worked on the expert panel with groups like Convention on Biological Diversity has prompted me to ask is any one of us really an expert. Do any of us have the expertise to address the whole question? No, we don't. And if it is difficult for those widely regarded as experts, it is many times more so for a lay person."

There was acknowledgement that, whether through lack of understanding or lack of trust, citizens often turn to outside experts for information. The value of independent information was not in dispute. None of us – not professionals or lay people – can know everything and independent experts or specialists have a role. But in the world of plant breeding, experts on all sides can end up being people with an axe to grind or who have been paid to promote a particular point of view. Experts can also speak in bumper stickers and slogans.

So how does the consumer – or anyone else – discriminate? In fact, many don't. Seeking information, especially on social media, can become an exercise in affirming beliefs rather than challenging them. If someone is identified – or self-identifies – as an expert, the natural assumption is that they know everything. But in a connected system like agriculture nobody has the whole picture in their head.

Making plant breeding sexy

One participant noted that at a recent seminar at Europe's largest organic fair, Biofach, plant breeders discussed how to talk to consumers about organic. A long list of technical and scientific facts about the benefits of organic was met with criticism by a sales person who said all of these facts were boring. What was needed, he said, was a sexy message that tells people that eating organic is fun.

Apart from living up to the idea that organic – or any other kind of food – is 'fun', the option of a 'sexy' message, it was noted, takes us back into the territory of bumper stickers and slogans. But underneath it lies some grain of truth about people's connection to food and how quickly choice becomes personal and emotional.

> "With plant breeding it's not black and white. It's more like 50 shades of green!"

Was it better to try and surprise people? To encourage their curiosity and sense of personal involvement instead? A number of attendees said that they had been involved in public events or they used social media to answer basic questions like, 'where do our fruits and vegetables come from?' The public were often surprised to see 'before and after' photos of common foods like bananas or wild cereals, and get a sense of their evolution through plant breeding.

For the most part, this type of outreach tends to offer a core message about plant breeding that is then used to promote a particular perspective, whether organic, conventional or genetic engineering.

There seemed little evidence of breeders coming from different perspectives and values systems speaking together from the same platform about what underpins their work and no sense at all that the public might be curious about these nuances.

Participation and citizen science

In terms of piquing citizens curiosity and finding a way to have a more equal engagement with lay people, participatory breeding and citizen science programmes are seen by some participants as a way forward.

> "I think especially for people in cities, participatory community gardening helps get people engaged on a smaller scale. Even if they are only trying to grow a tomato on a window ledge, input from scientists or experienced breeders can help them understand better the need for genetic diversity and how different varieties do better or worse in different situations."

In some countries, platforms for citizen science include mobile tools that everybody can set up and use. The example was given of a programme at the University of Hohenheim where soybean seeds were distributed to more than 1000 small farms to feed information back on which matured the fastest, and on how day length and temperature affects the ripening time.

Participatory programmes, it was argued, improve the balance of power in the relationship between the scientist/breeder and the farmer/citizen because the scientists receive important information from the citizen and not the other way around. Such programmes, however, do not usually involve urban dwellers – nearly three quarters of the European population – which still leaves a substantial communications gap between breeders and the general public.

For urban dwellers, engagement seems to be focused more on aesthetics and preferences of appearance and taste – through surveys, supermarket tastings and open days at breeding facilities. Motivated urban gardeners can participate in seed saving networks that can help preserve genetic diversity of vegetables. These are the more common forms of outreach. It was pointed out that preserving the genetic diversity of vegetables is easy this way, but it does not apply to cereals, which is a more complex area of breeding.

Speed breeding – sending the wrong message?

Citizens are increasingly exposed to narratives that portray genome editing as fast, limitless, sustainable and even natural. It was acknowledged that genome editing can indeed be quick and easy if it involves a single uncomplicated gene change. In the media this feature of genome editing has been communicated as 'speed breeding'. But as one participant said:

> "We have no idea what we can and will do in 10 years. For a citizen, like me, I want to know what are you doing now? Of course, you can add what you expect, but if you just talk about your future vision it becomes too far away."

"Maybe the method can be fast but then after that you still have the whole process of evaluating your materials. That takes easily five years if you are looking to develop new varieties. With potatoes varieties it normally takes about 20 years and maybe a hundred thousand potato plants that a breeder has to evaluate to develop a single variety."

