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The Potential of Technology to Meet World Food Needs in 2020

by Peter Oram

World population was about 2.5 billion in 1950; by 1988 it had doubled. Despite this unprecedented population explosion, global food supply kept pace with the additional demand for food. A technological revolution after World War II in the agriculture of the industrialized countries initially made this achievement possible. In the developing countries, where growth of food production had relied heavily on plowing up new land and on irrigation development, technology was increasingly responsible for production growth after 1965.

This new technology was based on genetic improvement of the major cereal crops and the adoption of other improved farming techniques, including irrigation, fertilizer use, selective herbicides to kill weeds without harming the crops, chemical pesticides, and mechanized cultivation and harvesting methods. The combination of these techniques with cultivars of higher yield potential was symbiotic: it is estimated that about 50 percent of the gains in farm yields have resulted from plant breeding and the balance from the application of other improved practices.

However, after three decades of fairly steady growth of productivity, growth rates of food production have begun to lag worldwide, especially since the early 1980s. Warning signs include

- Declining growth of new arable and irrigated areas, even in Sub-Saharan Africa and Latin America, which have untapped resources.
- Widespread salinity and waterlogging of irrigated land, water pollution, and overpumping of aquifers, which are affecting yields of rice and wheat in densely populated Asia. Competition for water between agricultural and other end uses is also rising.
- Fertilizer growth rates have fallen sharply, from 14.6 percent per year for 1961-71 to 5.3 percent per year for 1985-92 in the developing countries, and from 7.9 percent to -0.4 percent over the same period in the developed countries.
- Tractor use growth rates have declined by more than 50 percent everywhere since 1980.
- Environmental pollution and health hazards are leading to stringent controls on pesticide use.
- World food prices have fallen to an historic low, discouraging investment in agriculture.
- International and national support for agricultural research has eroded, due partly to economic recession and partly to perceptions of agriculture as a major source of environmental pollution. While these perceptions are not groundless, no viable alternative

to current technology yet exists for sustaining world food production. Strategic and applied research in the biological and environmental sciences should be reinforced and linked more effectively to social sciences, in order to better understand the impediments to making existing technology more efficient, sustainable, and environmentally friendly.

The Future Outlook for Agricultural Technology

These trends confirm the views of agricultural scientists that the road ahead will not be easy. It would be rash to assume that yields will rise at the same rate as in the past, since shrinking land and water reserves are placing a greater burden on technology. Nevertheless, human ingenuity allied to science has confounded prophets of doom in the past and has the capacity to do so again.

Technology research in the following areas should receive high priority.

(1) *Improved application of technology to natural resource management*. This fundamental need has been somewhat neglected in the past compared with genetic and chemical technology.

- The resource base must be characterized and evaluated, both in relation to existing cultivated areas and to land currently under forest or pasture. Modern tools and techniques for resource assessment, such as remote sensing, aerial photography, sonic devices, and geographic information systems, have greatly enhanced capacity in this field.

- Soil and water management in rainfed farming, especially in erosion-prone upland watersheds, needs to be improved. Numerous conservation techniques exist, but they are not systematically adopted because of cost and technical and social obstacles (for example, these techniques often require community action for their success). Participatory approaches are crucial, especially with common property resources and water use.

- Better management of irrigated land and water is essential. Existing techniques to reduce salinity and waterlogging, such as drainage, canal lining, and conjunctive use of tubewell and surface water are costly and not always feasible, and they may be ineffective if unsupported by policies to reduce wasteful water use. Changes in cropping systems, the introduction of sprinkler or drip-feed systems where feasible, or switching from full to supplementary irrigation may lead to more efficient water use and reduce pollution. As competition for water increases, it may be necessary to use lower-quality water with crops tolerant of salinity, or to desalinize sea water. Ongoing research on solar and wind energy may reduce the energy costs of desalinization.

