THE ROLE OF RESEARCH IN THE OUTLOOK FOR WORLD FOOD[1]

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Modern science offers humankind a powerful instrument to assure food security for all without degrading the environment. Through enhanced knowledge and better technologies for food and agriculture, science has made major contributions to food security in recent decades. Food availability per person has increased by almost 20 percent since the early 1960s. There are 150 million fewer hungry people today than 25 years ago, and an additional 1.5 billion people in developing countries are being fed. The application of science through agricultural research has transformed food production in industrialized and developing countries. Higher yields and reduced risks have resulted in the production of more food at lower unit costs, higher farm incomes, and reduced food prices for the benefit of rural and urban poor people. Without effective use of science in agriculture, a large share of current forests would have been cut down and millions of hectares of land not well suited for agriculture would have been brought under cultivation with disastrous environmental effects.

In spite of past successes, hunger remains persistent at the threshold of the twenty-first century. Over 800 million people live in uncertainty of when or how they will get their next full meal, and 185 million preschool children suffer from seriously compromised mental and physical development because of malnutrition (FAO 1996). This situation is unconscionable, especially when resources are available to meet the food needs of each and every person in the world. Every man, woman, and child has the right to access to sufficient food to lead a healthy and productive life, whether that right is enshrined in official documents or not.

About 80 million people are expected to be added to the world's population every year for the next quarter century, increasing the world's population by about 35 percent to a total of 7.7 billion people by 2020 (UN 1996). With business as usual, global demand for cereals is projected to increase by 55 percent between 1990 and 2020 to 2.68 billion tons, for livestock products by 75 percent to 284 million tons, and for roots and tubers by 50 percent to 878 million tons (Rosegrant, Agcaoili-Sombilla, and Perez 1995). Developing countries, home to 98 percent of

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the increased world population in the next 25 years, are projected to increase their demand for cereals by 80 percent to 1.5 billion tons, for livestock products by 140 percent to 156 million tons, and for roots and tubers by 64 percent to 631 million tons.

Meeting these increased food demands will require global cereal production to grow at an average annual rate of 1.5 percent between 1990 and 2020, livestock production at 1.9 percent, and production of roots and tubers at 1.4 percent (Rosegrant, Agcaoili-Sombilla, and Perez 1995). In developing countries, cereal production will need to increase at an average annual rate of 1.9 percent between 1990 and 2020, livestock production at 3.0 percent, and production of roots and tubers at 1.7 percent, in order to meet increased food demands. Yield increases will have to be the source of most of the production increases; significant expansion of cultivable land is not an economically or environmentally sound option in most of the world. Cereal yields will have to increase by at least an average annual rate of 1.5 percent in developing countries and of 1.2 percent in the world as a whole, otherwise farmers will be forced to encroach on land unsuitable for agriculture, with devastating effects on the natural resource base.

Existing technology and knowledge will not permit production of the food needed to assure a food-secure world in the years to come. There are no grounds to assume that yield increases can and will continue to grow at the same rates as in the past. Significant research investments are required simply to maintain current yields. If research support is not sufficient, yields can not only cease to grow but may decline. Low-income developing countries are grossly underinvesting in agricultural research compared with industrialized countries, even though agriculture accounts for a much larger share of developing countries' employment and incomes (IFPRI 1995). Their public-sector expenditures on agricultural research are typically less than 0.5 percent of the value of agricultural output, compared with 1-2 percent in higher-income developing countries and 2-5 percent in industrialized countries. Low-income developing countries must increase their national agricultural research expenditures in the near term to 1 percent of the value of agricultural output, with a longer term target of 2 percent. National and international agricultural research systems must be mobilized to develop improved agricultural technologies and knowledge, and extension systems must be strengthened to disseminate the improved technologies and techniques. Interactions between public-sector agricultural research systems, farmers, private-sector research enterprises, and non-governmental organizations must be strengthened to assure relevance of research and appropriate distribution of responsibilities.

Research has a key role to play in maintaining and raising yields in more-favored areas where significant yield gains have already been achieved. In these areas, conventional plant-breeding approaches are reaching their limits in raising the biological potential of plants to give higher yields, while misuse and overuse of agricultural inputs such as fertilizer, pesticides, and irrigation technology are leading to degradation of natural resources and consequent losses in agricultural productivity. Already, rates of increases in yields of rice and wheat have begun to slow under both experimental conditions and on farmers' fields (CGIAR 1995). Accelerated agricultural research is required to develop plants with greater tolerance or resistance to adverse production factors such as pests and diseases; to develop biological alternatives to chemical fertilizers and pesticides; to improve the use and quality of agricultural inputs such as irrigation technology; to improve crop management techniques; and to rehabilitate areas that have been degraded and restore their productivity to the extent possible.

