COMMENT

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AJAY VERMA/REUTERS/CORBIS

Students demonstrating against the use of GM aubergine (brinjal) in the northern Indian city of Chandigarh in 2010.

Africa and Asia need a rational debate on GM crops

Policy-makers in developing countries should not be swayed by the politicized arguments dominant in Europe, say **Christopher J. M. Whitty** and colleagues.

In Europe, scientists, politicians, industry representatives and environmentalists often present genetically modified (GM) crops either as a key part of the solution to world hunger or as a pointless but dramatic threat to health and safety. Neither position is well founded.

Recently, the often shrill debate that has unfolded in some European countries, including France and the United Kingdom, for the past 20 years has been spilling over to developing economies. The government of India, for instance, is considering banning all field trials of GM crops for the next decade — a move that could hurt large- and small-scale farmers by blocking their access to certain crop varieties that have been modified to grow better in local conditions, including types of cotton, soya bean and tomato. Meanwhile, in Kenya, where more than one-quarter of the population is malnourished, the government chose to ban the import of GM food at the end of last year but not GM crop research[1]. Like similar rulings made in Europe, such decisions seem to be based in part on emotional responses to the technology.

To enable science to improve the lives of the poorest in the world, policy-makers in developing countries should resist being swayed by the politicized debate in Europe, a continent where food insecurity and malnutrition are not widely present. Instead of being either pro- or anti-GM crops, governments in developing countries should start with the specific problem at hand and assess the risks and benefits of all possible solutions — of which GM crops may be one.

Over the past 50 years, improved crop varieties have contributed almost 1% each ▶

year to the gains made in worldwide agricultural productivity[2]. In developing countries especially, new cultivars will be key in addressing the challenge of feeding rising populations in the face of climate change — along with better use of water and fertilizers, improved soil and crop management, and better storage and transport infrastructure.

Many alterations to crop varieties — to boost yields, resistance to disease and pests, nutritional value or tolerance of droughts or floods[3] — do not rely on genetic engineering. Or it may be one option among several approaches that could achieve the same result. Even in cases in which it has proved useful, genetic engineering often complements rather than supplants conventional breeding.

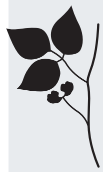
In some cases, however, it is the only viable option, for instance when there is only limited genetic variation in the trait of interest in a crop. Take the cowpea, a legume grown throughout the savannahs of Africa. Using conventional breeding, researchers have struggled for years to make cowpea resistant to a major insect pest called the Maruca pod borer (*Maruca vitrata*). The soil-borne bacterium *Bacillus thuringiensis* produces a toxin (*Bt*) that kills certain insects, including the Maruca pod borer. By crossing the *Bt* toxin gene into local cowpea varieties, researchers in Nigeria have produced resistance in 95% of plants in confined field trials (M. Ishiyaku, personal communication). In principle, *Bt* cowpea could increase yields throughout Africa by about 70% (see 'Potential life savers'). Trials on *Bt* cowpea for Maruca control are ongoing in Burkina Faso, Ghana and Nigeria, and resistant seeds will be released to farmers from 2017.

Genetic modification also offers a way to incorporate multiple traits into a plant, and to do so faster than is possible through conventional breeding.

POTENTIAL LIFE SAVERS

Genetically modified crops could transform quality of life for millions of people and boost survival rates. All three crops are in field trials.

PROVITAMIN-A-ENRICHED GOLDEN RICE
- Poor people (living on less than US$1.25 per day) eating rice each day: **400 million**
- Preschool children affected by vitamin A deficiency: **250 million**
- Deaths in children under five years that could be prevented through vitamin A provision: **>1 million**



MARUCA POD-BORER-RESISTANT COWPEA
- Consumers of cowpea in Africa: **200 million**
- Cowpea yield increase expected from pod-borer resistance: **70%**
- Reduction in insecticide spray expected with resistance: **67%**

WATER-EFFICIENT MAIZE
- Africans dependent on maize as their staple: **300 million**
- Proportion of sub-Saharan maize that suffers yield loss due to drought: **10–25%**
- Potential yield increase with drought tolerance: **20–30%**

SOURCES: GOLDEN RICE HUMANITARIAN BOARD; AFRICAN AGRICULTURAL TECHNOLOGY FOUNDATION/WEMA

Take cassava, for instance, a staple crop for millions of people in Africa. Two viral diseases — cassava mosaic disease, which stunts growth, and brown streak disease, which rots roots — affect cassava crops throughout the continent, and especially in East Africa. Varieties that are resistant to one or the other disease exist, but in many places in East Africa, both diseases are widespread. Because cassava flowers every two years, it would be enormously challenging to obtain resistance to both diseases through conventional breeding. So in Uganda and Kenya, researchers are currently investigating GM approaches.

