Viewpoint: Part 2 — Which developing countries are taking the lead in crop biotechnology innovation?

In Part One of this series, we “set the stage” for the economic reasons for acceptance of GM foods in developing countries, and the effects of global NGOs and other organizations that oppose GMOs. Part Two examines specific actions countries are taking to approve GM (and gene edited) foods and crops.

African nations have been in the forefront in recent years in adopting GE crops. On December 19, 2019, for example, Kenya approved the growing of *Bt* cotton after five years of field trials. Commercialization began in March of 2020. Kenya joined a growing list of African countries that cultivate GMO crops. They include South Africa (cotton, corn and soybeans), Nigeria (cotton and cowpeas), Eswatini – formerly Swaziland – (cotton), Sudan (cotton), Malawi (cotton) and Ethiopia (cotton).

[Editor’s note: This is the final part of a two-part series. Read the first part here: Viewpoint: Part 1 — Opposition stirred by anti-GMO advocacy group propaganda fading in the developing world, as more countries embrace crop biotechnology.]

Kenya has also successfully field-tested GM insect-resistant corn with expectations that full commercialization will begin by 2023.

Other nations in Africa appear to be on the verge of sanctioning the planting of GMO crops. Ghana and Burkina Faso, for example, have conducted confined field tests of GMO cowpeas and there are expectations their governments will soon approve full scale commercialization of the crop. The government of Ethiopia meanwhile has sanctioned confined trials of GMO corn.

Credit: Cornell Alliance for Science

Out of Africa

Outside of Africa a growing list of developing countries cultivate GMO crops. They include India (cotton), Myanmar (cotton), Bangladesh (brinjal – a variety of eggplant), Pakistan (cotton), Indonesia (sugar cane), the Philippines (corn), Vietnam (corn), Mexico (cotton), Chile (corn and canola), Bolivia (soybeans), Costa Rica (cotton and pineapple), Colombia (corn and cotton), Paraguay (soybeans, corn and cotton), Uruguay (soybean and corn) and Honduras (corn).

For most of these countries, the planting acreage of GMOs is relatively small as is the quantity of crops produced. India is a notable exception. In terms of acreage, it is the fifth largest producer of GMO crops, all of which is cotton. The commercialization of GM cotton has enabled it to become the largest cotton producer in the world and the third largest cotton exporter (measured in US dollars).

Many more developing countries are likely to adopt and expand GE crop production because it will enable them to diversify their economies, boost farm incomes and protect their crops from diseases and drought. It can also help to biofortify crops and thus lead to a healthier population. Vitamin A deficiency in this regard is a major problem for many developing nations.

In 2018, the UN estimated more than 140 million children are at greater risk of illness, hearing loss, blindness and even death globally because of Vitamin A deficiency. According to the World Health Organization;

> Vitamin A deficiency contributes to blindness by making the cornea very dry, thus damaging the retina and cornea. An estimated 250,000–500,000 children who are Vitamin A-deficient become blind every year, and half of them die within 12 months of losing their sight. Deficiency of vitamin A is associated with significant morbidity and mortality from common childhood infections, and is the world's leading preventable cause of childhood blindness. Vitamin A deficiency also contributes to maternal mortality and other poor outcomes of pregnancy and lactation. It also diminishes the ability to fight infections.

Scientists have been able to engineer crops that have higher levels of Vitamin A. On July 23, the Philippines became the first country in the world to approve the commercialization of genetically modified "golden rice" when it issued a biosafety permit for the crop. The rice is enriched with the Vitamin A precursor beta-carotene. The Philippine-based International Rice Research Institute (IRRI) spent about two decades working with the Philippine Agriculture Department to develop the rice. Limited quantities of seed will be distributed to farmers in 2022. Golden rice is also being reviewed by regulators in Bangladesh for possible approval for commercialization.

Scientists have been working on developing other crops that are enriched with beta carotene including cassava, sorghum and bananas as well as fortifying crops with iron and zinc.

Disease resistant crops

Many staple and export crops grown by developing nations are plagued by diseases that reduce output and thus restrain farm income. Farmers have to spend large sums purchasing fungicides to deal with these diseases. Genetic engineering though could make such purchases no longer necessary by creating plants that are effectively inoculated against diseases.

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One of the most important crops in Africa is cassava. Of the top twelve producers of cassava in the world in 2019, seven were African nations with Nigeria in first place followed by the Democratic Republic of the Congo.

