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Caught Between the War of Giants

How Can Less Developed Countries Benefit from Ag-Biotech?

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Abstract: Developments in modern agricultural biotechnology have proved to be a boon to industrialized nations, and the same technology in the hands of farmers in less developed nations have been shown to help them even more. In addition, many biotech products currently in the research pipeline are being developed specifically for resource-poor farmers. To make those benefits available, political issues must first be overcome, but the technology has been demonstrated to be safe for consumers and the environment, justifying widespread use.

> *"To deny desperate, hungry people the means to control their futures by presuming to know what is best for them is not only paternalistic but morally wrong…we want to have the opportunity to save the lives of millions of people and change to course of history in many nations. … The harsh reality is that, without the help of agricultural biotechnology, many will not live."*[1]
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> Hassan Adamu, Nigerian minister of agricultural and rural development, writing in *The Washington Post*, September 11, 2000.

Today, most people around the world have access to a greater variety of nutritious and affordable foods than ever before, thanks mainly to developments in agricultural science and technology. The average human lifespan—arguably the most important indicator of quality of life—has increased steadily in the past century in almost every country. Even in many less developed countries, the average human lifespan has doubled in the past few decades. Despite the massive increase in population, the global malnutrition rate decreased in that period from 38 percent to 18 percent, and meanwhile, giants such as India and China have quadrupled their food grain production.

The record of agricultural progress during the past century speaks for itself. Those countries that developed and embraced improved agricultural technologies have brought unprecedented prosperity to their people, made food much more affordable and abundant, helped to stabilize farm yields, and reduced the destruction of wild lands.[2] The productivity gains derived from scientifically bred, high-yielding crop varieties, as well as improved use of synthetic fertilizers and pesticides, allowed the world's farmers to double global food output during the last 50 years, on roughly the same amount of land, at a time when global population rose more than 80 percent.[3] Without these improvements in plant and animal genetics and other scientific developments, collectively known as the Green Revolution, we would today be farming on every square inch of arable land to produce the same amount of food, destroying hundreds of millions of acres of pristine wilderness in the process.

The Challenge of Food Security in Developing Countries

Many less developed countries in Latin America and Asia benefited tremendously from the Green Revolution. But due to a variety of reasons, both natural and human, agricultural technologies were, unfortunately, not spread equally across the globe. Many people in sub-Saharan Africa and parts of South-Asia continue to suffer from abject rural poverty driven by poor farm productivity. Consequently, some 740 million people go to bed daily on an empty stomach, and nearly 40,000 people—half of them children—die every day due to hunger- or malnutrition-related causes. Unless trends change soon, the number of undernourished could well surpass 1 billion by 2020.[4]

What can we do about this needless and cruel situation? In many less developed countries—where subsistence farmers eke out meager livings and the ability to provide enough food for mere survival is perilously uncertain—the vital importance of increasing the yields of staple crops such as rice, millet, cowpea, sweet potato and cassava cannot be overstated. In many places, the loss of a crucial crop to pests, diseases or weather can literally mean the difference between life and death, threatening the well-being of entire communities.

Despite assertions by critics of technology, providing genuine food security for such people must include solutions other than mere redistribution. According to a report published jointly by the National Academies of Science from Brazil, China, India, Mexico and the United States, the UK's Royal Society, and the Third World Academy of Science:

> *"In developing countries…about 650 million of the poorest people live in rural areas where the local production of food is the main economic activity. Without successful agriculture, these people will have neither employment nor the resources they need for a better life…Farming the land is the engine of progress…in less developed countries."*[5]

Coupled with that great need is the fact that the rate of increase in food production globally has dropped from 3 percent per annum in the 1970s to 1 percent per annum now.[6] Burgeoning populations, especially in the developing world, could very well soon outstrip global food production. The U.N. Food and Agriculture Organization (FAO) expects the world's population to grow to more than eight billion by 2030. The FAO report, *World Agriculture: Towards 2015/30*, projects that global food production must increase by 60 percent to accommodate the estimated population growth, close nutrition gaps and allow for dietary changes over the next three decades.[7]

