CellPress

Opinion

The Role of Public Opinion in Shaping Trajectories of Agricultural Biotechnology

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Science and technology are not autonomous entities and research trajectories are largely influenced by public opinion. The role of political decisions becomes especially evident in light of rapidly developing new breeding techniques (NBTs) and other genome editing methods for crop improvement. Decisions on how those new techniques should be regulated may not be based entirely on scientific rationale, and even if it is decided that crops produced by NBTs do not fall under the umbrella of genetically modified organisms (GMOs), their commercialization is by no means certain at this time. If and when adopted regulations do not comply with the public's perception of risks, policy makers will find themselves under pressure to ban or restrict the use of the respective products.

Trends

A plant breeding company has developed the first crop produced by a gene editing technology that does not contain foreign genetic material.

The EU faces the challenge of how to handle next-generation plant breeding techniques.

In January 2015, a coalition of eight NGOs published an 'open letter to the Commission on new genetic engineering methods' calling for stringent regulations on new breeding techniques.

Most recent regulations on the cultivation of GM crops in the EU were shaped by public pressure.

Public Risk Perceptions of Biotechnology

New scientific reports and research results rarely directly trigger perceived fears of environmental and health risks [1,2]. People are often confronted first with emerging technologies and their implications via reading newspapers, watching television broadcasts, or browsing the internet; thus, media claims often trigger public risk perceptions of emerging technologies [3,4]. In many cases, scientific research data are marginalized or even overlooked intentionally when reporting science [5–8]. Moreover, media attention on specific issues often is imbalanced and selective [9]. A good example is the case of the genetically modified (GM) maize variety StarLink. The Genetically Engineered Food Alert, enhanced by statements from Friends of the Earth, received major media coverage and thus sounded a public alarm about the perceived allergenic effect of a variant of the *Bacillus thuringiensis* (*Bt*) protein; scientific research stating the safety of StarLink corn was barely mentioned in this coverage [6]. In another instance, public media sounded the alarm over GM food toxicity after one research group reported an increase in tumors among rats fed GM corn and the herbicide Roundup. Emotive headlines triggered a chain reaction [10] prompting additional coverage and, in some regions, the overall reporting of perceived risks of transgenic organisms increased [11]. Even widespread criticism of studies' methodology and inconclusive data leading to the retraction of a scientific paper from *Food and Chemical Toxicology* in 2013 did not shift the attitudes of the public.

Recently, increasing attention has been paid to NBTs and other plant genome editing methods (particularly RNA-guided endonucleases) for crop improvement [12–14]. In the USA, the plant breeding company Cibus has used gene editing technology to engineer a herbicide-tolerant rape oil seed [15]. The improved plant, with no foreign genetic material, is now available in the USA and will probably be available in Canada in 2017. There has not, however, been an obvious regulatory response in the EU. The discussion in Europe has heated up in the scientific

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community and is now slowly entering the public arena. How information about these novel techniques will be shared with the public is in our view of extreme importance as we move forward with these new technologies. Based on past experience with the regulation and acceptance of transgenic organisms, we are convinced that once NBTs are framed in a specific context, it will be very difficult to change the public's perception of their safety and value. In our opinion, it is time to rethink and reformulate the way that scientists engage with the public.

Society, Policy, and R&D

Society's role in developing a regulatory framework for scientific R&D has tended to increase significantly in many regions of the growing global economy [16]. Good examples are recent regulations regarding the cultivation of GM crops in the EU [17] that were driven by perception of risks and consumer sentiments rather than by interpretation of scientific data and reports. Under previous regulations, EU member states could not oppose the cultivation of GMOs or their use within their territories without a strict evaluation and safety assessment based on case-by-case studies; this regulation could be avoided only if the member state invoked safeguard or emergency clauses. This arrangement has changed, and the new regulations adopted in March 2015 are the result of strong sectoral advocacy against transgenic foods and an inability to achieve consensus among EU countries. The latest directive allows each EU member state to restrict or prohibit the cultivation of GM plants in all or part of its territory based on compelling reasons other than risk to human or animal health or the environment, including environmental policy objectives, town and country planning, land use, socioeconomic impacts, avoidance of GMO presence in other products, agricultural policy objectives, and public policy. Nineteen member states have 'opted out' of growing transgenic crops within all or part of their territories (http://ec.europa.eu/environment/europeangreencapital/countriesruleoutgmos/). The new regulations favor region-specific public policies above technical reasoning in decision making and thus have direct consequences for products of targeted genome engineering. If crops produced by NBTs and other genome editing techniques are considered GMOs, all 19 EU countries might prohibit these crops from being grown in their territories. It is unsurprising, therefore, that discussions have focused mostly on whether new approaches meet the legal definition of a GMO and on how to regulate different methodologies for improving plants [18–22].

Determining the regulatory status of NBTs is ongoing worldwide; most regulators consider various methodologies on a case-by-case basis. In May 2015, the government of Argentina issued the first regulation in the world applied to NBTs [23]. Under the Argentinian regulatory framework, the status of each crop is determined based on the presence of a new genetic combination, defined as when 'a stable and joint insertion of one or more genes or DNA sequences that are a part of a defined genetic construct have been inserted into the plant genome in a final product'. A similar, product-based approach adopted by the USA resulted in the definition of the status of two products obtained through NBTs (herbicide-resistant canola and maize with lower levels of phytate) as non-GMOs [24]. Australia and New Zealand are other frontrunners in intensively discussing their position on NBTs. In 2013, the authorities competently exempted some of the new genetic improvement techniques from GM legislation as no foreign genetic material was present in the final products [25]. Questions have, however, been raised against such an interpretation (www.scionresearch.com/general/publications/scion-connections/previous-issues/past-issues-list/issue-12,-june-2014/new-genetic-improvement-technologies-and-the-laws-challenge-to-keep-up).

Besides product-based regulations, there exists a process-based approach to governing GMOs. Such a paradigm for decision making does not seem to be viable in the case of breeding processes that do not introduce a transgene and traceability limitations pose a serious risk of disrupting trade (Box 1). While most scientists argue that the new tools are just an extension of traditional plant breeding practice and are as safe as their conventional equivalents