EMBO reports

viewpoint

Beyond risk

A more realistic risk–benefit analysis of agricultural biotechnologies

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Like any technology, agricultural biotechnologies that use genetically modified organisms (GMOs) have their opponents and supporters. For their proponents, the significant benefits of GMOs for humans, animals and the environment clearly outweigh any risks that are inherent with new technologies (Jauhar, 2006; Reis *et al*, 2006). For example, crops could be genetically engineered to grow more quickly and more densely to use less land, feed the increasing world population and slow environmental degradation. These new crops could also be engineered to reduce the need for pesticides and herbicides, thus decreasing the contamination of soil and water. Similarly, animals could be engineered, for example, to lack the traits that account for their suffering in large-scale, intensive animal farming environments.

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Critics of GMOs and other agricultural biotechnologies do not find such claims compelling, and see the balance between risk and benefit as less clear-cut (Margulis, 2006; Seralini *et al*, 2007). They contend that GM plants might have an allergenic potential that would render them unsafe for human consumption, that their nutritional value could be altered for the worse and that they could contribute to the spread of antibiotic resistance. Opponents also question the potential benefits of GMOs for the environment and animals. They worry that genetically altered plants could transfer recombinant DNA to other plants—thus threatening biodiversity—or that they might create superweeds or kill unintended organisms. Detractors also point out that GMO crops alone could not feed the world's population without serious social, economic and political changes.

These concerns about GMOs—although not a complete list—also indicate that previous and current discussions about the ethics of developing and using agricultural biotechnologies have focused solely, or at least primarily, on narrow assessments of risks and possible benefits (Borlaug, 2000; Raven, 2005; Weil, 2005; Singh *et al*, 2006; Oeschger & Silva, 2007). Any questions about whether and how to use biotechnology in agriculture have been, and continue to be, framed as technical concerns. Will the new crops be more productive than the old ones? Will they reduce the use of herbicides and pesticides? Are these technologies safe for humans, the environment and other animals? Will the new crops create more allergies in humans? As a result, ethical concerns are reduced to technical questions and, of course, technical questions beg for technical answers. It is thus not uncommon for those who support or reject biotechnologies to claim that their critics and the public are simply ill-informed, that they do not understand the science and that better scientific education would help people to realize the promises or perils of new technologies.

Here, we argue that limiting the ethical discussion about agricultural biotechnologies to questions of risk assessments is problematic for at least two reasons. First, doing so incorrectly assumes that the potential risks and benefits of agricultural biotechnologies, as normally understood in current risk assessments, are the sole significant normative concern. Although risk assessments are certainly important, there are many other ethical and social concerns that must also be addressed with respect to agricultural biotechnologies. Second, framing the debate as one that involves only technical problems effectively limits who can legitimately participate in the discussion. Presumably, only scientific experts are trained sufficiently to determine the risks or benefits of GMOs, and non-scientists are therefore disqualified from participating in the dialogue. But this erroneously presupposes that the evaluation of risks and benefits requires only scientific and technical analysis. Nonetheless, risk assessments not only involve scientific values, but also ethical and social ones. Thus, we make the case that these normative issues must not be left to scientific experts in a democratic society, but should be subjected to proper public deliberations—not ones steered by the media or pressure groups.

Although risk assessments are certainly important, there are many other ethical and social concerns that must also be addressed with respect to agricultural biotechnologies

Much of the scientific literature about the ethics of developing and using GMOs has identified a narrow set of issues as the crucial ethical concerns. These focus on a limited range of questions about the risks and benefits of transgenic crops for food supply, human health and the environment. With a similarly narrow focus, scientists have identified various potential benefits of GMOs; for example, GM strains could produce higher

yields than conventionally bred or wild strains (Borlaug, 2000; Raven, 2005; Jauhar, 2006; Singh *et al*, 2006; Oeschger & Silva, 2007). Citing golden rice, scientists have also made the case that GM plants could be fortified with essential nutrients to address malnutrition amongst the poor (Borlaug, 2000; Jauhar, 2006). Others argue that GM plants can be engineered to function as biopharmaceuticals, including biovaccines (Jauhar, 2006; Singh *et al*, 2006), and that GM crops are beneficial for the environment as their use requires less insecticides and herbicides (Borlaug, 2000; Jauhar, 2006).