Modern Biotechnology Joins Crop Development

Although better farm machinery and development of synthesized fertilizers, insecticides and herbicides have been extremely useful, an improved understanding of the principles of inheritance and modern genetics has been the single most important factor in enhancing food production. In a recent survey, members of the professional society North American Agricultural Journalists ranked crop hybridization, recombinant DNA genetic modification, the discovery of DNA's double helix structure and the Green Revolution's development of modern crop varieties as the four most important events in agriculture during the past 50 years.[8]

Every crop is a product of repeated genetic editing by humans over the past few millennia. Our ancestors chose a few once-wild plants and gradually modified them simply by selecting those with the largest, tastiest, or most robust offspring for propagation. In that way, organisms have been altered over the millennia so greatly that traits present in existing populations of cultivated rice, wheat, maize, soy, potatoes, tomatoes and many others, have very little in common with their ancestors. Wild tomatoes and potatoes contain very potent toxins, for example. But today's cultivated varieties have been modified to produce healthy and nutritious food.

Hybridization, the mating of different plants of the same species, has helped us assimilate desirable traits from several varieties into elite cultivars. And when desired characteristics were unavailable in cultivated plants, genes were liberally borrowed from wild relatives and introduced into crop plants. Commercial tomato plants are commonly bred with wild tomatoes to introduce improved resistance to pathogens, nematodes, and fungi.[9] Successive generations then have to be carefully back-crossed into the commercial cultivars to eliminate any unwanted traits accidentally transferred from the wild varieties, such as glyco-alkaloid toxins common in the wild species.

Even when crop and wild varieties refuse to mate, various tricks can be employed to produce "wide crosses" between two plants that are otherwise sexually incompatible. Often, the embryos created by wide crosses usually die prior to maturation, so they must be "rescued" and cultured in a laboratory environment. Even then the rescued embryos typically produce sterile offspring. They can only be made fertile again by using mutagenic chemicals that cause the plants to produce a duplicate set of chromosomes.[10] The plant triticale, an artificial hybrid of wheat and rye, is one such example of a wide-cross hybrid made possible solely by the existence of embryo rescue and chromosome doubling techniques. Triticale is now grown on over three million acres worldwide, and dozens of other products of wide-cross hybridization are also common.

When a desired trait cannot be found within the existing gene pool, breeders can create new variants by intentionally mutating plants with x-ray or gamma radiation, with mutagenic chemicals, or simply by culturing clumps of cells in a Petri dish. A relatively new mutant wheat variety has been produced with chemical mutation to be resistant to the BASF herbicide ClearField. Mutation breeding has been in common use since the 1950s, and more than 2,250 known mutant varieties have been bred in at least 50 countries, including France, Germany, Italy, the United Kingdom, and the United States.[11]

Recombinant DNA methods thus must be seen as a recent extension of the continuum of techniques that we have employed to modify and improve our crops. The primary difference is that modern bioengineered crops involve a precise transfer of one or two known genes into plant DNA—a surgical alteration of the a tiny part of the crop's genome compared to the sledgehammer approaches of traditional and wide-cross hybridization or mutation breeding, which bring about gross genetic changes, many of which are unknown and unpredictable. Furthermore, unlike varieties developed from more conventional breeding, modern bioengineered crops are rigorously tested and subjected to intense regulatory scrutiny prior to commercialization.[12]

The scientific community, plant breeders and farmers have thus overwhelmingly accepted and supported the use of gene technologies in crop improvement. Accumulated knowledge after decades of plant breeding, combined with expert judgment, science-based reasoning and empirical research, has further generated confidence that modern bioengineered crops pose no new or heightened risks which could not be identified and mitigated, and that any unforeseen hazards are likely to be negligible and manageable.