This time frame of anywhere from 5-15 years is normal for any kind of plant breeding and many felt frustration that citizens were unaware of how much time

and effort went into improving existing varieties and making new ones. As one participant said:

"*That breeding takes time I think that's an important message that is missing at present and we have to communicate that.*"

Some questioned who was promoting the idea of fast breeding, believing that media – also on the lookout for the 'sexy' story – were partly to blame. Others suggested that corporate lobbyists and those looking to raise funds for their breeding programmes tended to exaggerate the speed and ease of genome editing.

Of course, some responsibility also lies with those who accept those claims (e.g. bureaucrats leading government innovation programmes) without confirming their veracity.

> "There are so many options and so many niches. We sit around this table and we can't even focus on it for five minutes, so pity the poor consumer who's trying to make sense of it all."

Some felt that the narrative around 'speed breeding' was part of a world that values speed above all. The world is speeding up and information about everything is coming to us at a much faster rate, in part because of the deep and all-pervasive reach of social media.

That barrage of information also has a consequence for consumers who no longer have time to reflect and digest information and make considered choices. This works to the disadvantage of all types of plant breeding since it encourages simplistic messaging and shallow engagement – the polar opposites of what the majority around our tables felt was needed.

How can transparency be assured?

No one who visited the table felt that transparency was a bad thing, or in any way undesirable. There were, however, several discussions about what transparency actually meant in the context of lengthy and complex food chains.

Many felt that transparency took on very different meanings depending on whether you were talking about fresh or processed foods. For instance, it was easier to say where a piece of fresh fruit came from or what variety it was, compared to a processed food product that may have multiple ingredients sourced from multiple countries or sources.

For some foods – potatoes and apples were common examples given – variety is a selling point. But in the processed food chain, foods are not traded by variety or identity. 'Flour', for example, may come from many sources and varieties. 'Vegetable oil', similarly, can be pressed from different types of plants. This is a problem for consumers wishing to avoid genome edited foods.

> "I mean if you if you buy a beer you don't know what kind of brewing barley varieties you have in that beer."

It was pointed out that in some countries organic growers want to know how a plant has been bred as some breeders wish to avoid plants bred using certain mutagenic techniques such as protoplast fusion, chemicals or radiation. However, it was felt that in most cases consumers likely are not interested in this much detail.

Indeed some participants felt that it was possible to give citizens too much information and that information overload could be detrimental and off-putting. In truth we don't know much about what citizens want to know about their food. Genuinely open surveys on this topic – as opposed to marketing surveys designed to produce a certain answer – are rare.

Is there commitment to genuine engagement?

Information overload, the fast pace of the demand for change and the relative slowness of plant breeding all seem to combine to make communication of a complex subject even more complex.

Efforts at public outreach take many forms – online, via workshops, informal talks and lectures, and farm open days – but their organisation and messaging tend to be scattered and inconsistent. Absent, a more widespread and coordinated approach, regulation and labelling become the proxy for citizen engagement. Participants were divided on how helpful this could be.

Labelling and Regulation

As the food system becomes more complex, the list of things citizens might want to know about their food also grows. Many felt that while consumers also wanted more information, it was not always clear what information they wanted. Labelling was seen as a crude form of communication and one that can hide as much as it reveals and which, ultimately, might not make the public any better informed than it was before.

Others felt that we already had an "overkill" of transparency, with labels that provide nutritional and allergy information, third party certification and faith group endorsements (e.g. Kosher, Halal). In the EU if a product is bred through a GMO process or contains GMO ingredients, this must also be on the label. In this respect there is already a great deal of transparency in the EU food chain.

There was real disagreement about how the products of genome editing should be treated in any labelling system. Some felt that, in addition to labelling, there was a need for an online registry where citizens could easily find all the registered edits of particular plants.

> "I think we've all agreed that it's impossible to add a label onto a packet that reflects everything that we think citizens might want to know. So, we've got to change the way that food and consumers interact. And that is a big, big task."

But several expressed the idea that if we need more labels and information hubs, it is an indication that the system itself is problematic and following the wrong trajectory.

Communication mediated through technology

The use of technology to make the interaction easier – or at least more streamlined – was discussed in this light. Emerging technologies like QR codes and block chain have the potential to provide large amounts of information at the push of a button or the stroke of a key.

With organic cotton textiles, for example, users can scan the QR (quick response) code on the OEKO-Tex label, enter the product ID and see which farmer or organisation produced it, where it was manufactured and that the final product has been tested for the presence of harmful substances. Many felt that a system like this could be used to inform consumers who wish to know about the origins of their food, including breeding methods.