Biofortification, whereby the nutritional value of crops is enhanced, is another area in which genetic engineering has a role. Inroads have already been made with conventional breeding methods to combat vitamin A deficiency, which can cause severe problems — for instance, by increasing the risk of childhood death from infections such as measles. An international team of researchers[4] working to improve nutrition in Mozambique and Uganda has introduced orange sweet potatoes, rich in provitamin A, into some sectors of these populations. This has translated into increased vitamin A levels in people.

In other parts of the world where sweet potatoes are not part of the staple diet, genetic modification has been used to enhance other staple crops. Producing 'golden rice', a variety genetically engineered to be rich in provitamin A, would have been impossible without using transgenic technology. Eating 150 grams of this cooked rice can provide around 60% of the Chinese recommended nutrient intake of vitamin A for 6–8-year olds[5]. Unfortunately, golden rice has not yet been approved for wide-scale use in any country, so its impact on human health has yet to be directly tested (see 'Potential life savers').

WEIGHING UP

There are good reasons for farmers in developing countries to question transgenic solutions to problems when alternatives exist. Growing non-GM crops may make better economic sense if using a GM variety would tie farmers to proprietary seeds or agrochemicals, lock them out of certain European markets, or restrict them to providing only animal feeds. The import of GM soya and maize (corn) into the European Union, for example, is currently highly regulated and limited to animal feed. Furthermore, the concern that an introduced gene will escape from one species into another with unforeseen consequences is a legitimate one, if often overstated.

Yet decision-makers in developing economies should be wary of a polarized debate that is playing out in countries where the potential benefits to society of improved crop varieties are marginal, and where people's stances towards GM foods do not necessarily reflect a considered view about the scientific technique and its alternatives.

Much of the European opposition to GM crops, although couched solely as worries about safety, also stems from concerns about the effect of large-scale farming on small-scale farmers, and the potential for biotech companies to create monopolies. In fact, people often equate all biotechnology with genetic engineering — putting the wide range of advanced non-GM techniques used to improve crops, such as tissue culture and marker-assisted breeding, into the 'unacceptable' category. These techniques can greatly assist conventional breeding efforts[6].

CARL WALSH/AURORA PHOTOS/CORBIS

In Kenya, the staple crop cassava is being genetically engineered to resist two viral diseases.

To begin with an emotional debate about GM techniques is to look down the wrong end of the telescope. Policy-makers in developing countries should instead start with the problem and make their own decisions about the balance of pros and cons of different solutions in their local context, guided by biosafety legislation.

The level of hunger and malnutrition people are currently facing in Africa and Asia, and the fact that a much higher proportion of the population in both continents depends on agriculture for their livelihoods, means that it makes little sense for decisions on GM crops to be overly influenced by European perspectives. First, by the end of the century, the United Nations estimates that less than 10% of the world's population will be living in Europe. Second, in Europe, where the benefits of better crop yields are slight, the risks (although largely theoretical, and in some cases, arguably irrational) may dominate in a risk–benefit analysis. It is worth noting that where GM technology is essential to products that Europe is short of, including some medicines, fewer concerns are expressed.

Genetic engineering is not essential, or even useful, for all crop improvements. But in some cases, it helps to improve yields and nutritional value, and reduces the risks and costs associated with the overuse of fertilizers, pesticides and water. Excluding any technology that can help people to get the food and nutrition that they need should be done only for strong, rational and locally relevant reasons. ■

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XINHUA NEWS AGENCY/EYEVINE

Terraced fields in China, where researchers are pushing crop yields close to their biophysical limits.

An experiment for the world

China's scientists are using a variety of approaches to boost crop yields and limit environmental damage, say **Fusuo Zhang**, **Xinping Chen** and **Peter Vitousek**.

For the past two decades, commentators have hailed genetically modified (GM) crops as the magic bullet that will solve the world's food crisis. Yet obtaining the drastically bigger yields needed to feed a growing and increasingly wealthy global population — without further depleting soils, destroying natural habitats and polluting air and water — will demand an all-embracing approach.

China is taking steps towards such a strategy, and so offers an extraordinary laboratory for the rest of the world. In 2003–11, the country increased its cereal production by about 32% (more than double the world average[1]), largely by improving the performance of its least-efficient farms. Yet in the next ▶