Leading scientists around the world have attested to the health and environmental safety of agricultural biotechnology, and they have called for bioengineered crops to be extended to those who need it most—hungry people in the developing world. The technology has been endorsed by dozens of scientific and health associations, including the U.S. National Academy of Sciences,[13] the UK's Royal Society,[14] the United Nations Development Programme,[15] and many others. Nearly 3,500 eminent scientists from all around the world, including twenty Nobel laureates, have signed a declaration supporting the use of agricultural biotechnology (see www.agbioworld.org). And a review of 81 separate research projects conducted over 15 years and funded by the European Union found that bioengineered crops and foods are just as safe for the environment and for human consumption as conventional crops, and in some cases are even safer because the genetic changes in the plants are much more precise.[16]

This confidence has been validated by the excellent safety record of the biotech crops and food derived from such crops since their commercial inception almost a decade ago.[17] When given a choice, most farmers readily choose biotech seeds because of the value they bring. Farmers around the world have embraced modern genetic technology because it makes farming more efficient, protects or increases yields and reduces reliance on chemicals that, other things being equal, they would prefer not to use. Opponents of the technology like to discount or even ignore such information as corporate public relations puffery. But, crops enhanced through modern biotechnology are now grown on nearly 58 million hectares in 16 countries. More importantly, more than three-quarters of the 5.5 million growers who benefited from bioengineered crops were resource-poor farmers in the developing world.[18]

Unremarkably, most commercially available biotech plants were designed for farmers in the industrialized world. They include varieties of corn, soybean, potato and cotton modified to resist insect pests, plant diseases, and to make weed control easier. However, the increasing adoption of transgenic varieties by developing countries over the past few years has shown that their counterparts can benefit at least as much as, if not more than, their industrialized country counterparts. The productivity of farmers everywhere is limited by crop pests and diseases—and these are often far worse in tropical and subtropical regions than the temperate zones.

About 20 percent of plant productivity in the industrialized world, but up to 40 percent in Africa and Asia, is lost to insect pests and pathogens, despite the on-going use of copious amounts of pesticides.[19] The European corn borer destroys approximately seven percent, or 40 million tons, of the world's corn crop each year—a sum equivalent to the annual food supply, in calories, for 60 million people. So, naturally, it should come as no surprise that when they are permitted to grow bioengineered varieties, poor farmers in less developed nations have eagerly snapped them up. According to the International Service for the Acquisition of Agri-Biotech Applications, farmers in less developed countries now grow nearly one quarter of the world's transgenic crops on more than 26 million acres (10.7 million hectares), and they do so for many of the same reasons that farmers in industrialized nations do.[20]

But the benefits of these traits don not end there. It should be relatively easy to move insect- and disease-resistant traits into crops such as cassava and sweet potato, staples of the central African diet, which provide vital sources of calories and essential vitamins and minerals to millions. In 1998, the people of Africa lost 60 percent of their cassava crop to mosaic virus. Sweet potato yields in many African nations have been laid dangerously low, with some farmers losing up to 80 percent of expected yields due to the sweet potato weevil and the feathery mottle virus.

Biotech scientists are working to solve these problems by producing plants that resist pests and disease, major causes of crop damage in the developing world. Research is under way on sweet potatoes that produce their own protection against feathery mottle virus, as well as beans, cassava and other staple foods with enhanced natural tolerance to diseases, pests and physical stresses. In 1997, the World Bank's Consultative Group on International Agricultural Research estimated that, with important traits like these, biotechnology could help improve world food production by up to 25 percent.[21]

In the words of late Dr. John Wafula, the head of biotechnology research at the Kenya Agricultural Research Institute:

"The need for biotechnology in Africa is very clear. The use of high-yielding, disease-resistant and pest-resistant crops would have a direct bearing on improved food security, poverty alleviation and environmental conservation in Africa."[22]

Biotechnology Has Begun to Impact the Developing World

World hunger is a complex problem, one for which there is no single solution. Biotechnology will not, by itself, be a solution to the problem, but it can be a valuable tool in the struggle to feed a hungry world. South African and Chinese farmers have been growing transgenic insect-resistant cotton for several years, achieving yield increases of more than 20 percent and cost savings of nearly 30 percent.[23] The Indian government approved insect-resistant cotton for commercial cultivation in the spring of 2002. This cotton variety, similar to the varieties so popular in the United States, boosted yields by 30 percent or more in field trials conducted by Indian farmers.[24] Eventually, it could even transform India from the world's third largest producer of cotton into the largest.

