Keynote Address 1: The state of the art and current dilemmas of biotechnology for poor producers and consumers

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Since the dawn of agriculture humans have modified, in a direct or indirect way, the genetic constitution of plants, animals, insects, bacteria and viruses to feed themselves and improve their wellbeing. As a result, only a few present day crops or domestic animals still resemble their ancestors. To restore useful lost traits, cross-breeding with wild ancestors is – if at all possible – a tedious task. Improvements in crops and animals were based initially on rather random visual selection and trial and error, also affecting lower life forms such as pathogens and beneficial species in agricultural systems.

From the 19th century onwards, more systematic approaches of breeding and agricultural processes became based on statistics and an understanding of the biological and chemical determinants of productivity. The discovery of DNA - the blueprint of heritable traits - in the 1950s and advances in molecular biology in the 1970s paved the way for the breakthrough of biotechnology in the 1990s. The term biotechnology designates a toolbox of many diverse molecular and genetic techniques allowing the ever more precise characterization of the genetics of specific traits and the full genome of useful species. Biotechnology does not equal genetic modification (GM) but genetically modified organisms can result from the application of biotechnology. However, public opinion often considers them identical.

Today, the genome sequences of some of the most important staple crops, fruits, vegetables, domestic animals and some fish have been determined and work is in progress for many more, allowing a more focused/targeted identification of important genes. This work is largely publicly funded research or joint public-private partnerships, even though relevant gene constructs may be patented. This provides insights into the genetics of traits and their transferability. Genetic modification has already allowed the insertion of traits from wild ancestors or unrelated species to remarkable effects, especially in the area of pathogen resistance, with *Bacillus thuringiensis* is the most widely used transfer mechanism. The latest molecular-genetic techniques, in combination with advanced bioinformatics, such as gene silencing, splicing and editing make it possible to change the genome at specific locations through which desired traits are obtained without the adding of foreign genes/DNA. Technically speaking these do not result in GMOs, although this is still under consideration from a legal point of view in some countries. These technologies have also sparked vast applications outside plant and animal breeding, in vaccine production, food processing and safety testing. In other words, genetically modified organisms are only one of the many outcomes of biotechnology applications. To use a simple analogy: if GM was like the MS-Dos of the first computers, new techniques like CRISPR/Cas9 resemble windows 10 and supercomputing.

The first GM-crops, planted 20 years ago, provided herbicide resistance for large-scale zero-tillage systems particularly in feed crops. Biotechnology and GM have rarely been targeted explicitly at poor farmers and consumers, although efforts in enhanced vitamin and mineral contents have been stepped up, and small farmers benefited from increased production. Further work on drought tolerance, digestive and processing qualities and enhanced bio-based products, taste, shelf life, open new avenues for farmers and consumers. New relevant applications of biotechnology are emerging in maintaining biodiversity through embryo rescue and advanced gene banks, reduction of greenhouse gases from agriculture through feed characteristics and ruminant bacteria, or the sexing of chicken embryos.

Like nearly all forms of breeding, biotechnology and GM are not inherently biased against small farmers or poor consumers. Numerous concerns have been expressed about the risks of biotechnology and GM for human, animal and ecosystem health, as well as the exclusivity of the materials. Such social and political concerns must be taken seriously, even if there is no evidence of such negative effects. Many new traits acquired in this way such as nutritional quality, disease resistance, adaptation to stress are scale-neutral. Vaccines and food processing applications underscore this point. The price of new breeding stock is generally not an overriding factor for small producers, nor is the dependency on commercial seed, as this is already common in nearly all parts of the world with hybrid seeds and improved animals breeds. Nevertheless, small farmers will only benefit if their mode of production is upgraded to a resilient, resource-efficient system.

However, issues of intellectual property rights and regulations may present considerable hurdles to allow biotechnology and GM to benefit poor farmers and consumers. Because of the controversy and lack of understanding of the nature of biotechnology most countries have imposed cumbersome regulatory systems with concomitant delays in approval procedures, particularly in the EU. Furthermore, the long opposition between patenting systems and breeders rights has resulted in a stalemate. A delicate balance must be struck between the need to compensate companies for R&D investments and the need to keep access open for further improvements. It would seem that breeders' rights systems, in contrast to patenting, allow and support farmer-to-farmer exchange among smallholders and work by local breeding companies and avoid painful court cases against inadvertent farmers using GM-seed. The greatest benefit of new biotechnology techniques such as CRISPR is that cultivars or breeds can be tailor-made more easily to specific small farmer conditions because the selection process is much faster and broad adaption is not necessary to achieve commercial success. Current regulations, however, add years to biotechnology based breeding programs, and more regulation means that private and public breeders have to aim for broadly adapted dominant applications such as cereals, resulting in a potential bias against poor farmers and orphan crops, breeds and processes. Hence the resolution of intellectual property rights and biosafety regulatory regimes is one of the priorities to provide full benefits of new biotechnology to the poor. Ironically, the same advances in genetic characterization that are under scrutiny will help traceability, labeling and determination of authenticity of products and processes, permitting to assuage potential conflicts with organic agriculture and consumer fears about lack of choice.

The bottom-line is that biotechnology is both a continuation of traditional and classical breeding as well as a qualitative and quantitative step towards high precision methods to increase the performance of biological species and processes that are relevant to the supply of food, feed, fibers, pharmaceuticals and flowers to mankind and that potentially allow poor farmers and consumers to reap the benefits of the advancement of science.

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