Cassava is a root vegetable that is the third largest source of food carbohydrates in the tropics after rice and corn. It is not only used as a staple food but is also used to make tapioca, flour to bake bread, used as animal feed and to make beer. Scientists have even been able to make biodegradable plastic from cassava starch.

On June 15, Kenya approved performance trials for GMO cassava that is resistant to cassava brown streak disease. The Kenya National Biosafety Authority (NBA) approved the application after conducting a thorough safety assessment that demonstrated the cassava is unlikely to pose any risk to human and animal health or to the environment when consumed as food or feed or when cultivated in open fields. The National Performance Trials that will be conducted are the penultimate step before full commercialization.

The Cavendish banana, which is the dominant exported banana, is threatened by Fusarium wilt, commonly referred to as Panama disease. It is spreading throughout the world devastating the major banana growing regions and threatening to wipe out the crop in the same manner as the Panama disease wiped out the Gros Michel banana in the 1950s. Gros Michel was the previous dominant banana variety.

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Credit: Alisbalb/Getty Images

Bananas are the most traded fruit in the world and a major source of jobs and export receipts for many developing countries. As a result, its demise will have a devastating economic impact in many parts of the world. In 2020, exports totaled $14.7 billion with Ecuador, the Philippines, Costa Rica, Colombia and Guatemala accounting for 58.2% of the total. Asia is the largest banana producing region but Latin America and the Caribbean account for about 80% of global exports. In Africa, bananas are a source of income and jobs for around 70 million people.

In February 2021, a team of Australian scientists announced they have successfully created a GMO banana resistant to Panama disease by inserting a gene into the Cavendish banana from a wild banana variety. Kenyan scientists meanwhile have created a banana resistant to the banana wilt disease using CRISPR technology.

Cocoa is another crop that is threatened by diseases. About 38 percent of the crop is lost every year to diseases such as black pod and swollen shoot, and to insects. Cocoa is grown mainly in developing countries with the Ivory Coast accounting for 41.9% of total output in 2020, Ghana 18.2% and Indonesia 13.6%.

Scientists at Penn State are using CRISPR technology to try to develop a cocoa plant that is resistant to diseases. The research is focusing on silencing a gene that suppresses the defense response of the tree. It is hoped that knocking out the gene will increase the resistance of the plant to natural pathogens.

Responding to climate change

Climate change will present challenges to many farmers in developing countries as rainfall declines and drought becomes more prevalent. African scientists therefore are using genetic engineering to create crops that are water efficient and drought resistant.

Nigeria, for example, has conducted performance trials for genetically engineered high-yielding nitrogen-efficient, water-efficient, salt-tolerant (NEWEST) rice. It is able to resist drought, withstand salty soil and make use of limited nitrogen in the soil, thus reducing the need for fertilizer. Abdullahi Mustapha, the director-general of the National Biotechnology Development Agency (NABDA), indicated that Nigeria is losing billions of naira a year as a result of the massive importation of rice. He identified nitrogen deficiency and drought as a key impediment to increasing rice production in Africa and said improved nitrogen use for rice production would boost crop yields, lower the Africa's nitrogen fertilizer deficit, reduce soil nutrient depletion and protect water quality.

Since 2017, Mozambique has been conducting field trials for GMO drought-tolerant insect resistant corn under the auspices of the Water Efficient Maze for Africa (WEMA) program. WEFMA was begun in March 2008. It is designed to help farmers manage the risk of drought by developing varieties of corn that yield 24% to 35% more grain under moderate drought conditions than currently available varieties. Kenya, Mozambique, Tanzania, South Africa, Uganda, Zimbabwe and Zambia are participants.

