Science and advocacy: the GM debate in South Africa

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SOUTH AFRICA HAS AN EFFECTIVE regulatory framework for transgenics, and its rate of adopting genetic modification technology is amongst the highest in the world. However, the ecological consequences of introducing genetically modified organisms in this country have not been systematically explored. It is critical to do so if we are to continue to make informed choices on the extent to which the technology should be adopted.

From a scientific perspective, the genetic modification (GM, referring to DNA transfer between organisms, rather than to the product of selective breeding) of plants and animals is a technological addition to the many manipulations of biological material that science has made possible. Nothing more and nothing less. It is the application of this technology that carries with it, as do most others, particular benefits as well as particular risks.[1,2] Moreover, genetic modification is not unique in being a technology where public perception and opinion play an important part in the extent to which the technology is adopted and advanced (other examples are stem-cell research and cloning[2–5]).

At the XXII International Congress of Entomology, held in Brisbane in August 2004, Jennifer A. Thomson, of the Department of Molecular and Cell Biology at the University of Cape Town, gave a plenary lecture entitled 'Genetically modified crops and food security: an African perspective'.[6] Her message was that biotechnology and genetically modified crops could contribute to relieving Africa's food crisis, and that developing countries need to use every opportunity available to improve productivity. She concluded: 'It is clear that farmers, who in Africa are so often also consumers, know a good thing when they see it'.[6]

Given the strong global anti-GM lobby and the uncertainty over the long-term benefits and environmental risks of genetically modified organisms (GMOs),[7–10] balanced against realized benefits and the vested interests of governments and agrochemical companies,[11–13] Thomson's plenary could well be considered controversial. What it did do was raise the question of what the responsibility of the scientist is in a situation where a technology is controversial,[14,15] where scientific uncertainty remains,[8] and where evidence of immediate economic and environmental benefits of its application are apparent.[1,16,17] Furthermore, what is the particular responsibility of the scientist in a South African context, where scientific capacity is underdeveloped and unrepresentative of the population at large, and public understanding of science is poor?[18]

South African circumstances

Fortunately, South Africa has a regulatory structure that compares well with international regulatory protocols for transgenics.[17] The Genetically Modified Organisms Act (No. 15 of 1997; see also the GMO Amendment Bill, *Government Gazette*, 8 October 2004, to incorporate the Cartagena Protocol on Biosafety) and the National Environmental Management: Biodiversity Act (No. 10 of 2004) are in place to attempt to ensure that the benefits of this technology are gained without compromising human health or the environment. Indeed, of the eight key components identified as characteristic of strong regulatory systems, South Africa not only compares well with the European Union and United States, but performs well on most criteria (including mandatory pre-market approval, transparency, public participation, use of outside scientists for expert scientific advice, and an enforcement authority and resources).[17] While there is room for improvement in several areas,[12,17] of relevance here is the fact that South Africa's regulatory framework requires advice from the scientific community on the impact of the development, production, use, application and release of GMOs on, amongst others, the environment (GMO Act 1997). At the same time, the rate of adoption of GM technology in South Africa is amongst the highest in the world.[19]

While issues of environmental risk continue to be broadly and actively debated in the scientific literature (for example, refs 7, 8, 14, 20–25), this debate must urgently be brought home. The South African context is markedly different from that in which most research has been conducted, including those studies cited here. South Africa is unique not only from social, economic and climatic perspectives, but it has an extraordinarily rich biodiversity for its small geographical area and is amongst the most biodiverse countries in the world.[26,27] For instance, it supports 10% of the world's vascular plants in less than 2.5% of the global terrestrial surface area.[28] Levels of endemism are also especially high, with nine recognized regions and centres of endemism in the country.[28,29] Furthermore, an ever increasing proportion of our biodiversity now interfaces closely with agricultural and other human-influenced landscapes. In this, we are following European experience where much biodiversity currently is located within agricultural areas.[22,30] The ecological consequences of new agricultural practices and technologies in South Africa are thus equally likely to be unique (see also the argument for devising local agricultural policy[31]).[1] However, these consequences have not been explored in any systematic way in this country, and local research on the subject remains scanty.

In the interests of scientific debate

In the interests of stimulating debate, therefore, here we raise several questions concerning the genetic modification of agricultural crops and their use in South Africa, a few of which were stimulated by Thomson's address.

What are the ecological risks and management change impacts of South Africa's biodiversity of planting GM crops (see, for example, refs 1, 8, 21, 22, 32)? Moreover, what are the consequences for biodiversity of extensive plantings of several different GM crops across agricultural landscapes? In the South African context, how appropriate (not only how correct) is the statement that the adverse environmental effects of conventional agriculture are worse than those of genetically modified crops (see refs 15, 33)?

Inevitably, this debate hinges on a weighting of the relative costs (environmental and otherwise) and benefits of GM technology.[14] What would a comprehensive, locally relevant assessment of risks and benefits entail? While an assessment of ecological risks fits comfortably within the domain of science, balancing these against socio-economic implications does not. Nonetheless, environmental risk-related questions are not independent of

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economic and social issues, as is well-illustrated in the issues we raise below.

