The contribution of technology

THE CHALLENGE

Global food production needs to increase by 70 percent by 2050 in order to feed an additional 2.3 billion people. Food production in developing countries needs to almost double, and 80 percent of the cereals production increases are projected to come from increases in yields and cropping intensity. But the fact is that globally the rate of growth in the yields of the major cereal crops has been steadily declining. The challenge for research and development in food and agriculture is to reverse this trend.

The challenge is made more pressing by climate change, which is expected to have a significant impact on agricultural production. According to the Intergovernmental Panel on Climate Change (IPCC), if temperatures rise by more than 2°C, global food production potential is expected to contract severely and yields of major crops may fall globally. The declines would be particularly pronounced in lower-latitude regions. In Africa, Asia and Latin America, for instance, yields could decline by between 20 and 40 percent if temperatures rise by more than 2°C and no effective adaptation measures are taken.

Technology progress will be needed to address various issues. For instance, an increasing demand for liquid biofuel may put additional pressures on global agricultural production. More research on and deployment of second generation biofuels technologies could make a key contribution to alleviate pressure on edible crops and natural resources. Technology change will also be needed to address the problem of rapidly increasing water scarcity and to reduce post-harvest losses.

THE ISSUES

CLOSING YIELD GAPS

Yield and performance gaps in both crop and animal agriculture exist mainly because known technologies are not applied in farmers' fields. One main reason is that farmers do not have sufficient economic incentives to adopt yield-enhancing seeds or production techniques. This may be explained by numerous factors, including lack of access to information, extension services and technical and managerial skills. Poor rural infrastructure, weak institutions and unfavourable farm policies can also create obstacles to the adoption and diffusions of technologies. Solutions lie with public sector investments in institutions and infrastructure, better research-extension linkages and sound policies to stimulate adoption of technologies that improve productivity and reduce costs. Changes in agricultural management techniques can also help close yield gaps along with a more efficient and sustainable use of genetic resources. Breeding plays an important role by adapting varieties and breeds to local conditions and by making them more resilient to biotic (e.g. insects, diseases, viruses) and abiotic stresses (e.g. droughts, floods). The global yield loss due to biotic stresses is estimated at over 23 percent of the attainable yield across major cereals. Many developing countries have not adequately invested in plant breeding, seed multiplication and delivery, or in modern production agronomy.

In the livestock sector, genetic progress contributes on average between 60 and 80 percent of annual productivity gains. It is projected that up until 2040, productivity gains in the ruminant sector will be driven by technology change generated in industrialized countries, much of which however will be transferable to production systems in developing countries where it will contribute to efficiency gains.

INCREASING INPUT USE EFFICIENCIES

Increasing input use efficiencies in agricultural production will be essential as natural resources are getting scarcer, and prices of non-renewable resources like fossil fuels, nitrogen, and phosphorus are expected to increase.

- *Conservation farming* using reduced tillage, soil cover and rotations, offers a major opportunity to reduce fuel use in agriculture by an average of 66 to 75 percent as well as sequester soil carbon. Conservation agriculture (CA) can improve crop yields and farm profitability, improve soil productivity and make agriculture more sustainable, providing greater resilience against drought and

other stresses. Payments for soil carbon sequestration could provide additional incentives to adopt CA.

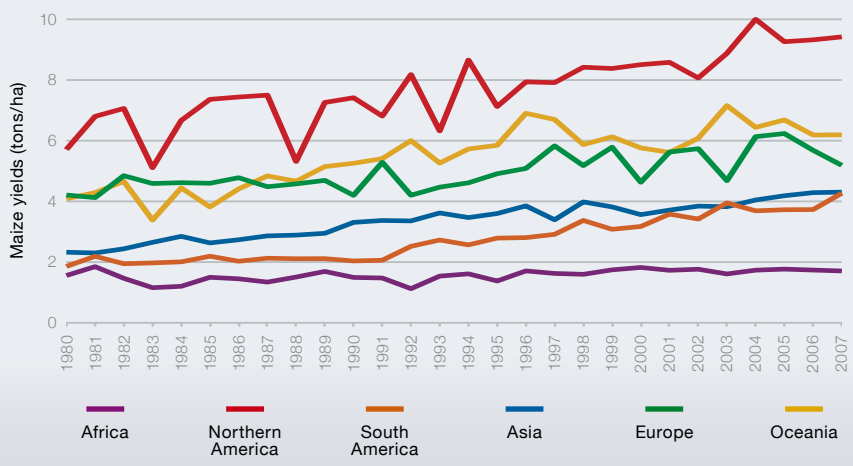
- *Fertilizer consumption* is expected to rise in developing countries. Nitrogen represents 90 percent of fertilizer consumption. Fossil energy accounts for 70-80 percent of the cost of manufacturing nitrogen fertilizer. Because major efficiency gains in manufacturing nitrogen have already been made, it is likely that fertilizer prices will in the future rise in line with energy prices. Precision agriculture and integrated plant nutrient management systems provide new tools for further improving efficiency.

