Biotechnology and the Poor

Maarten J. Chrispeels

Member of the National Academy of Sciences

Eight hundred million people on earth are poor and malnourished. They live on less than a dollar a day and cannot be sure that their fields will yield enough food or that they will earn enough money to buy food. Forty thousand people die each day of malnutrition, one-half of them children. The doubling of food production enabled by the Green Revolution unfortunately did not solve the problems of malnutrition and hunger. There were about a billion hungry people some 40 years ago, and population projections show that there may still be 600 million poor people by 2025, when the earth's population will have grown to 8 billion. The Green Revolution did many things, but it did not wipe out poverty. Not enough jobs were created in either the rural areas or the cities to generate the purchasing power that provides farmers with the incentive to grow more food. It is ironic that hunger persists while the prices for agricultural commodities are at an all-time low. Can this problem be solved?

Some try to get rid of the whole issue with the canards "It's just politics" or "It's only a matter of distribution." "Fix the distribution problem and hunger will disappear." This answer is as facile as it is incorrect. To eliminate malnutrition and hunger, food production and purchasing power both need to increase in developing countries. In addition, food production needs to increase in developed countries as well so that grain can be exported at a price the poor can afford. Since land and water are the most limiting resources for food production, there is only one option: to increase yields on the available land. Indeed, there is very little extra land that can be put to the plow. By 2020, the world's farmers will have to produce 40% more grain (200 million extra tons in the developed countries and 500 million extra tons in the developing countries). According to the forecasts of the International Food Policy Research Institute in Washington, DC (Pinstrup-Anderson et al., 1999), the less-developed countries will double their grain imports (mostly maize and wheat) by 2020. The reason is that the projected production increase of 500 million tons in those less-developed countries will still not satisfy demand. That imported grain will come from North America, Australia, the European Union, and the former Soviet Union. Thus trade will increase (assuming that prices remain stable and low), but redistribution is not the answer to the problem of hunger because there is not enough production capacity in the developed countries to satisfy the expected world demand.

The answer to the problems of the poor, according to a number of organizations that oppose genetically modified (GM) crops, is more organic, regenerative agriculture. We certainly need more sustainable regenerative agricultural practices (Pretty, 1995), but "organic" farming is the type of agriculture already practiced by the poor, primarily because they do not have the means to buy fertilizers, pesticides, and irrigation equipment. According to Dyson (1999), sub-Saharan Africa, where most food crop production is "organic," is unlikely to see much improvement in its already dismal food situation. Exhaustion of the soil caused by the lack of fertilizers is depressing yields and pushing agriculture onto more erodable soils. Organic agriculture is nearly always nitrogen starved unless land is set aside for the sole purpose of producing green manures, a luxury the poor can ill afford. Agriculture as it is practiced now in much of sub-Saharan Africa is environmentally unsustainable and a new approach that will require considerable investment in agricultural research is needed. This new approach must be research-driven and will most certainly include GM crops.

Those who oppose GM crops are also quick to point out that this technology primarily benefits the multinational corporations that sell the seeds, and that these corporations are more interested in their own bottom line (always referred to as "corporate greed") than in "feeding the poor." True enough, the big corporations are not working on the crops of the poor, such as cassava, millets, sorghum, sweet potatoes, yams, and legumes (other than soybeans). Furthermore, they are not giving away their technology to poor countries because they want to recover the costs of their investments in biotechnology. The poor will not have the resources to purchase transgenic seeds from multinationals. Research on these crops in the public sector is also unfortunately quite limited. Rice, an important crop of the poor, is an exception, with some research in the corporate sector and considerable research in the public sector taking place, primarily as a result of the Rockefeller Foundation's initiatives. So, if the poor won't have the means to buy the GM seeds from the multinationals, what then needs to happen for the developing countries to benefit from GM technology?

To understand the answer to that question we might first examine why there are still so many poor in spite of the spectacular successes of the Green Revolution. Spectacular indeed, when we consider that during the past 40 years, 3 billion people were added

to the world's population. The Green Revolution concentrated on three crops (rice, wheat, and maize) and adapted cultivars for those areas of the world where they would have the greatest impact on food production. Cultivars need to be bred for specific conditions of climate and soil and need to be resistant to the diseases and insects that are prevalent in the regions where they will be planted. Food production was raised substantially in large areas of the developing world, but other areas, especially Africa, were bypassed. An important feature of the Green Revolution is that the research was carried out in the public domain, and that the genetically improved crop varieties were given away free to the farmers without concerns for the intellectual property rights of those who produced them. It is unfortunate that "public-sector support for agricultural development has collapsed across the board" according to Robert Paarlberg, with a 57% drop in foreign aid to agriculture in poor countries between 1988 and 1996 and a 47% decrease in lending by the World Bank for agriculture and rural development between 1986 and 1998 (Paarlberg, 2000).