While cotton is not a food crop, many less developed country governments have felt more comfortable approving it as their first bioengineered crop. But cotton is an important cash crop, generating important financial gains for its growers. In addition, South African and Filipino farmers are now growing transgenic corn, and the former are also growing transgenic soybeans. This latter crop variety has proven to be quite popular in South America. Farmers in Argentina, the world's third biggest producer of soybeans, plant more than 90 percent of their soybean acreage with bioengineered varieties.[25] Experience with the product there has been so positive that neighboring farmers in Brazil and Paraguay, where no biotech varieties have yet been approved by the government, routinely smuggle bioengineered soybean seed from Argentina to grow the variety illegally.[26]

Aside from improved productivity, bioengineered plants have had other important benefits for farmers in less developed nations. In China, for example, where pesticides are typically sprayed on crops by hand, some 400 to 500 cotton farmers die every year from acute pesticide poisoning. A study conducted by researchers at Rutgers University in the United States and the Chinese Academy of Sciences found that adoption of transgenic cotton varieties in China has lowered the amount of pesticides used by more than 75 percent and reduced the number of pesticide poisonings by an equivalent amount.[27] Another study by economists at the University of Reading in Britain found that South African cotton farmers have seen similar benefits.[28]

The reduction in pesticide spraying also means that fewer natural resources are consumed to manufacture and transport the chemicals. Researchers in the United States found that in 2000 alone, U.S. farmers growing transgenic cotton used 2.4 million fewer gallons of fuel, 93 million fewer gallons of water, and were spared some 41,000 10-hour days needed to apply pesticide sprays.[29] The National Center for Food and Agricultural Policy further found that biotechnology-derived plants-soybeans, corn, cotton, papaya, squash and canola-increased U.S. food production by four billion pounds, saved $1.2

billion in production costs, and decreased pesticide use by about 46 million pounds in 2001.[30]

Soon many transgenic varieties that have been created specifically for use in less developed nations will be ready for commercialization. Examples include insect-resistant rice varieties for Asia, virus-resistant sweet potato for Africa and virus-resistant papaya for Caribbean nations. The next generation of transgenic crops now in research labs around the world is poised to bring even further productivity improvements for the poor soils and harsh climates that are characteristic of impoverished regions.[31] Scientists have already identified genes for resistance to environmental stresses common in tropical nations, including tolerance to soils with high salinity and to those that are particularly acidic or alkaline.

A Mexican research group, led by the highly regarded Luis Herrera Estrella, has shown that tropical crops can be modified using biotechnology to better tolerate acidic soils, significantly increasing the productivity of corn, rice and papaya.[32] These traits for greater tolerance to adverse environmental conditions would be tremendously advantageous to poor farmers in less developed countries, especially those in Africa. By making it easier to farm marginal lands and by improving the crop productivity, the hardier crops may also help to conserve hotspots of biodiversity such as wetlands and tropical rainforests by reducing or eliminating the need to convert undeveloped land to food production.[33]

The primary reason why Africa never benefited from the Green Revolution is that plant breeders focused on improving crops such as rice, wheat, and corn, which are not widely grown in Africa. Plus, much of the African dry lands have little rainfall and no potential for irrigation, both of which play essential roles in productivity success stories for crops such as Asian rice. And the remoteness of many African villages and the poor transportation infrastructure in landlocked African countries make it difficult for African farmers to obtain agricultural chemical inputs such as fertilizers, insecticides and herbicides—even if they could be donated by aid agencies and charities, or if they had the money to purchase them. But, by packaging technological inputs within seeds, biotechnology can provide the same, or better, productivity advantage as chemical or mechanical inputs, but in a much more user-friendly manner. Farmers could be able to control insect pests, viral or bacterial pathogens, extremes of heat or drought and poor soil quality, just by planting these crops.