For those who do not own a phone or know how to use a QR scanner, information points could be provided in supermarkets for shoppers to use. This is already happening in Switzerland.

Blockchain was given as an example of yet another way of providing complex information to citizens. The concept of blockchain is an open, shared online public 'ledger' to which independent participants can contribute entries and information.

But blockchain is also controversial because it is only as good as the information fed into it. There is already

some concern that large companies are creating their own bespoke blockchain systems that give them total control over what information is shared or not shared.

Every group felt that the discussion around transparency and information provision has been made more complex by the current globalised food system and that re-localising and re-regionalising the food system would address these issues without a need for more – and more complex – types of on package or online communication.

Is it worth it?

Some participants felt that public participation in the decision-making process around genome editing was crucial for facilitating transparency and accountability as well as for strengthening public support for the decisions taken regarding GMOs.

But as the discussion deepened others began to question whether citizen engagement is just too much of a complication and whether it is really worth it.

It was suggested that citizen engagement at the consumer end of the process might not effectively fulfil aspirations of giving citizens influence and agency in how their food is produced, whereas involving citizens at an earlier stage, in research and development, as well as in policy and regulation might be more meaningful and more democratic. It might even facilitate better knowledge at the purchasing end.

An example from the UK was given. There the Research Council gave money to Rothamsted and the John Innes Centre to develop what was originally a GM crop called camelina (in subsequent iterations it was genome edited).

> "What I struggle with is trying to make the best decision, the one that is right for you without harming some other things in the world. And the decisions around the production of food are the same as the decisions around other technologies like the production of phones. There's so many things that matter nowadays and you need to find the right information. But what's your source? If you Google for 'are GMOs good?' Then you will get lots of sources saying yes. And if you Google 'are GMOs bad?', then you get probably a similar amount saying no. I find that very difficult"

Camelina is an oilseed crop and the broad justification for developing it is that it could be fed to farmed salmon. Doing this, it was argued, would make the efficiencies of farmed salmon much greater because it was high in particular oils and therefore could, potentially, reduce the amount of small fish that are fed to farmed salmon.

In the UK regulatory process there is no way that anyone can debate and discuss that justification. Permission to trial the crop was, therefore, made entirely on a technical decision as to whether it was feasible to develop a high omega-3 camelina using genetic engineering technology.

Had there been a mechanism for citizen engagement that decision would not have been made on such a narrow technological basis. Instead, it might have taken into account how damaging to the environment farmed salmon is, for example, or whether we should be using land crops to feed fish instead of people.

For this reason, it was argued, early citizen engagement could substantially change the discussion around research and regulation in a direction that acknowledged complexity and social responsibility.

Another example was given of the regulatory process in Norway, which requires wider citizen involvement in decisions about GM. Norway was the first country to include broader issues of societal utility (public good) and sustainable development in its GMO regulations. As part of the process socio-economic considerations of genetically engineered products are evaluated, in part, through public participation in the decision-making process.

Societal utility is a complex concept closely linked to basic human needs, distribution between generations, between rich and poor countries and economic growth. But it also encompasses whether the technology is beneficial to small or large farms, whether it is likely to have any effect on employment, food security, landscape aesthetics or human and animal health and welfare, as well as an assessment of who will benefit from the technology.[10-12]

The UN Cartagena Protocol on Biosafety calls for an assessment of "*socio-economic considerations of genetic engineering technologies*". However, in reality the 156 countries that are party to the protocol struggle with achieve this. In general, assessment frameworks are largely created to address technical and health and safety issues. Most regulators find it difficult to incorporate wider issues into these frameworks and yet the broad consensus was that, in a democratic society, this was an area that warranted further exploration and possibly even investment.

FINAL THOUGHTS AND NEXT STEPS

The world café on The Boundaries of Plant Breeding was a chance for breeders from different perspectives to come together in a safe space and discuss differences and find some points of agreement. What emerged from the day is that plant breeding isn't a monolith. There is room for debate and the focus of the debate shifts over time. Likewise, the science of genetic modification is complex and evolving – but while the technology has changed, the discussion – outside of events like this – has stayed largely the same.

We observed that amongst the plant breeding fraternity the discussion is far more fluid and open than at the policy or activist level and perhaps it is here where some kind of consensus on pathways for moving forward can be found. This, of course, requires the full spectrum of views from all plant breeding approaches being brought into the forum.

In a generally good-natured meeting, the one overt clash was over the European Court of Justice's (and the organic sector's) stance on mutagenesis. Support for the ruling conflicted with passionately held views that the urgent need to improve sustainability and climate change resilience made genome editing tools necessary.