The benefits of the Green Revolution's technologies unfortunately were not spread evenly over society. This uneven distribution of technologies was the biggest failure of the Green Revolution and is the reason why some such as Vandana Shiva, the Indian physicist who heads the Research Foundation For Science, Technology and Natural Resource Policy in Dehradun, India, now strenuously oppose GM crops. Shiva's opposition to GM crops is so strong that she demanded that the United States stop using GM crops in its food aid for the victims of the recent super cyclone in the state of Orissa in India. As with the adoption of all technical innovations, there were winners and losers during the Green Revolution. It is now clear that many governments (national or local) did not do enough to ensure an even spread of the benefits among the different types of farmers and the different socioeconomic groups. For example, in Asia, many women farmers were displaced from the land and had to become part-time hired laborers, impairing their abilities to satisfy their own nutritional needs and those of their families. In Mexico, the businessmen who owned large irrigated wheat farms in northern Mexico benefited greatly from the Green Revolution strains, whereas the small maize and bean farmers of Chiapas and other mountainous regions were left behind. Gordon Conway, a champion of the Green Revolution, presents a detailed discussion of these problems in his recent book, *The Doubly Green Revolution*, and gives examples of successes and failures of spreading the benefits of the Green Revolution (Conway, 1999).

Production of genetically modified crops is not a complex technology and is clearly within the capabilities of national research institutes in many developing countries (e.g. Argentina, China, India, Mexico, Brazil, South Korea, and many others). Genetic modification of crops using recombinant DNA technology is also within reach of the institutes of the Consultative Group on International Agricultural Research (CGIAR), including Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT) in Mexico, International Rice Research Institute (IRRI) in The Philippines, and the International Institute For Tropical Agriculture (IITA) in Nigeria. Furthermore, these institutes have already assumed responsibility for biotechnological research and a number of crop improvement projects are under way. These institutes see biotechnology as a tool and not as an end in itself. Crop improvement through biotechnology need not be equated with transgenic plants. For example, marker-assisted breeding is a powerful biotechnology that can find widespread application with the crops of the poor. Detailed linkage maps of these crops will be tremendously useful. As these CGIAR institutes focus on their needs, they will want and need to reach out to public institutions in developed countries. Will the scientists there respond, or will they be preoccupied with their own research agendas? Alliances such as the Cassava Biotechnology Network that bring together researchers from many countries are an effective way to create synergy toward a common goal.

What is the role of the private sector (biotechnology companies) in this process? The private sector leads in every aspect of the agricultural biotechnology revolution and activities in the public sector will have to marshal the strength of the private sector through public-private partnerships. Such partnerships must be based upon mutual trust and common goals. The private sector can work with the CGIAR institutes and with national research institutions (the foreign equivalents of the U.S. Department of Agriculture) of developing countries to transfer technologies, train scientists, provide hands-on experience in intellectual property management, and facilitate the no-cost or low-cost licensing of inventions. Since the cost of these inventions is being charged to the consumers in developed countries, such approaches amount to a transfer of wealth by large corporations from the developed world to the developing world.

There are many avenues open to the private sector to make sure that the activities of this sector do not deprive the poor of their rightful access to this technological revolution. We are beginning to see some examples of such alliances, such as the decision by Monsanto to make the rice genome "public." This cooperation will certainly help the breeders; whether it will help the genetic engineers depends on the conditions that Monsanto will attach to the use of the information. The genomic era will generate so much information that public-private partnerships are the only way in which that information can be utilized for the benefit of all. The recent decision by Astra Zeneca to help develop the "golden rice" is certainly

a step in the right direction. Similarly, the Novartis Foundation for Sustainable Development (http://www.foundation.novartis.com/nfhome.htm) has a number of projects in developing countries.

The creation of an international clearinghouse or institute funded by the large multinationals (Am I a dreamer?) to foster such a partnership would be a significant development to bolster the confidence of scientists and the public that the agricultural biotechnology industry is serious about the transfer of technology. We don't need another institute that does research, but a high profile institute that fosters and mediates interactions between the public and the private sector: a group of people who make a real effort to solve the difficult problems that arise in these international collaborations. Such an institute could also be involved in placing lawyers from developing countries in intellectual property management environments where they can learn this important trade. Less-developed countries have very little expertise in this field and are at a serious disadvantage when they sit down at the bargaining table with the representatives of industry. Regaining the trust of the public will require more than "education campaigns." The public will support the multinationals if they are perceived to be truly concerned with helping to solve what looks to me like the greatest challenge of the 21st century: feeding 9 billion people with a sustainable agricultural production system.