Still, anti-biotechnology activists like Vandana Shiva of the New Delhi-based Research Foundation for Science, Technology and Ecology and Miguel Altieri of the University of California at Berkeley, argue that poor farmers in less developed nations will never benefit from biotechnology because it is controlled by multinational corporations. According to Altieri, "Most innovations in agricultural biotechnology have been profit-driven rather than need-driven. The real thrust of the genetic engineering industry is not to make third world agriculture more productive, but rather to generate profits."[34]

But that sentiment is not shared by the thousands of academic and public sector researchers actually working on biotech applications in those countries. Cyrus Ndiritu, former director of the Kenyan Agricultural Research Institute, argues that "It is not the multinationals that have a stranglehold on Africa. It is hunger, poverty and deprivation. And if Africa is going to get out of that, it has got to embrace [biotechnology]."[35]

Improved Health through Better Nutrition

Biotechnology also offers hope of improving the nutritional benefits of many foods. The next generation of bioengineered products now in development at labs around the world is poised to bring direct health benefits to consumers through enhanced nutritive qualities that include higher protein content, better quality proteins, lower levels of saturated fat, increased vitamins and minerals, and many others.[36] Bioengineering can also reduce the level of natural toxins (such as the cyanogens in cassava and phytohemagglutinin in kidney beans) and eliminate certain allergens from foods like peanuts, wheat, and milk.[37] Many of these products are being developed primarily or even exclusively for poor subsistence farmers and consumers in less developed countries.

Among the most well known is the variety called "Golden Rice," genetically enhanced with added beta carotene which is converted to vitamin A in the human body. Another variety developed by the same research team has elevated levels of digestible iron.[38] The diet of more than three billion people worldwide includes inadequate levels of essential vitamins and minerals, such as vitamin A and iron. Deficiency in just these two micronutrients can result in severe anemia, impaired intellectual development, blindness and even death.[39] And even though charities and aid agencies such as the United Nations Children's Fund and the World Health Organization have made important strides in reducing vitamin A and iron deficiency, success has been fleeting. No permanent effective strategy has yet been devised, but Golden Rice may finally provide one.

Importantly, the Golden Rice project is a prime example of the value of extensive public sector and charitable research activities. The rice's development was funded mainly by the New York-based Rockefeller Foundation, which has promised to make the rice available to poor farmers at little or no cost. It was created by scientists at public universities in Switzerland and Germany with assistance from the Philippines-based International Rice Research Institute and from several multinational corporations.[40]

Golden Rice is not the only example. Scientists at publicly-funded, charitable and corporate research centers are developing many similar crops. Indian scientists have recently announced that they would soon make a new high-protein potato variety available for commercial cultivation.[41] Another team of Indian scientists, working with technical and financial assistance from Monsanto, are developing and improved mustard variety with enhanced beta-carotene in its oil. One lab at Tuskegee University is enhancing the level of dietary protein in sweet potatoes, a common staple crop in sub-Saharan Africa. Researchers are also developing varieties of cassava, rice and corn that more efficiently absorb trace metals and micronutrients from the soil, have enhanced starch quality and contain more beta-carotene and other beneficial vitamins and minerals.

Research is already underway on fruits and vegetables that could one day deliver life-saving vaccines—such as a banana that could soon deliver the vaccine for Hepatitis B, and a potato that provides immunization against diarrheal diseases—making inoculation against deadly diseases possible by using locally grown crops that are easy to handle, distribute and administer.[42]

Admittedly, experts recognize that the problem of hunger and malnutrition is not solely caused by a shortage of food. The primary causes of hunger in some countries have been political unrest and corrupt governments, poor transportation and infrastructure and, of course, poverty. All of these problems and more must be addressed if we are to ensure real, worldwide food security. But producing enough for 8 or 9 billion people will require greater yields in the regions where food is needed most, and in crops consumed by resource-poor people. New varieties derived through biotechnology provide good, low-input tools to achieve this goal.

