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Technological Opportunities for Sustaining Wheat Productivity Growth toward 2020

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The Green Revolution has had a tremendous positive effect on food security in the developing world. Increased use of modern varieties of wheat (see table) has helped belie the conventional wisdom of the 1970s that the world was going to run out of food. But IFPRI projections indicate that global demand for wheat will rise by 40 percent by 2020, and the resources available for wheat production will significantly diminish. For the first time since the beginning of the Green Revolution, there are serious concerns about future wheat supply. In meeting projected demand, researchers and policymakers must recognize that global food markets are becoming increasingly integrated, agricultural resources devoted to crop production are being diverted, and research systems are facing declining budgets.

Productivity increases in wheat are needed in high-potential and marginal areas. Crop and resource management research should focus on increasing input use efficiency in the high-potential environments and moisture conservation and efficiency in the marginal environments. In addition, research on genetic improvement is needed to shift the wheat yield frontier and increase the stability of wheat yields. Finally, all efforts should be made to ensure free access by developing countries to germplasm and scientific information.

INCREASING WHEAT PRODUCTION IN HIGH- AND LOW-POTENTIAL AREAS

The rate of wheat productivity growth has slowed considerably in the past decade relative to the previous two decades.There are, however, opportunities for yield increases in both high- and low-potential environments.

High-Potential Environments

Four changes in the wheat production sector will affect yield increases in the high-potential areas: (1) increased integration of world food markets and the liberalization of wheat imports; (2) less preoccupation with food self-sufficiency among developing-country governments; (3) removal of output price supports and input subsidies for wheat farmers, in both developed and developing countries; and (4) long-term decline in real wheat prices coupled with rising costs of inputs, especially labor, land, and water. Also, reduced expenditures on irrigation have curtailed expansion of irrigated areas, inhibited proper maintenance of existing infrastructures, and reduced productivity growth.

Given the above changes in the economic environment, the competitiveness of wheat farming will depend on the potential for a dramatic reduction in unit costs of production. This can happen either through a shift in the yield frontier or an increase in input use efficiency.

Percent of area planted to modern varieties of wheat

Region	1970	1977	1983	1990	1994
Sub-Saharan Africa	5	22	32	52	59
West Asia/North Africa	5	18	31	42	57[a]
Asia (excluding China)	42	69	79	88	91
China	n.a.	n.a.	n.a.	70	70
Latin America	11	24	68	82	92
All developing countries	20[b]	41[b]	59[b]	70	78

Sources: D. Byerlee and P. Moya, Impacts of International Wheat Breeding Research in the Developing World, 1969-90, CIMMYT, 1993; and CIMMYT, World Wheat Facts and Trends (1995/96).

Note: Data exclude tall varieties released since 1965. If these varieties are included, the area under modern varieties increases.

[a]Important countries such as Morocco and Iran are not included.

[b]Excludes China.

Three distinct but interrelated strategies are being pursued for achieving a dramatic shift in the wheat yield frontier. The prospects for a substantial shift in the yield frontier within the next decade are high. First, new generations of wheat varieties are primarily being produced for irrigated and high-rainfall environments where economically achievable yield increases from existing cultivars are small. Second, three recent developments have made the reassessment of hybrids worthwhile: improvements in chemical hybridization agents, advances in biotechnology, and the emergence of the new wheat plant type. Third, an important source for enhancing the genetic diversity of cultivated species is through the incorporation of desirable genes from uncultivated plants in the wild.

The profitability of wheat production systems in the high-potential environments depends heavily on crop management technologies for enhancing input efficiency. The furrow-irrigated, reduced-tillage bed-planting system, a combination of wheat planting in beds and traditional ridge-tillage technologies, holds immense potential for making irrigated wheat-based cropping systems less resource intensive and more sustainable. Improvements in fertilizer use, weed control practices, and irrigation management result in marked production efficiencies and cost savings for farmers.

Low-Potential Environments

To what extent should research be concerned with technology for low-potential environments? In the case of large countries with high domestic demand for wheat, such as India and China, investment in unfavorable environments is essential for ensuring reliable food supplies, even if these countries are integrated into the global economy. In the case of countries with smaller wheat growing areas, the answer depends substantially on the level of global integration of these economies.

Further productivity gains are increasingly difficult to come by in marginal production environments. On the varietal side, although gains have been made through the exploitation of spillover benefits of germplasm developed for irrigated environments, further gains would have to come from specifically targeting breeding efforts to the unique characteristics of marginal environments. On the management side, there has been little effort put into developing crop management practices for marginal environments. These practices presumably would be different from those for irrigated environments. Real opportunities exist for yield increases in these areas.