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Not surprisingly, risk assessments to identify potential hazards have also focused on a narrow band of related issues, namely whether GMOs present any significant risks to human health and the environment. Some researchers argue that genetic engineering is akin to conventional plant breeding, but is more targeted and thus GM plants should not be held to a higher standard with respect to risk than their conventionally bred kin (Weil, 2005). Some have made the case that GMOs pose no substantial risk to human health (Thompson, 2000; Oeschger & Silva, 2007), whereas others have called for further testing and a strong regulatory system (Weil, 2005; Velkov *et al*, 2005). Some researchers have argued that the concerns about the risk of GM strains escaping into the wild, becoming superweeds, impacting biodiversity, and conferring disease and pest resistance to weeds are not justified (Trewavas & Leaver, 2001; Oeschger & Silva, 2007). However, other scientists take the risk of introgression more seriously and call for risk assessments by scientific experts, safety standards and regulatory mechanisms (Velkov *et al*, 2005; Weil, 2005; Singh *et al*, 2006).

This brief review of the scientific literature reveals that the discussion is grounded on a pervading and problematic assumption: that the primary, if not the only, ethical question about GMOs is the trade-off between the risks and benefits to human health, the world food supply and the environment. Of course, if one accepts this assumption, it seems reasonable to accept the extensive use of such products once risk assessments show that transgenics are safe for human health and the environment, or that the risks they pose are outweighed by their benefits and can be adequately managed.

As important as assessments of risk to human health and the environment are, they do not alone justify the widespread implementation of new agricultural biotechnologies. First, traditional risk assessments focus predominantly on possible harms to human health or the environment owing to the biological properties of transgenic plants and the manufacturing processes used to produce them. Such assessments fail to take into account the possible social impact of patented transgenic entities on specific human populations (Lacey, 2005). Second, even if one assumes that the magnitude, probability, significance and manageability of the risks are acceptable, one must also consider whether other alternatives exist that might be less risky or offer greater benefits. Third, the ethical aspects of risk are not limited to scale and significance.

Questions about the amount of reliable knowledge or possible action in the face of inevitable ignorance are also crucially important (Wynne, 2001).

Clearly, it is of paramount importance to evaluate the hazards that might result from the use of transgenic seeds as biological entities or from the processes used to create such seeds. However, other factors are also relevant to the public acceptance of transgenic organisms. For example, one might be concerned that the use of transgenic crops could lead to a loss of the knowledge that informs traditional farming. There are also concerns that these new agricultural products could impede the empowerment of local communities or popular participation in local decision-making processes.

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Moreover, transgenic seeds are not only biological entities, but are also the subjects of intellectual property rights, and could therefore be used to exercise control over agricultural systems and practices. Currently, a handful of seed companies own most of the patents for various GM plants, which means that farmers must purchase their seed stock from them, at prices set by those businesses. The increasing dependence of the developing world on the interests of the global-market and the effects that this might have on people's well-being are serious ethical concerns that should not be ignored. Of similar importance are considerations of the social and economic consequences of the increasing levels of ownership of the world's food resources by a handful of corporations.

Simply broadening the assessment of risk about the widespread use of new agricultural biotechnologies is not sufficient. Equally important is the question of whether better alternatives might exist—that is, alternatives that might be less risky or more beneficial. Such reflection requires that we evaluate both the goals that new biotechnologies presumably will accomplish and the particular means used to do so. For example, if the goal is to feed the hungry and to address the problem of malnutrition (Borlaug, 2000; Jauhar, 2006), it is valid to ask whether there might be alternative and/or better ways of producing sufficient food to feed the entire world population.

