Panelist's Remarks

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I am going to talk about the risks and benefits of biotechnology and genetic engineering in the food crops of developing countries. First, it is important to remember what we have learned from the green revolution.

The original objective of the green revolution was to increase yields, and this it certainly accomplished. It did this by developing seed varieties that had several advantages: short vegetation periods, which allowed more than one harvest a year; the ability to turn high fertilizer inputs into high crop yields rather than stem and leaf growth; relative insusceptibility to fluctuation in daylight; resistance to or tolerance of plant diseases and animal pests; and tolerance to irregular irrigation, poor soils, and other stress factors. The result was substantial yield increases for rice, maize, and wheat ranging from 100 percent to 170 percent boosts in productivity.

The Green Revolution also had the welcome effect of improving the nutrition of the poor by moderating food prices. Where the new technologies allowed second or third harvests in a year, there was also an increase in employment and thus in income. At the same time the higher-yielding seed varieties proved to be a land-saving technology, providing at least temporary relief of some of the pressures on forests and biological diversity. As an illustration of this process, consider that if India had to produce today's harvest with the technology of the 1960s, it would need to use 208 million hectares of arable land, 116 million more than were available between 1961 and 1963. If the yield per hectare had not doubled, achieving the results recorded from 1991 to 1993 would have required doubling the land under cultivation—a sheer impossibility without causing an ecological disaster by destroying the last remaining forests and converting them to cropland.

Of course the Green Revolution also had negative impacts. The technologies themselves and the benefits of using them were not distributed equitably. When the new seeds were introduced, those who already had access to land, irrigation, or extension services were at a distinct advantage. The poor were left further behind. Another negative effect was the reduced use of biodiversity—as people gained access to the new, high-yielding varieties, they abandoned traditional ones.

Turning to genetic engineering and biotechnology, we can also see potential benefits for food crops and some possible negative impacts. First the benefits: as diagnostic aids, these technologies can help identify plant diseases; gene mapping allows the rapid identification of commercially and biologically interesting genetic material; most significantly, seeds can be created that have resistance to, or tolerance of, plant diseases and animal pests, as well as tolerance of stress factors. Soon we may be able to transfer genes that confer the ability to fix nitrogen to grain. Last but not least, the quality of food can be improved by overcoming vitamin or mineral deficiencies. To illustrate these likely benefits, we can look at rice, based on work by Ingo

Potrykus at the Federal Institute of Technology in Zurich:

- Fungal diseases destroy 50 million tons of rice a year; varieties resistant to fungi could be developed through the genetic transfer of proteins with antifungal properties.
- Insects cause the loss of 26 million tons of rice a year; the genetic transfer of proteins with insecticidal properties would mean an environmentally friendly insect control.
- Viral diseases devastate 10 million tons of rice a year; transgenes derived from the Tungro virus genome allow the plant to develop defense systems.
- Bacterial diseases cause comparable losses; transgenes with antibacterial properties are the basis for inbuilt resistance.
- Vitamin A deficiency causes health problems for more than 100 million children; transgenes can provide provitamin A with the rice diet.
- Iron deficiency in the diet is a health problem for more than 1 billion women and children; transgenes can supply sufficient iron in the diet.

Similar benefits can also be cited for cassava, also based on work by Ingo Potrykus at the Federal Institute of Technology in Zurich:

- The African Mosaic virus causes immense damages in cassava; transgenes interfering with the life cycle of the virus could lead to virus-resistent varieties.
- Cassava contains toxic cyanogenic glycosides; the integration of transgenes could inhibit their synthesis.
- Cassava roots store starch efficiently but do not contain protein; the transfer of genes for storage proteins would improve cassava's nutritional quality substantially.
- Cassava roots have a basic capacity for provitamin A synthesis; transfer of appropriate genes could lead to regulated accumulation.

Most of these properties in rice and cassava can only be achieved through genetic engineering and biotechnology, not through traditional plant research.