High Anxiety – Public Unease over Bioengineered Crops?

Ingredients produced from modern biotech modification are found in thousands of food products consumed worldwide.[43] Yet, even though no legitimate evidence of harm to human health or the environment from these foods is known or expected, there is an intense debate questioning the value and safety of bioengineered organisms. Although it may seem reasonable for consumers to express a concern that they “don’t know what they’re eating with bioengineered foods,” it must be repeated that consumers never had that information with conventionally modified crops either.

Indeed, while no assurance of perfect safety can be made, breeders know far more about the genetic makeup, product characteristics, and safety of every modern bioengineered crop than those of any conventional variety ever marketed. Breeders know exactly what new genetic material has been introduced. They can identify where the transferred genes have been inserted into the new plant. They can test to ensure that transferred genes are working properly and that the nutritional elements of the food have been unchanged. None of these safety assurances has ever before been made with conventional breeding techniques.

Consider, for example, how conventional plant breeders would develop a disease-resistant tomato. Sexual reproduction introduces chromosome fragments from a wild relative to transfer a gene for disease resistance into cultivated varieties. In the process, hundreds of unknown and unwanted genes are also introduced, with the risk that some of them could encode toxins or allergens.[44] Yet regulators never routinely test conventionally bred plant varieties for food safety or environmental risk factors, and they are subject to practically no government oversight.

We have always lived with food risks. But modern genetic technology makes it increasingly easier to reduce those risks. Societal anxiety over the new genetic modification is, in some ways understandable. It is fueled by a variety of causes, including unfamiliarity, lack of reliable information about regulatory safeguards, a steady stream of negative opinion in the news media, opposition by activist groups, growing mistrust of industry and a general lack of awareness of how our food production system evolved over time. But saying that public apprehension over biotechnology is understandable is not the same as saying that it is valid. There is no evidence at all that bioengineering creates any new environmental or public health risks.

Do Bioengineered Crops Harm the Environment?

Certain aspects of modern farming have had a negative impact on biodiversity and on air, soil, and water quality. But do modern bioengineered crops pose greater environmental risks, as critics claim? In fact, the innovation of biotechnology has proven safer for the environment than anything dating after the invention of the plow.

The risk of cross pollination from crops to wild relatives has always existed, and such “gene flow” occurs whenever crops grow in close proximity to sexually compatible wild relatives. Yet breeders have continuously introduced genes for disease and pest resistance through conventional breeding into all of our crops. Traits, such as stress tolerance and herbicide resistance, have also been introduced in some crops with conventional techniques, and the growth habits of every crop have been altered. Thus, not only is gene modification a common phenomenon, but so are many of the specific kinds of changes made with rDNA techniques.[45]

Naturally, with both conventional and rDNA-enhanced breeding, we must be vigilant to ensure that newly introduced plants do not become invasive and that weeds do not become noxious as a result of genetic modification. Although modern genetic modification expands the range of new traits that can be added to crop plants, it also ensures that more will be known about those traits and that the behavior of the modified plants will be, in many ways, easier to predict. That greater knowledge, combined with historical experience with conventional genetic modification, provides considerable assurance that such risks will be minimal and manageable.

It should also be comforting to recognize that no major weed or invasiveness problems have developed since the advent of modern plant breeding, because domesticated plants are typically poorly fit for survival in the wild. If this were a genuine problem with domesticated crop plants, it would have emerged centuries ago. Indeed, concerns about bioengineered crops running amok, or errant genes flowing into wild species—sometimes characterized as “gene pollution”—pale in comparison to the genuine risk posed by introducing totally unmodified “exotic” plants into new ecosystems. Notable examples of the latter include water hyacinth in Lake Victoria, cord-grass in China, cattail in Nigeria and kudzu in North America.[46]

This is, of course, not to say that no harm could ever come from the introduction of modern bioengineered or conventionally modified crop varieties. Some traits, if transferred from crops to wild relatives, could increase the reproductive fitness of weeds and cause them to become invasive or to erode the genetic diversity of native flora, and a few cases of this happening have been documented with conventionally modified crops.[47] But the magnitude of that risk has solely to do with the traits involved, the plants into which they are transferred and the environment into which they are introduced. Consequently, breeders, farmers and regulators are aware of the possibility that certain traits introduced into any new crop varieties, or new varieties introduced into different ecosystems, could pose genuine problems, and these practices are carefully scrutinized. Again, this risk occurs regardless of the breeding method used to introduce new traits into a crop.