- *Resource use efficiency* in livestock and aquaculture production has made major progress. In poultry, breeding for high performance and improved feed conversion ratio (FCR) and reduced mortality due to better hygienic management have significantly reduced the amount of feed (and land needed to produce this feed). Genetic improvements and good farm management practices were able to considerably improve growth performance and FCR for fish species such as tilapia and carp.

- *Integrated pest management* (IPM) aims to minimize the amount of pesticides applied by farmers by using other control methods more effectively. Pest incidences are monitored and action is taken only when the crop damage exceeds certain tolerable limits. Many countries (e.g. Niger, Mali, Jordan, India, Bangladesh and Viet Nam) have introduced IPM and have experienced increased production accompanied by lower financial, environmental and human health costs.

- *Irrigation*. FAO estimates that some 1.2 billion people live in countries and regions defined as water-scarce, and the situation is projected to worsen, with the number rising to 1.8 billion by 2025. Yet the benefits of irrigation are immense, with a productivity differential between irrigated and rainfed areas of about 130 percent. Over the past decade, irrigation alone accounted for about 0.2 percent of the 1.1 percent overall annual yield growth rate of cereals. Experts estimate that at present in developing countries, irrigated agriculture, with about 20 percent of all arable land, accounts for 47 percent of all crop production and almost 60 percent of cereal production.

Figure 1: Historical development of maize yields, by geographic region



Source: FAOStat

BREEDING AND USE OF BIOTECHNOLOGIES

The sustainable utilization of genetic resources for food and agriculture plays an important role in closing yield gaps by adapting crops, forages, domestic animals

SOME BASIC FACTS

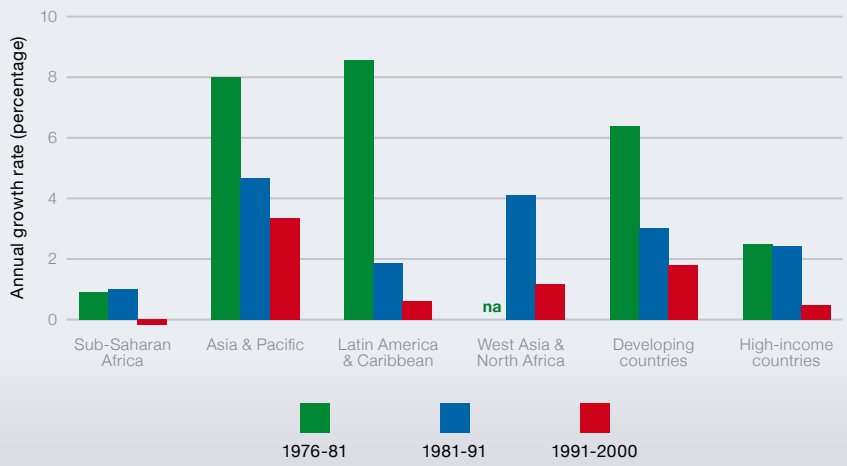
- **The Green Revolution played a key role in raising agricultural production over the past 40 years. Yield increases for major cereals (wheat, rice, maize) amounted to 100 to 200 percent since the late 1960s. However, yield growth rates were unequally distributed across crops and regions: despite the successes in cereal crops, yield growth for millet, sorghum, and pulses - which are major staples for resource-poor farmers and rural households - was slow.**

- **Large and economically exploitable yield gaps remain in many places, especially in the developing world and nowhere more so than in sub-Saharan Africa (see figure 1). Similarly, very considerable performance gaps need attention in livestock production and aquaculture.**

- **Public investments in agricultural R&D worldwide grew from USD 16 billion in 1981 to USD 23 billion in 2000, with large inter- and intra-regional differences. While public investments in the Asia-Pacific region (driven by China and India) more than doubled over**

and aquaculture fish to local conditions and by making them more resilient to biotic and abiotic stresses. To date 50 percent of the yield improvement in major crops has been attributed to conventional plant breeding and the remainder to crop management practices. Conventional plant breeding will continue to constitute an integral part of plant improvement in the future with modern biotechnology tools such as marker-assisted selection. Biotechnology-based diagnostic systems are also gaining increasing importance in crops, forest trees, livestock and fish as well as for food safety purposes while the development of vaccines using biotechnologies could provide an important option for preventing and managing animal diseases. Appropriate use of biotechnology has potential for the development of agriculture, forestry and fisheries. But given the various concerns about genetically modified organisms (GMOs), caution is needed in introducing them. Also efforts must be made to spread benefits to small-scale farmers, the poor and the hungry in a responsible way.