In southern Africa, two important stem borers attack maize and sorghum, namely, the maize stalk borer, *Busseola fusca,* and the spotted stalk borer, *Chilo partellus.*[34] Whereas *C. partellus* is effectively controlled using *Bacillus thuringiensis* (*Bt*) transgenic maize, the technology is less effective against *B. fusca.*[35] Indeed, *B. fusca* is responsible for higher levels of ear damage than *C. partellus,* and even *Bt* transgenic maize suffers ear damage from this species.[36] A problem associated with kernel damage by these pests is the production of mycotoxins that have adverse effects on human health.[37,38] One of the advantages of *Bt* maize in Africa is thus considered to be reduced risk of mycotoxin-related ailments (including aflatoxin).[6] However, how important is ear damage caused by stem borers in the production of mycotoxins in relation to, for example, damage caused before and during storage by *Sitophilus* grain weevils, against which *Bt* maize is not resistant (see, for example, refs 39–43), or because of inadequate storage facilities?[44]

Globally, the loss of genetic diversity in key crops (such as maize and sorghum) is of serious concern.[45] Will the use of GM crops accelerate this loss? Generally, selected high-yielding varieties replace a wider range of traditional varieties because of their enhanced output.[31] However, dependence on external resources, such as patented crop varieties, is not only expensive for small-scale, developing-world farmers, but makes them vulnerable to external shocks.[46] For example, one of the most important internal resources of farmers is seed that is saved from previous harvests.[47] In this way, farmers select for high levels of horizontal resistance.[48] This practice was largely responsible for saving maize production from destruction in tropical Africa after the unintentional introduction of the fungal disease, *Pucinia polysora,* or tropical rust.[48] As well as contributing to a loss of genetic crop diversity, the replacement of local varieties by patented ones therefore changes one of the most important resources for small-scale farmers from an internality to an externality, increasing their vulnerability to external factors.[31]

The relevance of examples such as this obviously differs for subsistence and commercial farming, as well as with the particular GM technology involved. Indeed, the South African GMO Act of 1997 gives consideration to socio-economic activities and the appropriateness of particular technologies, by enabling the minister of agriculture, through the executive committee, to address such issues when deciding on release approval. These factors do, however, require ongoing assessment in the context not only of national agricultural policy but also of ecological risk and the sustainability of food security.

Again in a local context, what resources do farmers require to take full advantage of GM crops, and what training do they need to use GM varieties in accordance with risk management guidelines?[49,50] What are the effects of environmental variability and stress on the expression of GM-based resistance?[51] What strategies are to be adopted if pest resistance to GM crops develops?[4,24,52,53] In other words, how does the consideration of the relative and long-term efficacy of GM crops alter risk–benefit assessments?[54,55] How would the latter change if it were assessed on the basis of a calorific investment to output ratio, rather than on the current basis of yield per financial investment?[46] The trend towards declining energy output/input ratios in agriculture (particularly in developing regions where traditional farming techniques are replaced by modern, energy-intensive systems), which means that human food security is increasingly dependent on a dwindling world oil supply and volatile markets.[31,56] Planning for sustainable agriculture must therefore consider not only economic efficiency, but also energy efficiency, food safety and security, environmental impact and the well-being of resource-poor communities.[31,57–59]

In conclusion

The points we wish to make, therefore, include the importance of understanding the appropriateness and potential environmental risks of GMOs in a South African context, the urgent need for informed local scientific debate on the subject, as well as the potential cost of advocacy given the current status of GM and its adoption in South Africa. The primary role of the scientist is, of course, her or his addition to knowledge, which may include a contribution to technological advancement as well as to risk assessment.[7] Scientists sometimes then transfer this knowledge by becoming involved in education and policy development and administration. They may also decide to join the ranks of pro or anti lobby groups, as happened, for example, after World War II with the Pugwash Conferences on Science and World Affairs.[60,61] However, there is a further, less overt, less organized and particularly important task. That task is to explore possible scenarios, to challenge untested assumptions on both sides of the argument, to ask questions, prioritize and then answer them. Importantly, this includes research with no 'industrial strings'.[12]

Sound and sufficient science, along with scientific debate, is the only basis on which informed priority setting and decision making are possible. They are critical if South Africa is to continue making informed choices that are in our own best interests regarding the future extent to which we adopt this biotechnology, as well as identifying research priorities for local risk assessment (ecological risk assessment for GMOs forms part of the research programme of the new DST/NRF Centre for Invasion Biology at the University of Stellenbosch). Such evaluation and debate should form the foundation of responsible recommendations and decision-making on genetic modification and its application in South Africa. It is only after science has performed this task that social and economic benefits can be weighed against uncertainty and potential risk. It is only then that advocacy may play its role to the benefit of society. We have not yet reached this point with regard to the adoption of genetically modified products in South Africa, particularly as concerns potential ecological risks in a country with such a rich biodiversity heritage. Images of poisoned, starving African children do little to further the scientific evaluation of the relative risks and benefits of GMOs, and the potential ramifications of its widespread adoption in Africa. While science has an important role to play in advocacy, advocacy has no place in science.

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