Finally, one must also recognize the potential positive impact of rDNA modified crops on the environment. Already, commercialized bioengineered crops have reduced agricultural expansion and promoted ecosystem preservation; improved air, soil and water quality as a consequence of reduced tillage, chemical spraying, and fuel use; and enhanced biodiversity because of lower insecticide use.[48]

Studies have shown that the eight most common modern bioengineered crops grown in the United States alone increased crop yields by nearly 2 billion kg, provided a net value of $1.5 billion and reduced pesticide use by 20 million kg.[49] A 2002 Council for Agricultural Science and Technology report also found that rDNA-modified crops promote the adoption of conservation tillage practices, resulting in many other important environmental benefits: 37 million tons of topsoil preserved; 70 percent reduction in herbicide run-off; 90 percent decrease in soil erosion; and from 15 to 26 liters of fuel saved per acre.[50]

Unnecessary Speed Bumps and Road Blocks

Although the complexity of biological systems means that some promised benefits of biotechnology are many years away, the biggest threat that hungry populations currently face are restrictive policies stemming from unwarranted public fears. Although most Americans tend to support agricultural biotechnology, many Europeans and Asians have been far more cautious.[51] Anti-biotechnology campaigners in both industrialized and less developed nations are feeding this ambivalence with scare stories that have led to the adoption of restrictive policies. Those fears are simply not supported by the scores of peer-reviewed scientific reports or the data from tens of thousands of individual field trials.

The evidence clearly shows there is no difference between the practices necessary to ensure the safety of transgenic plants and the safety of conventional ones.[52] In fact, because more is known about the genes that are moved in transgenic breeding methods, ensuring the safety of transgenic plants is actually easier. But the public's reticence about transgenic plants has resulted in extensive regulations that require literally thousands of individual safety tests that are often duplicative and largely unnecessary for ensuring environmental protection or consumer safety. In the end, over-cautious rules result in hyper-inflated research and development costs and make it harder for poorer countries to share in the benefits of biotechnology.

While most surveys and focus reports show that public's anxiety about bioengineered food is at the bottom of their food worries, the issue of "public acceptance" has been simply made a scapegoat by politicians in many countries to slow down the adoption of food biotechnology. A recent commentary in *The Times* of London put it aptly:

> "*Asking people whether they're for or against GM crops is as ridiculous as asking whether they're for or against fire. As Prometheus found out, a mastery of flame can be a boon or a curse. It is the tool of the arsonist and Gordon Ramsay. The technology is morally neutral. It is how it is applied that counts.*"[53]

Admittedly, advocates have to take the public's genuine concerns more seriously. Better sharing of information and a more forthright public dialogue are necessary to explain why scientists are confident that transgenic crops are safe. No one argues that we should not proceed with caution, but needless restrictions on agricultural biotechnology could dramatically slow the pace of progress and keep important advances out of the hands of people who need them. This is the tragic side effect of unwarranted concern.