- Soil fertility must be managed for higher productivity. In many developing countries, but especially in Africa and South Asia, inherently low soil fertility is a major constraint, and farmers are mining the soil to feed their families. Traditional measures to maintain soil nutrients and organic matter such as bush fallow are breaking down under population pressure, supplies of animal manure are inadequate, and farmers consider fertilizer on rainfed crops to be too expensive. An integrated approach to nutrient management is required, combining organic matter from animals or crops with nitrogen fertilizer, applying phosphate to legumes grown in rotation with cereals to build soil nitrogen, or plowing in legumes for green manure. Where local sources of phosphate rock, potash, or limestone exist their direct use may reduce the need for costly fertilizer imports. Better diagnostic methods are being developed to determine soil nutrient and micronutrient status, and their wider use should improve the efficiency of fertilizer application, which is often low.

Three factors may determine the future success of resource management in each of these priority fields of activity: the extent to which cultivars and cropping systems can be adapted to fit the resource rather than trying to modify the resource itself; the degree to which the local community can be involved in the planning and management of the resource and feel ownership of it; and the willingness of governments to adjust their policies to encourage efficient and sustainable resource management.

(2) *Protection of crops from biotic stresses without heavy reliance on pesticides*. Important progress is being made toward this goal using these techniques:

- Introduction of host-plant resistance through breeding. This is being accelerated by gene mapping and marker techniques to identify sources of genetic resistance in crops and their wild relatives.

- Biological control through the use of predators and parasites.

- Improved pest and disease monitoring and early-warning systems.

- Less toxic chemicals and more efficient application methods.

- Integrated pest management (IPM), combining biological and crop management practices to develop cost-effective control with reduced dependence on pesticides. Although valuable, this approach requires farmers to be highly skilled and may require community cooperation to maximize success.

Because pests and diseases do not respect national boundaries, crop protection merits high priority for international cooperation to better understand and monitor its status, improve diagnosis, maintain data bases, and identify natural enemies and sources of resistance.

(3) *Genetic improvement of key crops*. Plant breeding is the cornerstone of yield-increasing technology, and it also plays a key role in preventing yield losses from biotic stress. However, it faces the triple challenge of raising yields still further in regions where they are already high (for example, wheat in Western Europe and irrigated rice in East Asia); improving nutritional quality, especially of micronutrients; and of overcoming stresses that are not biotic such as drought, extreme temperatures, soil acidity, and other nutrient problems that keep yields low in many other areas.

Biotechnology offers hope of finding solutions to these problems, and is already contributing to genetic improvement of cereals, root crops, vegetables, industrial crops, and to animal health. Its near-term promise probably lies in improved diagnostic and asexual propagation techniques, in raising the nutritional density of crops, and in increasing resistance to biotic stress. The evolution of new man-made species to complement existing cereals and the improvement of tolerance to stresses appear more distant. If the property to produce seeds asexually could be incorporated into cultivated crops, it could produce hybrids that breed true--that do not lose their genetic makeup through outcrossing when grown by farmers.

(4) *Global action to advance scientific knowledge and its application*. Whether the food needs of 2020 can be met both quantitatively and qualitatively is likely to depend on the effective mobilization of scientific resources for research and on the enhancement of farmers' skills to manage their resources sustainably through knowledge dissemination, training, and availability of inputs. Despite recent cutbacks in support to research there are hopeful signs:

- Strong international support for germplasm collection, conservation, and evaluation, although an adequate supply of quality seed is still a problem at the farm level.
- Increasing international cooperation in resource assessment and monitoring.
- Development and application of the potential for expanding knowledge created by modern information networks, videos, computers, and related technology.
- The expansion of regional research and technology transfer networks among developing countries.

Although these developments will increase the efficiency of research and its application, it would be unwise to assume that they will be cheap. Privatization of research may reduce costs to governments, but such research is likely to be focused on technology that offers a quick, substantial payoff that can be protected. Enhancing international and national support to public-sector research may be a more effective means of transferring knowledge to farmers, especially where difficult problems of poverty or resource management exist.

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"A 2020 Vision for Food, Agriculture, and the Environment" is an initiative of the International Food Policy Research Institute (IFPRI) to develop a shared vision and consensus for action on how to meet future world food needs while reducing poverty and protecting the environment. Through the 2020 Vision initiative, IFPRI is bringing together divergent schools of thought on these issues, generating research, and identifying recommendations. The *2020 Briefs* present information on various aspects of the issues.