The balance between less-favored and more-favored areas must be redressed. Although more-favored areas will remain a key source of expanded food production in the future and, by minimizing the need to exploit new lands, will help to reduce pressures on the natural resource base, a continuation of past low priority on less-favored areas is inappropriate and insufficient to assure sustainable food security. Less-favored areas — areas with limited and unreliable rainfall and fragile soils — comprise much of the cultivable area in many developing countries, are home to many of the world's food-insecure and poor people, and are subject to considerable degradation resulting from poverty, population pressures, and lack of agricultural intensification. Yields are low and variable in the less-favored areas. In order to reduce risks and uncertainties for farmers, accelerated research is required to develop crop varieties that are more tolerant of droughts and better suited to fragile soils and more diverse ecological settings. Research is also needed to reduce soil erosion, to capture and utilize more moisture in the soils, to generate and recycle organic sources of plant nutrients, to develop more diverse cropping systems, and to better integrate livestock and trees into cropping systems (Hazell 1995). Much more attention must be directed to the development of appropriate technology for the less-favored areas.

Investment in agricultural research is an important factor in assuring food security. Projections to the year 2020 suggest that, under the most likely or baseline scenario, the number of malnourished children in the world could decline to 155 million from 185 million today (Rosegrant, Agcaoili-Sombilla, and Perez 1995). However, should investments in international and national agricultural research significantly decline along with reductions in investments in education and health, projections indicate that the number of malnourished children could increase to 200 million in 2020. Alternatively, should national and international agricultural research systems be strengthened along with increased investments in education and health, projections suggest that the number of malnourished children could decline to 100 million in 2020. Scenarios to the year 2020 developed for China suggest that if the rate of growth in investment in agricultural research and irrigation were to increase from 3.5 percent a year to 4.5 percent, China would shift from being a net importer of grain to a net exporter by 2020 (Huang, Rozelle, and Rosegrant 1997). Grain production would be higher by 36 million tons in this scenario relative to the baseline. However, if growth in investment in agricultural research and irrigation were to decline from 3.5 percent a year to 2.5 percent, grain production would decline by more than 50 million tons relative to the baseline and China's imports in 2020 would triple to 76 million tons from the baseline forecast.

Genetic engineering and other agricultural biotechnology are among the most promising developments in modern science. Used in collaboration with traditional or conventional breeding methods, they can raise crop yields or productivity, increase resistance to pests and diseases, develop tolerance to adverse climatic conditions, improve the nutritional value of foods, and enhance the durability of products during harvesting or shipping. Yet, with the exception of a very limited amount of work by the centers of the Consultative Group on International Agricultural Research (CGIAR), little research in agricultural biotechnology is taking place in or for developing countries. Most biotechnology research is occurring in private firms in industrialized countries, focuses on the plants and animals produced in temperate climates, and aims to meet the needs of farmers and consumers in industrialized countries. Low-income developing countries are constrained in their pursuit of agricultural biotechnology research by limited public- and private-sector funding and by shortages of trained personnel. They can address these constraints, however, by providing incentives to the private sector to engage in such research, by collaborating with international research programs, and by seeking private- and public-sector partners in industrialized countries. It is essential that agricultural biotechnology research that is relevant to the needs of farmers in developing countries and to conditions in those countries is undertaken, and that the benefits of that research are transmitted to small-scale farmers and consumers in those countries at affordable prices. Otherwise, developing countries will not only fail to share in the benefits of agricultural biotechnology, but will be seriously hurt as synthetic alternatives to their products are developed in industrialized countries, as is already happening with cocoa and vanilla.

A more fundamental constraint to the use of agricultural biotechnology in and for developing countries is the attitude toward risk among the nonpoor in both industrialized and developing countries. Considerable resistance to agricultural biotechnology has arisen on the grounds that it poses significant new ecological risks and that it has unacceptable social and economic consequences. Although no ecological calamities have yet occurred, some people fear that transgenic crops will develop troublesome new weeds or threaten crop genetic diversity. Of course, any new products that pose such risks should be carefully evaluated before they are released for commercial development. But by raising productivity and food production, agricultural biotechnology will reduce the need to cultivate new lands and could therefore help conserve biodiversity and protect fragile ecosystems. To address concerns about ecological risks, developing countries can adopt regulations that provide a reasonable measure of biosafety without crippling the transfer of new products into the field.

As for the social and economic consequences of biotechnology, some people are concerned that large-scale and higher-income farmers will be favored because they will have earlier access to and derive greater benefits from agricultural biotechnology. These concerns are remarkably similar to those raised about the Green Revolution. Whatever the shortcomings, real or alleged, about the Green Revolution, it did avert widespread starvation and helped many millions of people escape hunger once and for all. Similarly, agricultural biotechnology can contribute to feeding many more people in a sustainable way. Appropriate policies can make new technologies accessible to small-scale farmers. Instead of rejecting the solutions offered by science, we should change policies to assure that the solutions benefit the poor.

If we are to produce enough food to meet increasing and changing food needs, to make more efficient use of land already under cultivation, to better manage our natural resources, and to improve the capacity of hungry people to grow or purchase needed food, we must put all of the tools of modern science to work. In a world where the consequence of inaction is death for thousands of children daily and persisting hunger for millions of people, we cannot afford to be philosophical or elitist about any possible solution, including agricultural biotechnology. Modern science by itself will not assure food for all, but without it the goal of food security for all cannot be achieved.

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