Moreover, if one does regard producing sufficient food for the world's population as a legitimate goal, one can also become legitimately concerned with producing and distributing it in a way that means people are actually fed. Hunger and malnutrition around the globe are the products of many factors, which include an inequitable distribution of wealth within and between nations, a lack of infrastructure to transport and distribute food to those who need it, civil wars, corrupt governments and financial policies that require poor nations to cut government spending on food for the poor. As long as these conditions exist, it is necessary to question whether and how transgenic crops alone could alleviate hunger and malnutrition among the poor.

Disagreements about the reliability or adequacy of risk assessments are not an expression of irrationality or a misunderstanding of scientific knowledge. To believe that they are is to ignore an important epistemological issue with moral significance. Risk assessments cannot eliminate uncertainty about long-term consequences and unanticipated effects (Tannert *et al*, 2007). Nonetheless, discussions about the reliability of risk assessments often fail to recognize the limits of the knowledge that they advance (Wynne, 2001). This is both a scientific issue and an ethical one. It is ethically problematic when scientists and policy makers systematically evade discussions about the possibility that even the best scientific data and analyses might be limited. If such considerations are excluded from the debate, it is unlikely that institutional regulations and safety mechanisms will be developed to deal with such unknown consequences. This is not an irrational demand to eliminate all uncertainty from scientific and technological applications; it is simply a call to seriously deliberate the goals that we want to achieve with particular innovations. Clearly, one can tolerate uncertainty if the ends are thought to be worthwhile and if there is sufficient trust in the institutional response to such uncertainties. But people might as well reject such uncertainty when the purposes are far from valued or when the trustworthiness of institutional responses is at stake.

This is not a demand to put unreasonable burdens on the risk evaluations of GMOs. The idea is not to require a complete anticipation of future consequences, as such an exhaustive consideration is impossible; the issue is actually one of intellectual humility and institutional accountability. It is unlikely that we will ever be able to fully predict and control the consequences of our scientific and technological decisions. Thus, rejecting exaggerated claims by risk experts about the power of our knowledge can also amount to a value judgment of the quality of the institutions that create and assess such knowledge, but that are disinclined to publicly discuss issues of responsibility owing to the inherent limitations of that very knowledge.

Restricting the ethical discussion about agricultural biotechnologies to questions related to the assessment of risks is problematic for reasons other than the normative concerns discussed above. It supposes that risks are objective technical phenomena that can be measured and analysed. Presumably, risks are objective because, given sufficient data, their probabilities and scope can be determined definitively (Lacey, 2005). Moreover, as decisions about risk are supposedly objective, conflicting assessments of risk–benefit balances can be attributed to scientific failures, ignorance or to ideological agendas, rather than to shortcomings of the theoretical model of risk (Vasil, 2003; Miller, 2007).

Although analysts often argue that risk assessments deal with facts, not with values, and that such evaluations do not include any normative or evaluative components, such claims are incorrect. First, all scientific investigation is unavoidably laden with theory because it requires both a definition of the research problem and a criterion for relevant evidence that relies on particular normative standards. In the case of GMOs, the questions posed by the inquiry frame and limit the types of answers that can be given. For example, traditional risk assessments of agricultural biotechnologies regard GMOs as decontextualized biological entities that can be subject to empirical investigations. Although, of course, this is perfectly legitimate under particular contexts, such assessments are problematic because they overlook the fact

that those seeds are also objects of social value with economic, legal, cultural or aesthetic significance (Lacey, 2005). Factoring those aspects of transgenics into risk analyses can certainly generate very different evaluations of GMOs and expand the range of people who can effectively take part in the debate about them.

