Risks to biodiversity: real or imaginary?

Juergen Wiesler/Zoonar/Specialist Stock

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I am delighted to contribute to this collection of essays because I have long seen the potential of genetic engineering (GE) of crops as a tool to help feed the developing world. The idea that it is only more developed countries which profit from the use of genetically modified (GM) crops is increasingly shocking when we see that one in eight people in the world continue to go hungry. It is my hope that these essays will encourage all leaders to investigate the potential of genetically modified crops for their region and not be put off by the negatives and misrepresentations that have circulated so widely.

The new focus of agriculture is sustainable intensification ... a strategy in which GM crops can play their part

The new focus of agriculture is *sustainable intensification*. This is a key recommendation of a recent report from the Royal Society,[1] the UK's leading academy of science. It is a strategy for converting research into practice for agricultural practitioners, whether smallholders or large landholders, and for agribusinesses alike, and one in which GM crops can play their part. However, I have been a known critic of the first generation of GM crops which were developed and commercialised primarily by the private sector. Insufficient attention was paid in the early days to their potential impact on the environment, or to addressing the needs of small farmers in African and other developing countries, many of whom could benefit from the technology if applied appropriately. This situation shows signs of change, with public efforts directed towards the conservation of biodiversity, preservation of traditional crops and landraces, and increased focus on plant genetic resources such as indigenous or 'orphan' crops. Private–public partnerships are also beginning to bear fruit with the provision of technological and financial services for smallholder farmers, which can improve their well-being and help them to become entrepreneurs. It is notable that the vast majority (over 90 per cent) of farmers growing GM crops are small-scale farmers in the developing world.[2]

Dealing with risks

A risk often cited by opponents of genetic engineering is that to expand the use of GM crops would lead to the escape of genetically engineered genes into the natural environment with consequences for related varieties and species. Several common weeds in the USA have developed resistance to herbicides and there are claims that gene flow may have already occurred in wild relatives of maize in Mexico.[3] But the development of resistance to herbicides (or pesticides) is a fact of life both in agriculture and medicine, and in biology in general. It

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should surprise no one. Also, the flow of genes from modern conventionally produced maize hybrids into traditional crops (landraces) is well known.[4] Landraces have not perished or been destroyed, nor have there been cultural consequences as farmers in Mexico have taken advantage of the new crops.[5] Changes take place in plant genomes anyway because they are dynamic and not static parts of the plant itself. This is just as true of landraces as it is of GM crops. Landrace varieties are the product of generations of continuous crossing and selection by farmers themselves to achieve the optimal characteristics the farmer wants.

The message is that changes have to be accommodated and this can be achieved by making mindful choices before creating GM plants in the first place, and by rigorous monitoring of the development of a GM crop through the tests required by the international regulatory and biosafety regimes, which are far more demanding than for conventional plant breeding.[6]

One of the most important aspects of biodiversity conservation is the preservation of the habitats where wild relatives of crop species occur. It is vital to decide at the outset whether these plants should be preserved from 'contamination' by engineered genes with which they can interbreed. Each introduction of a genetically modified crop needs to be assessed on a case-by-case basis, and there is no reason why they should be denied to small farmers once they have been fully tested. Most crops are grown far from their place of origin but, even so, some favour a precautionary approach. Using this approach the modified seed of sugar beet or rape would not be introduced into the UK because they can both cross with native species; similarly with rape (*Brassica napus*), which can cross with its wild relative *Brassica rapa*, the wild turnip. But 'contamination' by gene flow should not be considered a 'show-stopper' for the reasons already pointed out. Maize does not cross with native grasses of the UK

and the use of GM maize is very unlikely to have an effect through the distribution of modified genes into the environment.

One of the greatest potentials of GM crops in the future is to enable the use of marginal lands, especially in such places as the arid regions of Africa

It is already evident in many places that the increased intensity of farming, whether using GM or conventionally bred crops, has caused the decline of various important species of birds, butterflies and other insects. This needs to be heeded and monitored. A UK government farm-scale study of three GM crops over four years showed that in the cases of rape and beet, insect wildlife was considerably reduced, but for maize there was no loss of biodiversity.[7] GM crops should only be used after adequate research has been carried out on the effect each crop has on wildlife. *Sustainable intensification* of farming methods as envisaged by the Royal Society report[1] may help to avoid destroying more native habitats and environments. Unexpectedly, in Argentina and Brazil where GM crops are widely grown, there has been an increase in certain insect populations due to a reduced frequency of pesticide use.

Invasive species are seen as another threat to native biodiversity, namely, the danger of GM plants having the genetic make-up to out-compete native plants. However, most cultivated plants have very different characteristics from weeds, of which aggressive species are well documented. Many crops never establish themselves in nature and rarely reseed after cultivation, and this is as true for maize as it is for soya beans. In general, there appears to be no reason to fear gene flow from GM plants to relatives that produce new weeds, but every situation must be dealt with by appropriate agronomic practices, whether it involves GM plants or not.[8] For example, a transgenic strain of the creeping bentgrass (*Agrostis stolonifera*) that was bred for golf courses has spread from

test plots and established itself in the wild.[9] Seeds and pollen were spread in the wind and this raises the question of whether this is the beginning of a new breed of invasives that could threaten biodiversity. Or is this an example of how special situations can arise and will need to be dealt with on a case-by-case basis?[8]

Recognising the benefits

One of the greatest potential benefits of GM crops in the future is to enable the use of marginal lands, especially in such places as the arid regions of Africa. The technique of genetic modification will also be an essential tool to create crop plants that are adapted to and can tolerate climate change. Examples of the benefits of GM crops are outlined elsewhere in this book, but in terms of helping to preserve biodiversity the greatest benefit is that it can lead to sustainable intensification of land use, and the cultivation of those marginal habitats that are of little importance for conservation. The application of GM crops that leads to more intensive use of existing croplands could reduce the need to destroy more of the natural habitats that harbour so much of the remaining biodiversity of the world. For example, salt-toleration and drought-resistance traits could enable the use of marginal land rather than destroying land currently covered by pristine habitats.

Davidson recounts the tragedy of the papaya in Thailand where a GM variety was developed with resistance to the ringspot virus that was killing the plants.[10] Greenpeace protested and dumped fruit outside the Thai Parliament to protest against the legislation that would have legalised the use of this GM papaya. This inconsiderate action has resulted in an economic loss of US$850 million in 2007 and the loss of a vitamin-B-rich source of nutrition for the Thai people.[11] The use of this GM fruit is unlikely to do any more harm to biodiversity than any other ordinary fruit crop.

Conclusion

I have outlined risks and benefits of GM crops to wildlife, recognising that many of them are no different from the introduction of any new plant variety or advanced hybrids derived from the well-established methods of conventional plant breeding.

Where GM crops are used on a large scale coupled with the use of herbicides and pesticides, they are subjected to regulations which demand that they are monitored and their effects controlled in such a way as to minimise impacts on biodiversity. Later generations of GM crops in the pipeline derived by new breeding techniques (e.g. zinc finger nuclease technology, cisgenesis and intragenesis, RNA-dependent DNA methylation) will be the subject of careful evaluation of risks and benefits to ensure that genes do not impact biodiversity. Therefore, dangers to biodiversity are controllable given adequate research and legislation and should not be used as an excuse to keep almost a billion people starving.

The challenge is to make GM varieties of crops with added benefits readily and cheaply available to the starving poor around the world. Biotechnology should be within the economic reach of poor farmers because, after all, it is the smallholder farmers of Africa (mostly women) who need to produce more food consistently and by sustainable means with little adverse effect on biodiversity.

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