Now let us look at the potential risks of these technologies. These include dangers to the environment and to public health, aggravation of the prosperity gap between North and South, growing disparities in the distribution of income and wealth within poor societies, and loss of biological diversity. It is imperative to distinguish here between risks that are inherent to a technology and those that transcend it—a distinction seldom made when the green revolution is discussed. There are major differences between these risks, and technology should not be blamed for problems that are part of the political and social environment of a country.

The risks inherent to technology are those potential hazards—unforeseeable problems or unwanted side effects—that might occur during the research, development, or implementation of a technology designed to improve an existing situation. Examples of these include the unexpected and harmful interaction of genetically engineered organisms with the environment, and the reduced use of biodiversity by farmers who now have access to higher-yielding varieties. (This does not mean, however, that the traditional varieties need be lost, for they can be kept in vitro or farmers could be offered an incentive to continue using them.)

In contrast, technology-transcending risks stem from the application of a technology in certain political and social circumstances. In developing countries today these risks arise from both the current course of the global economy and the specific situation in certain countries. Consider, for instance, the varying impact of introducing a new technology in a country that has policies that support small farmers (tenure reform, access to extension services) and in a country where 95 percent of the land is in the hands of 2 percent of the people and where the poor have no access to services.

Some of these risks can have the effect of aggravating the prosperity gap between North and South. The ability to produce tropical agricultural products in the laboratory or in temperate zones, for example, can have a significant impact on developing-country exports. The gap between North and South can also be widened when control of plant genetic resources is given free of charge.

The story of thaumatin illustrates both these trends. Some 10 years ago Nigerian researchers at the University of Ife identified the sweetener thaumatin in the berries of *Thaumatococcus* *danielli,* which is common in the forests of that part of Nigeria. At that time no industry was interested in using the fruit as a sweetener. With the advent of biotechnological possibilities, however, the gene for thaumatin—a protein that gram-for-gram is some 1,600 times sweeter than sugar—has been cloned and is now being used for the industrial production of sweetener in the confectionery industry. Patents on the process have been registered, but the people from whose lands the gene was obtained never received any compensation. And countries like Cuba or Mauritius, which depend on sugar cane for a decisive share of their export earnings, could find themselves extremely hard-pressed should the industrial manufacture of thaumatin or similar substances broadly supplant sugar cane.

Technology-transcending risks can also aggravate disparities in income and wealth in poorer countries themselves. For it is certainly true that where land ownership and tenancy systems, access to key services, and credit and marketing channels are governed by a power structure that favors only a small minority, technological progress cannot possibly be neutral in impact.

How can we manage these risks? Again, it is important to look at the two categories separately. First, risks inherent to technology. Biosafety risks are normally evaluated by specialists, controlled by good scientific practices and an appropriate regulatory framework. The only ethical risk here is if an institution supported by public funds used different standards of risk in the North and the South. We have an ethical duty to use the highest standards everywhere.

As a social scientist I am not qualified to pass judgment on biosafety risks, but I draw to your attention the comment of the U.S. National Academy of Sciences on this issue: "The safety assessment of a recombinant DNA-modified organism should be based on the nature of the organism and the environment into which it will be introduced, not on the method by which it was modified" (Persley 1990).

Management of technology-transcending risks is more difficult, for it involves more players. Political wishes, for example, cannot determine whether vanilla is produced in Madagascar, where it creates an income for 100,000 people, or in a laboratory in Switzerland or England. Or do we wish that to be controlled by politics. Market "logic" tells us that if "lab vanilla" or "lab sugar" (thaumatin) is cheaper or has some other edge—is healthier than the natural product, for example—then the innovation or substitution will simply happen.

Similarly, the price of copper is determined by the metal's electrical conductivity. Once electric current can be conducted cheaper and better by glass or carbon fibers, copper will in due course no longer be used for this purpose—with not surprising consequences for demand and thus price. The substitution will take place despite crumbling copper prices and rising unemployment in countries such as Chile and Zambia.