Drought affects approximately 20 percent of all wheat-growing areas. Enhanced drought tolerance in wheat varieties could lead to improved food security for populations living in these areas. In addition to chronic drought-prone areas, irrigated wheat production environments are becoming increasingly subject to growing water scarcity. Drought-tolerant varieties could help reduce water-related variability in favorable environments.

Wheat crops grown in tropical regions often face high temperatures during the height of the growing season. Heat stress indirectly reduces yields by directly affecting various yield components. Researchers are observing crop yields to select for heat-stress tolerance, and some lines have been released.

Acid soils are usually found in regions of higher rainfall where forests or savannas were once the native vegetation. Work in areas such as Brazil has resulted in new wheat varieties that have maintained their natural favorable characteristics, but whose yield potential is 30 percent above that of the old varieties.

Marginal environments face several other challenges: combining drought tolerance with heat tolerance; dealing with nutrient deficiencies and salinity; improvements in crop and resource management technologies; and diversification of crop and enterprise systems.

POLICIES FOR RESEARCH AND INTERNATIONAL INFORMATION EXCHANGE

One important factor in the tremendous success of the Green Revolution in wheat has been the free and widespread global exchange of germplasm. International spillovers of research results, together with the resulting economies of scale, have led to large and small wheat-growing countries benefiting from investments in wheat research. The following policy issues will bear on wheat productivity growth: Liberalization of world food markets: As the global food economy becomes more integrated, developing countries may find it more profitable to borrow wheat germplasm for their wheat-growing areas and turn their own agricultural research resources toward high-value commercial crops. The liberalization of food markets could, in and of itself, lead to a greater demand for international linkages in wheat research.

Urbanization and the political economy of agricultural research: Domestic wheat supplies to meet urban demand will increasingly come from large-scale, mechanized farms in irrigated or high rainfall areas. Because wheat germplasm for such environments is adaptable across national boundaries, economic development could increase the reliance of countries on international cooperation in wheat improvement research.

Strengthened capacity of national agricultural research systems (NARS): The spillovers in wheat research will favor countries with small wheat-growing areas that adapt breeding, as well as countries with large areas in wheat that need material for crossing programs. Strong NARS capacity in either type of country could lead to greater international interdependence in germplasm enhancement activities.

Advances in agricultural science: Applications of the latest scientific tools to wheat breeding will require significant collaboration between developed-country institutions, international centers, and some national programs in developing countries. The spillover benefits of such science are very high, and international linkages will be enhanced as a result.

Reduction in intellectual property rights (IPR): Because of IPRs, breeders may be less willing to share breeding lines for fear of jeopardizing future royalties, and because genetic enhancement research holds the least potential for generating patentable discoveries, resources may be diverted from these efforts. Thus, enforcement of IPRs may significantly reduce exchange of wheat germplasm and developing-country access to wheat research and increased yields.

CONCLUSIONS

Given the steady rise in wheat demand due to population and income growth, wheat productivity growth over the next two decades must at least match the rate observed over the past three decades if the increased wheat demand projected by IFPRI is to be met. These production increases must come from favorable, as well as marginal, production environments.

In high-potential and irrigated environments, shifting the yield frontier while improving input use efficiency are the priorities for research. In the case of marginal environments, improved tolerance to physical stresses will continue to be the priority. Innovations in crop and resource management will be important from the viewpoint of productivity and sustainability in both the high-potential and low-potential environments.

Continued success in wheat germplasm and technology dissemination worldwide depends on the free and uninhibited flow of genetic materials and information. Restrictions imposed on such movement due to intellectual property protection could have serious consequences on the ability of developing countries to sustain wheat productivity growth.

For more information, see Prabhu Pingali and Paul Heisey, "Cereal Crop Productivity in Developing Countries: Past Trends and Future Prospects," CIMMYT Economics Program Working Paper, forthcoming in 1998; and Prabhu Pingali and Sanjaya Rajaram, "Technological Opportunities for Sustaining Wheat Productivity Growth," in Meeting the Demand for Food in the 21st Century: Challenges and Opportunities. University of Illinois Press, forthcoming in 1998. For further information about these publications, please contact Prabhu Pingali at CIMMYT, Lisboa 27, Apdo Postal 6-641, 06600 Mexico DF, Mexico.

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