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Second, risk assessments of GMOs also include crucial ethical assumptions, such as: what counts as a serious risk? What is the relevant time frame for investigating such risks? What are the standards required to judge that unmanageable risks are not present? What is an acceptable level of risk? Moreover, social affiliations—such as profession, gender and political ideologies—influence what one determines to be a risk (Douglas & Wildavsky, 1982). Not surprisingly, the views of laypeople and experts as to what constitutes a risk are often different (Savadori *et al*, 2004). Laypersons tend to value both the context of risk as well as its content, whereas experts usually place greater emphasis on risk endpoints rather than their context. Equally important are considerations about alternatives, the voluntary nature of the risks, concerns about equitable distribution and trust in those in charge of imposing and managing risks. All these factors shape what one perceives to be risks as well as benefits (Kunreuther & Slovic, 1996; Slovic, 1999; Eiser *et al*, 2002; Gaskell *et al*, 2004). It is therefore crucial that the discussion of such issues be as broad as possible to encompass this range of views.

As we mentioned earlier, scientific proponents of GMOs tend to categorize opposition to transgenics as either lacking scientific validity or being based on fears owing to a lack of scientific knowledge (Borlaug, 2000; Raven, 2005; Jauhar, 2006). They also seem to believe that the public should simply accept GM products that scientific experts and regulatory agencies have found to be reasonably safe (Jauhar, 2006; Singh *et al*, 2006). If we are correct, the supposition underlying traditional risk–benefit evaluations—that decisions about what are acceptable risks and appropriate trade-offs are the purview of experts—must be questioned. Given that there are several ethical and social issues at stake with respect to the development and usage of transgenics, such decisions should be subject to public deliberations, rather than treated by scientific experts—be they from government, industry or independent organizations. Scientific experts might be qualified to calculate the risks and benefits of GMOs to human health and the environment, but they are certainly not experts at determining and evaluating what the public might consider to be acceptable types of risk for several reasons (Jasanoff, 1990; Shrader-Frechette, 1991; Wynne, 1992).

First, risk assessment experts are not trained in ethics and therefore are not qualified to identify ethical and social values, and to make judgments about how those might be balanced. Second, scientists might not know enough about the public's values to be able to make decisions on its behalf. Third, a scientist, like any other individual, might be self-interested, or might be influenced by his or her particular social position when making risk assessments. Fourth, given that a substantial amount of research is funded by corporations, which shape research agendas and have a vested interest in their products reaching the market place, the decisions of scientists who are funded by such organizations might be subject to bias. Fifth, government regulatory bodies, such as the US Food and Drug Administration (FDA; Bethesda, MD, USA), the Environmental Protection Agency (EPA; Washington, DC, USA) or the Department of Agriculture (Washington, DC, USA), often consult with the industry in setting standards and regulations. Therefore, they might not take into account public values that could conflict with industry interests when they make decisions about the type and levels of risks that are ethically and socially acceptable.

The regulation of new scientific and technological advances concerns everyone. Experts should have a voice in assessing the risks and benefits of such advances; however, they do not have the right to impose their evaluative preferences on the public under the incorrect assumption that they are making only a technical decision—at least not without taking into account societal values.

We have argued that traditionally conducted risks assessments are not sufficient to support the widespread use of new agricultural biotechnologies such as GMOs. To assume that they do reduces all ethical concerns to technical questions about risks to human health and the environment. As technical questions tend to have technical answers, this presupposition comes with the belief that only the opinions of scientists and engineers, and not the ideas of the layperson, are essential to such assessments.

Many other ethical and social concerns pervade decisions about the acceptance of GMOs. In a democratic society, these normative issues must not be left to scientific experts, but should be the subject of public deliberations. Interestingly, the belief that decisions about the acceptable types and levels of risks ought to be left to experts might reinforce the idea within the scientific community that the public is unable to rationally decide which ethical and political values should govern technological developments and usage, or that the public is uninterested in those questions. Neither supposition is justified; in fact, this assumption is inappropriately paternalistic.

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We recognize that including the public in such deliberations about risk assessments might create problems of its own. There might be issues of literacy, as some people might not even have a basic science background. It might be difficult for the public to reach a consensus about what risks to accept, especially in light of conflicting scientific opinions. Nonetheless, it seems more compatible with the values of a democratic society to overcome these problems rather than to simply eliminate the public from decisions that will have a significant impact on their lives.

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doi:10.1038/embor.2008.39