Given this, there were real and significant differences between participants over process- or trait- (final product) based risk assessment, which remained unresolved.

Differing responses to the idea of "using all the tools in the tool box" were also revealing. There was general agreement that genome editing is "one tool in the toolbox". No-one argued, however, that it was *the* tool.

There were, however, points of agreement as well:

- There was acceptance by participants who support genome editing of the viability and value of the organic approach to plant breeding.
- The alternative (organic) participants acknowledged the value of genomic tools in lab-based research and in genome mapping as a tool of selection.
- However, there was little or no understanding by many – possibly a majority of – participants of the rationale for organic plant breeding to avoid or prohibit some approaches (tools in the toolbox) especially targeted mutagenesis/SDN-1.
- There was an implied sense from some participants that some genome editing tools, which are currently seen as problematic, might gain acceptance in the future after further consideration, research and/or experience of use. In this case issues of risk, risk assessment and regulation are more important than perceived conceptual differences over methods.
- There was a degree of willingness to accept that public perceptions are not purely 'emotional' or 'irrational' but are shaped by a complex range of factors and values which are relevant to the debate.

Several other important philosophical and practical takeaways arose from the day, and these are detailed in the headings below.

Conflicting concepts

There was broad agreement that the use of the term 'nature' as a defining concept is less relevant to plant breeders than it is to citizens and consumers. Given that citizens and consumers are the ultimate end-users

of the products of plant breeding this is problematic.

There was little understanding from 'conventional' participants of the boundary established by organic plant breeders around the concept of the 'integrity of an organism'.

Even though there was firm adherence to this position by some organic plant breeders, it was not clear that everyone from the 'alternative' side shared this adherence. There was even a suggestion that concepts of sustainability and eco-efficiency might be more important in the overall picture of plant breeding.

We heard no answer to the question of whether there are, or should be, boundaries in genome editing and if so what might these be. The public face of this technology as one without bounds makes it attractive from an investment, and possibly even a political, perspective, but it can be problematic when it comes to identity and to understanding where it might fit in, practically and philosophically, in a 'pluriform' approach to agriculture.

It was not clearly stated, but was implied in a number of comments, that breeders from conventional and biotech backgrounds see no validity in setting limits on breeding methods other than those set a result of pragmatic risk assessment.

However, it was recognised by many that economics – structures and markets – set *de facto* limits on breeding approaches. There was unease and no consensus over how these limits are influenced by consumer attitudes. This unease was generated by confusion over what consumers 'have a right to know' if this right encourages prejudicial publicity, as well as by the high cost of information provision and the risk of confusion.

There was general acceptance of the idea of the need for wider engagement with stakeholders – farmers and citizens – for instance through participatory breeding programmes. However, it was not clear how much of a priority this was across the board.

Exaggerated claims

There was a significant level of agreement that claims for genome editing are 'over hyped' and that, as these claims are widely publicised, they unbalance mature discussion and consideration of the technology.

There was broad concern that exaggerated claims are made, in part, to promote political, policy and economic agendas that overshadow a more realistic and nuanced scientific and public discourse around the technology and the issues it might help address.

However, there was also some acknowledgement that over-hyped and distorting claims are not restricted to the promotion of genome editing. They are also present in the promotion of other approaches. Unless we sincerely believe that 'two wrongs make a right' the entire discourse around plant breeding needs to change.

The need for regulation

There was some degree of consensus on the need for regulation of genome editing technology and its products. Even so there was a significant spectrum of opinion, with some adamant that regulation is neither needed nor desirable and some questioning where to sensibly draw the line.

Participants were split over whether SDN-1 techniques should be regulated. There was more support for regulating SDN-2 and SDN-3 approaches as GMOs but, again, this fell short of consensus.

The most commonly held view was that regulation should be consistent and the most commonly used example of inconsistency was that of random mutagenesis versus targeted mutagenesis. To exempt one from regulation and not the other was seen by many as unfair to targeted mutagenesis and misleading

about the safety or otherwise of the products of random mutagenesis.

There was dismay amongst a significant number of participants that in the face of profound environmental challenges, such as climate change and biodiversity loss, a breeding approach that many believe is akin in effects to traditional breeding or natural impacts is being ignored and by implication undermined. This was a significant conceptual clash that was largely treated with kid gloves during the discussions.