Figure 2: Annual growth rates in agricultural R&D, by geographic area



Source: Beintema & Elliott (2009)

INVESTMENTS IN AGRICULTURAL RESEARCH AND DEVELOPMENT

In low-income countries, agricultural R&D is the most productive investment in support of the agricultural sector. Massive public and private investments in R&D are required today in order for agriculture to benefit from effective technologies in the future given that benefits from agricultural research tend to materialize after a considerable time lag. In 2002, FAO estimated that an incremental USD 1.1 billion (at 2002 prices) would have to be invested every year into strengthening the capacity for knowledge generation and dissemination in order to reduce hunger effectively. The R&D agenda should include strategies to adapt or develop effective technologies for food production, preservation and storage, suitable for resource-poor farm families. Increased research and knowledge dissemination for indigenous food crops would also have a positive impact on household food security and improved nutrition status.

More investments in agricultural R&D are also needed to address the emerging challenges of water scarcity and climate change adaptation. Broadening the agricultural research agenda includes the development of more effective public research systems and financing mechanisms as well as increased investments in agricultural education, and enhancing access to, and exchange of, information and knowledge. Increasing private sector involvement in agricultural R&D also means addressing issues of intellectual property rights (IPRs) and ensuring that a balance is struck so that access of poor farmers to new technologies is not actually reduced. Appropriate regulatory systems that are

this period, investments in sub-Saharan Africa only grew at an annual average rate of 0.6 percent from 1981 to 2000 and actually fell during the 1990s (see figure 2). Agricultural R&D investments are increasingly concentrated in a few leading countries in each region.

- **Poultry is the fastest growing livestock subsector, but receiving only 3 percent of public R&D investment and is largely driven by private sector investment. Developments in poultry breeding, feeding and housing have enabled unprecedented increases in output and productivity.**
- **Aquaculture is also a rapidly growing sector, by an average of about 7 percent annually over the last three decades, producing 50 million tonnes in 2007. Production is still concentrated in Asia while significant opportunities also exist in many other regions.**
- **In 2008, genetically modified crops worldwide were cultivated on 800 million hectares in 25 countries (15 developing and 10 developed countries). Herbicide tolerant soybeans are the major genetically modified crop, occupying 53 percent of the total area under genetically modified crops, followed by maize (30 percent), cotton (12 percent) and canola (5 percent).**

adapted to a country's needs and effectively enforced IPRs will be essential to stimulate private sector investments.

EXTENSION AND ADVISORY SERVICES FOR INFORMATION, KNOWLEDGE AND TECHNOLOGY DISSEMINATION

Spreading knowledge, skills and technology is a major challenge. In many countries, investments in extension services have been drastically cut. Public extension services declined, but new forms of extension and advisory services have emerged in response. Private enterprises took over some of the advisory services, especially those related to inputs in profitable areas but not those related to food crops. In countries where civil society evolved, NGOs, farmers' organizations, Farmer Field Schools and others are providing services. Yet, overall there is little coordination among the different stakeholders as well as insufficient monitoring and research to compare and assess the performance of the different institutions and to measure their impacts.

Most extension systems, including public, private and civil society providers, remain severely under resourced, badly equipped, gender imbalanced and with limited access to training, new information and technologies. In many regions of the developing world, women form the majority of farmers, while many advisory and training services are targeted primarily to men. Rebuilding and strengthening public institutional capacity and empowering farmers' organizations and women should be a priority.

POLICY CONSIDERATIONS ARISING FROM THE FAO HIGH-LEVEL EXPERT FORUM ON HOW TO FEED THE WORLD IN 2050 (ROME, 12-13 OCTOBER 2009)

- In order to make significant contribution to food security, technologies and policies should:
  - be developed for a purpose, using participatory approaches;
  - be targeted towards real farmers, i.e. women and smallholders;
  - be adapted to local environmental and social conditions;
  - be supported by appropriate policies;
  - contribute to sustainable productivity growth.

- No amount of technology and/or external assistance can feed a nation that does not itself prioritize food security and agriculture in its budget and development plans.

- Organic agriculture was advocated by some panellists; however, other panellists and participants who included farmers, representatives of farmers, scientists and policy-makers spoke in favour of a variety of options, as farmers continuously face new and unpredictable challenges. It was mentioned that with use of just 9 kg/ha of fertilizers, African farmers were 'organic' by default.

- Improved information exchange among farmers, researchers, extension workers and policy makers was needed for development and deployment of useful technologies.

- Gene-based technologies will likely play a large role in feeding the world in 2050 but policies should ensure that such technologies are available to, and affordable by, smallholder farmers.

- Integrated and sustainable crop-livestock systems are important to increasing food production and mitigating climate change.

- The forestry sector contributes to food security via packaging, transporting and cooking. More than 50 percent of rural household energy in 2050 will still come from fuelwood.

- Sustainable wood production could be achieved through soil treatment, weed control, fertilization and development of fast-growing plantations.

- Enhancement of farm power in sub-Saharan Africa needs special attention.

For further information

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WSFS Secretariat
Office of the Assistant Director-General
Natural Resources Management and Environment Department
Food and Agriculture Organization of the United Nations
Viale delle Terme di Caracalla, 00153 Rome, Italy

Tel: (+39) 06 570 53101
Fax: (+39) 06 570 56172
Email: wsfs2009-secretariat@fao.org