The discussion here should not be how we can prevent such a substitution from happening, but how to create an early warning system to find out what kinds of crops are vulnerable to substitution, and then help countries and communities to diversify. A larger allocation of international development funds to diversification efforts is therefore called for. A comprehensive risk-benefit analysis of the substitution of agricultural commodities from the tropics should also examine potential alternative uses of the land freed up in this way—for increasing local food production perhaps, or for reforestation.

There should also be fair compensation for the use of genetic resources. Suppose for instance, that a private seed company discovers a property in an Ethiopian barley strain that makes it resistant to certain plant diseases. The company transfers this property genetically to a wheat variety which is then commercialized in Ethiopia. Obviously, the farmers of Ethiopia have contributed something by selecting and preserving this variety for a long time, but without the research and development of the seed company this characteristic would not have been turned to use outside Ethiopia or in food grains other than barley. So both the farmers of Ethiopia and the seed company have contributed to the new wheat variety, and both have some kind of intellectual property right, and thus a right to compensation.

Although most industrial countries have signed the Convention on Biological Diversity, few national legislatures have ratified it. An important step in satisfying claims to compensation would be to work out binding national and international regulations. What especially needs unequivocal regulation is who should compensate whom for what, and how much the compensation should amount to. As a rough first approach, I have recommended for some time that the issue be dealt with through license agreements, with the price left to the mechanism of supply and demand. Those who benefit should pay the license fee to those who, over the centuries, helped preserve the varieties in question. It is crucial to ensure that remuneration, through whatever mechanism, does not land in the pockets of those who have ready access to it, while those the funds are meant to help end up empty-handed once again. As the Consultative Group on International Agricultural Research (CGIAR) already exists and does excellent work for the poor farmers of the world, no new institution need be created to address this problem. If license fees were funneled to CGIAR, the funds would go toward research on plants that improve the living circumstances in communities that are responsible for these crops.

In addition, to help with diversification and fair compensation for genetic resources, another way to avoid aggravating the North-South prosperity gap is to provide more publicly financed research for the South and in the South, where there are many excellent research capacities.

The second major technology-transcending risk described earlier is the growing disparity in the distribution of income and wealth within developing countries. Managing this risk requires good governance—a quality that is unfortunately in short supply lately. Take the case of Nigeria, to cite just one example. Nigeria has had an income from crude oil of hundreds of billions of dollars over the past 20 years. Have the multinationals wrecked this country? Or is it a lack of good governance? In giving these issues serious consideration, we must not release governments from their responsibility to do their job—serve their countries, not use them as illegitimate resources for private gain. Good governance in this case includes land reform, tenancy reforms, extension services for small farmers, appropriate credit and marketing systems, and so on. In short, the economic and social impact of genetic engineering and biotechnology can only be as good as the sociopolitical soil in which the resulting new varieties are planted.

One more point must be made about reducing disparities both between the North and the South and within countries. The private sector needs to be asked to cooperate further. For example Novartis, has made a gene of *Bacillus thuringiensis* available to the International Rice Research Institute. If the World Bank asked the five or six largest biotechnology companies to consider where private-sector research could be made available in poor countries—not in competing markets—they could surely come up with some useful recommendations.

In conclusion, when assessing the impact of genetic engineering and biotechnology on food security, we must live with ambivalence. It is intrinsic to every technical advance. But the existence of ambivalence and ethical dilemmas should not paralyze us. On the contrary, they must serve to clarify the course of action and expand our horizon of responsibility. There are both clear benefits and clear risks in this case. Balancing them will require a permanent political assessment process regarding what is acceptable under specific circumstances. Certainly there are no technical solutions to social or political problems, nor is there a silver bullet answer waiting to be discovered. Nevertheless underlying the political process should be the understanding that sustainable food security will not be achieved without better governance and a new dimension of solidarity between the "rich" and "poor" of this world. But it will also require new technologies, such as genetic engineering and biotechnology.

Reference

Persley, G. J. 1990. "Beyond Mendel's Garden: Biotechnology in the Service of World Agriculture." World Bank, Washington, D.C.