There was some agreement, but it was not clear how much, that science alone does not provide answers as to how or why we should regulate the products of genetic engineering. The case for a much broader approach where regulations reflect societal values was, however, sympathetically received. This would incorporate philosophy, ethics and sociology and relate to clear goals for a resilient, sustainable agriculture

Labelling and citizen engagement

There was acceptance that citizens should be – and many want to be – better informed about plant breeding and agriculture and there was broad general support for the desirability of providing them with information, through labelling but also through in-store information and better outreach by plant breeders.

No one objected to the idea of citizen engagement in policy and funding decisions or in regulatory frameworks and decisions. Some even felt it could be helpful to the process of assessing the products of genome editing – though most recognised the lack of framework to facilitate this.

For this reason, interest in public engagement was tempered by concerns over how this can be achieved, what form it might take, whether it would generate confusion and how much benefit would result in reality.

Sustainability

There was universal agreement that sustainability should become a major driver for technology development and implementation.

The question of what is meant by sustainability required more time than we could devote to it. Different people had different approaches to and definitions for 'sustainability' and there was no consensus as to whether sustainability criteria should, for example, include limitation on technology and economic growth, or whether/where societal values such as accountability, fairness, quality of life, individual choice and the right to health and welfare should also be included.

Given the need for a sustainable and resilient agricultural sector this confusion is worrying.

Co-existence

"Pluriformity" or the acceptance and equal status of a range of methods in plant production, and the need for co-existence was accepted and welcomed in principle. This implies, but it was not clearly stated, the possibility of something that might be termed 'equitable co-existence', which is distinct from a co-existence dominated by one side and/or forced on the other. However, what this means in practice – e.g. whether 'light touch' regulation or more robust regulation is needed to facilitate co-existence – was not examined.

The issue of what happens if one approach impacts on another e.g. through 'contamination' of land, seed stocks, breeding materials, or through reputational damage which undermines credibility and value, was raised but not explored due to lack of time.

The uncomfortable truth for all sides of this debate is that:

- It is stated and agreed policy in the EU, throughout all member states and even post-Brexit Britain to

encourage and develop a range of agricultural systems – whether conventional, GM or organic;

- There is no possibility of any overt political shift from this position;

- There has been no meaningful discussions for well over a decade as to how this co-existence can actually work with the implementation of genetic engineering technologies.

Probably most uncomfortable of all, there is scant evidence of clear intent that any of the relevant stakeholders are willing to concede ground to bring about "pluriformity" and co-existence.

Next steps

This world café created the conditions for and facilitated a robust but respectful discussion of people perceived to hold fundamentally different positions about the use of genome editing in plant breeding. There were no Damascene moments but there was some recognition of grey between the black and white, an indication of greater understanding of differing views and positions, and some declarations of shared concerns, aspirations and principles.

Consequently, the event has thrown up a numerous potential next steps to pursue issues – technical, ethical, societal, policy, regulatory – in greater depth and detail.

Within this mix, for Beyond GM, there are some key next steps we will be endeavouring to follow.

- **Continuation of A Bigger Conversation meetings** With each meeting we are clarifying what lies behind and between the different positions taken on genome editing in farming and food. We are also building a network of people who are willing to engage with each other respectfully across sometimes wide conceptual divides. These are important factors for creating pluriformity and equitable co-existence.

- **Promote further engagement of this type** The character of this meeting (and others in our series) is unusual. The balance of participants brought together a mix not normally found in meetings of just "stakeholders" and lobbyists. All are prominent in their fields but have a wider perspective; they have robust opinions but are not opinionated and are respectful of others' views; they are affiliated with organisations but do not always feel compelled to represent or speak for those organisations.

- **Engage constructively with policymakers around regulatory issues** There is currently a great deal of upheaval and debate in the regulatory sphere with regard to genome editing. We believe this brings opportunity to consider regulation in a new light, particularly with regard to ethics and societal values. Our work engages us with issues in the UK and the EU and indeed we believe that regulatory issues in both places are interlinked. We will therefore continue to pursue this line under our own banner but also in coordination with like-minded groups and individuals.

- **Pursue in greater depth and detail what the conditions for "equitable co-existence" will be** There is an urgent need to understand what an equitable co-existence might look like and how it might be implemented practically and in terms of policy, regulation and politics. This will involve across the board co-operation in research, analysis, discussion and debate.

- **Explore the possibility of a civil society forum** where criteria for 'values-based' non-market aspirations could be discussed and refined and used to inform regulation and influence the direction of public sector-based plant breeding.