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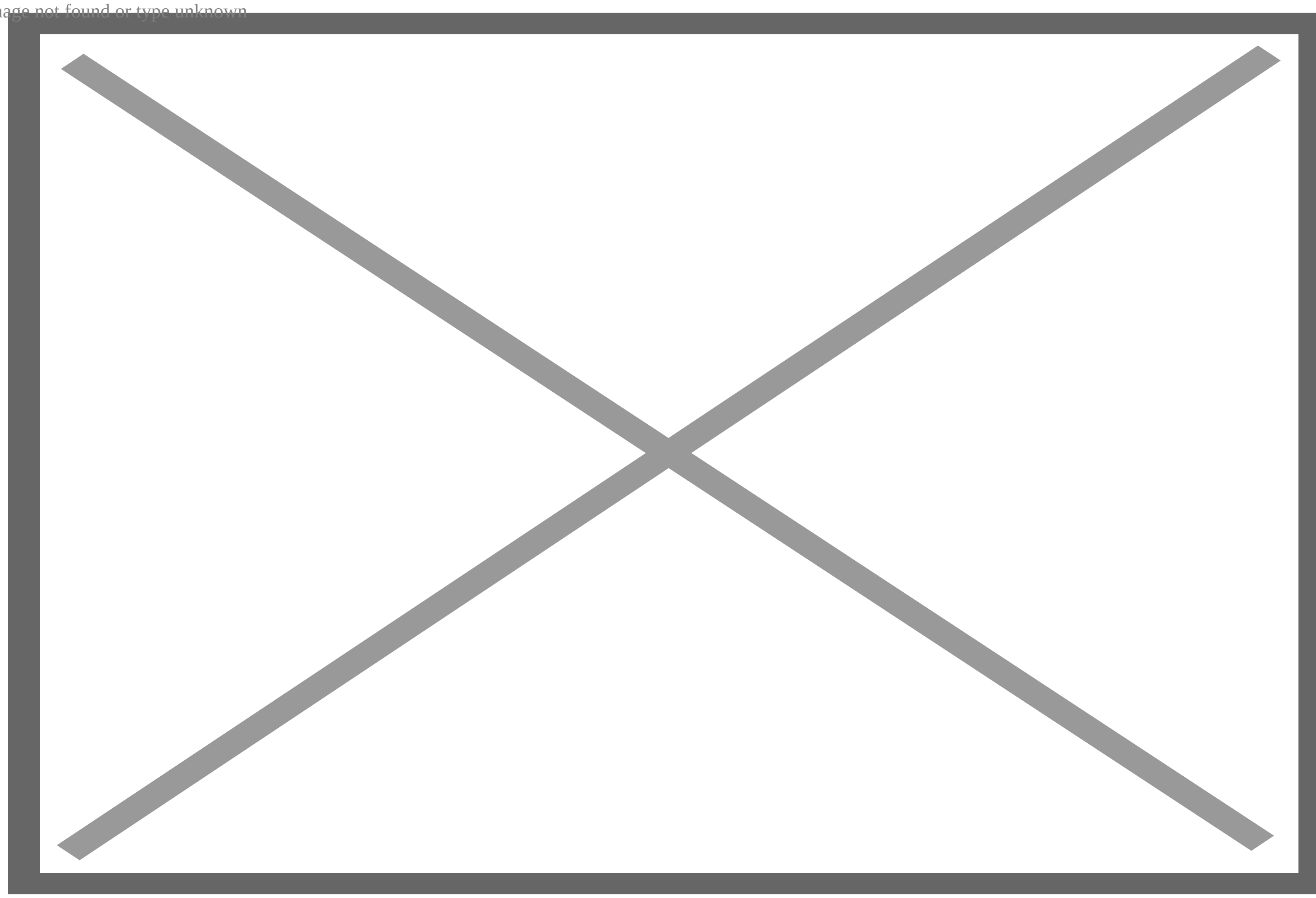

Credit: WEMA

In October 2020, Colombia announced that it along with the US have sanctioned the commercialization of a gene-edited rice via CRISPR technology that is resistant to bacterial blight disease. Six research institutions collaborated on the project. According to the IRRI bacterial blight can cause losses of as much as 70%. Once rice plants are infected there are no chemical or crop management practices that can stop the disease.

Indonesia, long wary of GMO crops, is also emerging as a prospective biotechnology innovation hotspot. According to a USDA Global Agriculture Information Network Biotechnology Report:

> The Government of Indonesia and local universities continue to research a number of GE crops, including virus resistance for tomato, rice, potato and sugar cane… To date, 15 GE corn varieties, nine GE soybean varieties, three GE sugarcane varieties, one GE potato variety and one GE canola variety have undergone risk assessment for either food, feed or environmental safety… It has also started researching Bt rice and genome editing for gemini virus resistant chili, greening disease resistant citrus, and low cadmium absorbent rice… The University of Jember, is conducting research on golden rice… with the expectation that these crops will be ready for risk assessment in two years. Research on mosaic virus resistant sugar cane at the

University of Jember has completed and pending further assessment for possible commercialization.

More and more developing countries are likely to realize the benefits of genetic engineered crops as a tool in helping them increase food production at a time of growing population, climate change and the spread of diseases that could potentially devastate crop output. Instead of shunning GE technology they will be embracing it because they have no other choice. They will ignore the scare tactics of many anti-GMO NGOs and the doubts of Europe because as poor countries with a growing population they do not have the luxury of shunning science.

Steven E. Cerier is a freelance international economist and a frequent contributor to the Genetic Literacy Project.