The application of biotechnology to the problems of the poor will not be straightforward and the models we have from developed countries will probably not be applicable. Agriculture in developing countries does not need to be "modernized" although it does need to be improved. The developing countries can hopefully skip the high input unsustainable phase through which agriculture is now passing in developed countries and proceed immediately to more sustainable practices. Agricultural research for the crops and problems of the poor has to proceed from the bottom up, not from the top down. Crops have to be created that fit not only in the agroecology of the poorest regions often characterized by marginal and heterogeneous environments, but the crops must also fit into the social and economic systems. Agricultural research has to start with studying farming practices (so called "on-farm research"), asking the farmers—men and women—what they want, allowing the farmers to make choices between often conflicting objectives such as higher yield versus yield stability, and examining the possibility of marketing the excess production. Will the crop be used by women in their kitchen gardens or by men in their cash crop fields? Aid workers have to begin by soliciting the help of the farmers to describe farming practices and analyze these practices to pinpoint problem areas and opportunities. Together, the aid workers and farmers have to generate a range of choices that the farmers could implement. The major objective of this approach is not the transfer of technology, but empowerment of the farmer to improve production. The major objective has to be the productivity and profitability of smallholder farms with synergy between food crops, cash crops, livestock, agroforestry, and aquaculture with integrated management of soil, water, and nutrients (Serageldin, 1999). This goal and the process for achieving it are more important than the introduction of GM crops.

There are many aspects of providing food for the poor that are well beyond the control of either laboratory scientists or agricultural advisors in the field. The governments of poor countries must realize that agriculture can be an important engine of economic growth and therefore must invest more in agricultural research. These governments need to encourage agricultural development and create the rural infrastructure that will permit crop surpluses to be marketed. Cheap food policies that favor the urban poor are attractive to city dwellers but discourage development of food production capacity in the countryside. Such policies amount to a transfer of wealth from the agricultural sector to the industrial sector. This does not mean that countries should not strive for self-sufficiency at all costs (Runge and Senauer, 2000). Rather, developing countries should look at the entire package—food production, rural development, job creation, land reform, and lending institutions—and enact enabling policies. Developing countries need to examine whether these policies would benefit only the big farmers who rely primarily on purchased outside inputs, or also the smaller farmers who might be engaged in more sustainable practices. If the entire framework for supporting agricultural development is put into place, then biotechnology can also play a role. "Biotechnology is only one tool, but a potentially important one, in the struggle to reduce poverty, improve food security, reduce malnutrition, and improve the livelihoods of the rural and the urban poor" (Persley, 1999).

Are the prospects for achieving these goals good? Only if we put our collective shoulder to the wheel, not only in the lab but also in the social/political arena. Funding for agricultural research has declined 50% on a worldwide basis. The intrusion of intellectual property rights into the arena of crop improvement, while beneficial to the economies of the developed world, is making the lives of many researchers more difficult. The failure of the United States to ratify the 1992 Convention on Biological Diversity is decidedly unhelpful. The cacophony of voices opposing GM crops is casting an aura of suspicion over all "genetic" research and improvement of crops. And yet we know that there are no health issues at stake in the consumption of GM crops and that the environmental issues of GM crops that are still unresolved pale in comparison to the environmental impact of rural populations that practice low-yield agriculture on marginal lands.

Similarly, the ethical considerations of genetic engineering of crops pale in comparisons to the ethical considerations of not improving the lives of the poor. I remain optimistic that we will overcome those obstacles to solve a great challenge of the 21st Century: feeding the human population in an environmentally sustainable manner.

LITERATURE CITED

Conway G (1999) The Doubly Green Revolution. Comstock Publishing Associates, Ithaca, NY

Dyson T (1999) World food trends and prospects to 2025. Proc Natl Acad Sci USA **96:** 5929–5936

Paarlberg R (2000) The global food fight. Foreign Affairs **79(3):** 24–38

Persley GJ (1999) Agricultural Biotechnology and the Poor: Promethean Science. (http://www.cgiar.org/biotech/rep0100/persley.pdf)

Pinstrup-Anderson P, Pandya-Lorch R, Rosegrant MW (1999) World Food Prospects: Critical Issues for the Early Twenty-First Century. International Food Policy Research Institute, Washington, DC

Pretty, JN (1995) Regenerating Agriculture. Joseph Henry Press, Washington, DC

Runge CF, Senauer B (2000) A removable feast. Foreign Affairs **79:** 39–51

Serageldin I (1999) Biotechnology and food security in the 21st Century. Science **285:** 387–389

Maarten J. Chrispeels
Division of Biology
University of California
San Diego, California 92093–0116