PARTICIPANTS

Plant breeder participants

- Edith Lammerts Van Buren – Emeritus Professor, Organic Plant Breeding, Wageningen University
- Erhard Ebmeyer – Senior Breeding Advisor, KWS Cereals
- Gary Barker – Senior Lecturer, Bioinformatics, University of Bristol
- Guusje Bonnema – Group Leader Growth and Development Group, Wageningen University
- Huw Jones – Chair in Translational Genomics for Plant Breeding, University of Aberystwyth
- Maarten Rouwet – Biotech Breeder Leafy Vegetables, Enza Zaden; organic breeding projects, Vitalis
- Michael Palmgren – University of Copenhagen, Department of Plant and Environmental Sciences
- Grietje Raaphorst-Travaille – General Director, Nordic Maize Breeding
- Monika Messmer – Department of Crop Sciences, Group Lead Plant Breeding, FiBL
- Niels Louwaars – Managing Director, Plantum
- Peter Kunz – Founder and Director Getreidezüchtung (GZPK); farmer, agronomist, biodynamic plant breeder
- Petra Jorasch – Manager Plant Breeding and Innovation Advocacy, Euroseeds (ESA)
- Ricarda Steinbrecher – Co-Director, Econexus, UK; biologist and molecular geneticist
- Stephanie Klaedtke – Researcher, Seed and Crop Diversity, LIVESEED project manager, Institut Technique de l'Agricluture Biologique (ITAB)
- Trine Antonsen – GenØk Centre for Biosafety, Tromso, Norway
- Ulrich Quendt – Cereal Breeding Research Darzau, Germany
- Urs Niggli – Director, FiBL

Host participants

- Eric Gall – Deputy Director / Policy Manager, IFOAM EU
- Lawrence Woodward – Director, Beyond GM
- Martin Sommer – Policy Coordinator on GMOs, Patents and Seeds, IFOAM
- Thomas Haselberger – Policy Unit, IFOAM EU

Meeting organiser

- Pat Thomas – Director, Beyond GM

Moderators

- Barbara van Dyck – Research Fellow at the Science and Policy Research Unit, University of Sussex
- Juliet Leroux – Policy Advisor, Greens/EFA
- Pat Thomas – Director, Beyond GM
- Tom Wakeford – Programme Manager, ETC Group

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Click on the journal title/publisher to access material online.

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READING LIST

This reading list was circulated to all participants prior to the world café. Click on the journal title/publisher to access material online.

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ABOUT A BIGGER CONVERSATION

Beyond GM was established to raise the level of, and broaden, the debate around the use of genetic engineering technology in food and farming.

As the name implies, at our core is the belief that focussing on narrow technological aspects is fruitless and misleading. It is also inappropriate at a time when our farming and food system and arguably, our socio-economic structures and behaviour need a profound, and for some, bewildering degree of transformation – and is therefore vulnerable to promises of quick fixes. The rapid emergence, promotion and potential reach of genome editing starkly demonstrates this vulnerability.

For our civilisation to survive on what, after all, is a planet of finite and diminishing resources, transformation must encompass more than techno-fixes and more people need to be involved in the discussion and decision-making process.

Consequently, Beyond GM has been engaging in what we call 'A Bigger Conversation' – events and meetings aimed at encouraging people out of the conceptual, professional, political, technological and philosophical silos, which are barriers to less prejudiced, more open discussion and discourse.

We do not seek to hide or mask differences between our views and those of others. Some of these are fundamental and may even be incompatible, but that does not mean there is no common ground; nor does it have to mean that a plurality of approaches cannot be found and developed.

In exploring topics such as plant and animal breeding, regulation, conservation, the nature and role of science structures, and the balance between innovation and precaution, several interesting themes are emerging:

- The response from the food and farming sectors, as well as the broader sustainability movement, to genome editing is variable and not monolithic; a debate is emerging.
- Irrespective of degrees of support for genome editing technology, there is a wish for greater transparency, for labelling, for more robust regulation and greater citizen engagement in decisions about whether, where and how public money in R&D is spent.
- There is a strong feeling that public investment in genome editing technology should be for public need and not private profit.
- Decisions about whether and when to use genome editing should be made in a wider socio-economic context as well as in the context of considering alternatives.

Ahead of our world café on plant breeding we were interested to see whether these would present themselves, and indeed they did alongside multiple other issues that characterised a day of wide-ranging discussion, which we have tried to capture in this report.

We are grateful to our colleagues at IFOAM EU who co-hosted this event with us and who have been supportive of the Bigger Conversation we are trying to create.

We are also grateful to our moderators for this event (see page 46) who brought expertise and insight to the discussion.