Globalization of the EU Moratorium

European restrictions on bioengineered food imports and their onerous labeling requirements for such foods have caused many governments around the world to block commercialization—not out of health or environmental concerns, but because of a legitimate fear that important European markets could be closed to their exports. As the 2001 United Nations Development Report acknowledged, opposition by European consumers and very strict legal requirements in European Union member nations have held back the adoption of transgenic crops in underdeveloped nations that need them.[54]

Furthermore, the Cartagena Protocol on Biosafety, adopted in January 2000 and recently ratified by the EU, will tend to reinforce these counterproductive policies because it permits governments to erect unwarranted restrictions based on the 'Precautionary Principle,' the notion that even hypothetical risks should be enough to keep new products off the market, regardless of their benefits. Thus, EU nations can restrict imports of transgenic crops from both industrialized and less developed nations, no matter how much scientific data have been presented showing them to be safe, because opponents can always hypothesize yet another novel risk.[55]

Zambian President Levy Mwanawasa last year rejected some 23,000 metric tons of food aid in the midst of a two-year-long drought that threatened the lives of over two million Zambians. President Mwanawasa's public explanation was that the bioengineered maize from the United States was "poison." But, other Zambian government officials conceded that the bigger concern was for future corn exports to the EU market. If even a little of the food aid were diverted to seed stock, it could threaten the exportability of the entire Zambian maize crop for many years to come.

Zambia is not unique. European bioengineered restrictions have had other, similar consequences throughout the developing world. Thai government officials have been reluctant to authorize any bioengineered rice varieties, even though it has spent heavily on biotechnology research.[56] Uganda has stopped research on bioengineered bananas and postponed their introduction indefinitely.[57] Argentina has limited its approvals to two bioengineered crop varieties that are already permitted in European markets. Even China, which has spent hundreds of millions of dollars funding advanced biotechnology research, has refused to authorize any new bioengineered food crops since the moratorium began.[58] More recently, the International Rice Research Institute in the Philippines, which has been assigned the task of field-testing Golden Rice, has indefinitely postponed its plans for environmental release in the Philippines, fearing backlash from European-funded NGO protestors.[59]

The EU moratorium persists after five long years, despite copious evidence that biotech modification does not pose any risks that aren't also present in other crop-breeding methods. The EU's own researchers have found over and over that bioengineered crops and foods are just as safe for the environment and for human consumption as conventional crops, and in some cases are even safer because the genetic changes in the plants are much more precise.[60] And even if (or when?) the moratorium is ended, the European Union will replace it with the world's most rigorous regulatory oversight of bioengineered crops and foods, and a labeling and "traceability" regime that literally requires every biotech seed, plant, and food ingredient derived from them to be tracked with a paper audit trail all the way from breeder, to farmer, shipper, processor, and retailer.[61] Industrialized countries like the United States, Canada, and Australia may be able to comply, in limited cases with certain biotech products. But for poor developing countries, the added cost and complexity of the labeling and traceability rules could shut them out of the biotech revolution for good.

The Road Ahead: Towards Improved Food Security for All

During the next 50 years, global population is expected to rise by 50 percent to nine billion people, with nearly all of that growth coming in the poorest regions of the world.[62] Fortunately, mankind will face the extraordinary challenge of hunger and poverty with the very powerful tool of crop biotechnology. The many causes of hunger during this century have been political unrest and corrupt governments, poor transportation and infrastructure, and, of course, poverty. All of these problems and more will need to be addressed if we are to truly conquer worldwide hunger. But ensuring true food security in a world of eight or nine billion will require greater food productivity.

As population increases, farmers must be able to grow more and more nutritious food on less land. Biotechnology can provide one very powerful way to do just that. Without such gains in productivity and nutrition, the growing need for food will require plowing under millions of hectares of wilderness—an environmental tragedy surely worse than any imagined by biotechnology's opponents. Furthermore, 650 million of the world's poorest people live in rural areas where agriculture is the primary economic activity. They are highly dependent upon the income that comes from growing and selling crops, so boosting the productivity of their crops would make a tremendous contribution to the battle against hunger and poverty.

Ultimately, biotechnology is more than just a new and useful agricultural tool. It could also be a hugely important instrument of economic development in many poorer regions of the globe. By making agriculture more productive, labor and resources could be freed for use in other areas of economic growth in nations where farming currently occupies 70 or 80 percent of the population. This, in turn, would be an important step in the journey toward genuine food security.

Acknowledgements: The authors thank Andrew Apel and Richard Levine for their help in reviewing the manuscript.

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