Agricultural Research

Developing new technologies to increase crop yields, generate economic growth and reduce poverty

By DANIEL MILLER and KRISTEN EASTER

Small shoots of wheat, in long straight rows like green ribbons, emerged out of the ground where the no-till planter had sliced a swath through the dry, yellow rice stubble and into the soil. Saranjit Singh, the farmer who owned the field, pointed out where the new wheat crop was sprouting through the dried stalks of the summer rice crop. "Not only have I saved myself the headache of plowing, I spend less on seeds and save about 2,500 rupees per acre on diesel," Singh said. "By using this new technology and not plowing the soil as I did in the past, I also save time, getting the crop in quicker, giving me higher yields."

Resource conservation tillage has been practiced in the North American Great Plains since wind erosion led to the "dust bowl," driving thousands of farmers off the land and contributing to the Great Depression of the 1930s. More

Farmers produce sunflowers, cucumbers and cauliflower in the fields near Hyderabad.

intensive research on zero-till farming began in the 1960s. Today, it is well known in the United States and Europe that no-till or reduced tilling reduces labor and fuel costs. When combined with other resource conservation technologies, such as laser leveling of fields and direct seeding, farmers save water, fertilizer, seed and time. The extra layer of last season's rice stubble acts as a mulch to help regulate soil temperature and extend the growing season. Reducing tillage also has broader environmental benefits, as carbon is captured in the soil instead of being released into the atmosphere.

The U.S. Agency for International Development (USAID) is helping to introduce no-till and other new cropping techniques to Indian farmers with the Rice Wheat Consortium for the Indo-Gangetic Plains, one of the programs of the Consultative Group on International Agricultural Research, a global alliance that mobilizes science and technology to enhance agricultural production, raise farmers' incomes and reduce land degradation in South Asia. Farmers across Haryana, Punjab and Western Uttar Pradesh are quickly picking up on some of the new techniques developed by the consortium, and by 2006 more than 500,000 farmers had been reached by the program.

The benefits are clear. Less work and more income mean that farmers can recover the 3,500-rupee investment for laser-assisted precision leveling in their first crop. The consortium also promotes the use of other resource saving techniques, such as raised beds, crop rotation and inter-cropping, to help farmers become more efficient producers.

The Rice Wheat Consortium is promoting no-till with a technology innovation coming out of Punjab Agricultural University—the Combo Happy Seeder—which cuts, chops and lifts the rice straw, allowing for direct seed drilling instead of the traditional method of plowing the fields before planting. The crop residue is then dropped as mulch behind the machine after the seed is drilled into the soil.

Saranjit Singh's field is just one example of how the results of agricultural research are being disseminated to farmers in India to promote more efficient agricultural production and management practices.

Advances in science and technology from agricultural research contributed to considerable gains in agricultural productivity throughout the world in the 20th century. Research resulted in better soil, nutrient, water and pest management and more efficient and economical methods of

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George Deikun, India Mission Director for the U.S. Agency for International Development (USAID), addressing the third conference on "Linking Markets and Farmers: Exploring Leading Practices to Foster Economic Growth in Rural India," in New Delhi on March 12, 2007.

harvesting, storing and processing agricultural products. Scientific research also contributed to a better understanding of the complexity of agricultural systems and the natural ecosystems that sustain farming. This led to research into the development of agricultural practices based on ecological principles, such as no-till farming.

These developments contributed to an abundant and affordable food supply for most of the world. For example, it was scientific research that made possible the improvements in Indian crop yields during the Green Revolution of the 1960s and 1970s.

In the early 1960s, India faced a severe food crisis and was barely able to feed its growing population. Agronomists from international agricultural research institutes, working with Indian scientists, introduced high yielding varieties of wheat to India. The improved crop varieties, along with increased use of fertilizer, raised crop yields. The growth in Indian agriculture was rapid enough to move the country from the severe food crises of the early 1960s to the food surpluses of the early 1990s, despite the population increasing by more than 400 million people between 1963 and 1993. Underlying this growth in agriculture were huge investments in irrigation, research, farm credit and farmer development programs. The growth occurred despite macroeconomic policies and market regulations that penalized agriculture and are still causing distortions.

Although the gains were impressive, not all parts of India benefited equally. The challenge for the 21st century is to ensure that

Golden Rice Bio-fortified with Vitamin A

Despite india's achievement of food security since the "Green Revolution," close to half of all Indian children are still chronically malnourished and more than 2.4 million (25 percent of the global figure) die each year from preventable or curable diseases. Micronutrients such as iodine, vitamin A and iron are essential to proper nutrition and public health. Their presence in small quantities allows the body to produce enzymes, hormones and other substances necessary for growth and development. Their absence reduces disease resistance and increases maternal and child morbidity and mortality.

Globally, an estimated 250 million preschool children suffer from vitamin A deficiency, which causes night blindness and eventually blindness, growth retardation, damage of mucous membranes and reproductive disorders. Lack of vitamin A in children significantly increases the risk of severe illness, and death, from common infections including diarrhea. Annually, between 250,000 and 500,000 young children go blind from vitamin A deficiency, about half of them dying within 12 months of going blind.

Enhancing the nutritional value of staple foods can help to improve the nutrition of poor people who are forced to rely on staples and are often not able to afford a balanced diet. Rice is one such staple. Because of the high per capita consumption of rice in India and other Asian countries, fortifying its nutritional value can improve the lives of millions. Through bio-fortification, crops that are rich in nutrients can be developed. The U.S. Agency for International Development has supported research on bio-fortified, golden rice in India through HarvestPlus, an international research alliance that seeks to reduce micronutrient malnutrition through the fortification of staple foods around the world. Through research on the enrichment of Indian rice with beta-carotene, the effort aims for marketable, enriched rice varieties within five years, to significantly reduce vitamin A deficiency in India.

ERIC WITTE http://www.goldenrice.org

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Right: Near Matiala village in Ghaziabad, Dr. Olaf Erenstein, an agro-economist with the Rice Wheat Consortium, discusses the benefits of no-till farming with Dr. M.L. Jat, project director for Cropping Systems Research in Meerut, Uttar Pradesh, and farmer Saranjit Singh.

Far right: Retired Colonel S.C. Deswal in a field of carrots at his 500-acre Sunshine Farm in Uttar Pradesh. Conservation methods such as raised beds have helped to reduce water use and labor costs by 30 percent and improved the quality of his produce.

people everywhere have access to the latest innovations and knowledge that could improve incomes, achieve food security and improve nutrition. Nearly 300 million poor people are still found in India and most of these live in rural areas and depend, either directly or indirectly, on agriculture. Since the bulk of food consumed in India is produced locally, increases in crop yields and diversification of agriculture to more nutritious and higher value crops could improve the health and livelihoods of millions of people.

Poverty cannot be reduced without large investments in agricultural research. Countries with strong agricultural economies have a record of sustained investments in agricultural science and technology.

The United States is a world leader in agricultural research. The U.S. Department of Agriculture (USDA) has four agricultural research agencies: the Agricultural Research Service (ARS), the Economic Research Service, the Forest Service, and the Cooperative State Research, Education and Extension Service, which provides funding to the land-grant universities. The ARS has 2,000 PhD level scientists carrying out research at more than 100 U.S. laboratories. Much of this work is in partnership with university and industry organizations, and many ARS laboratories are located at the land-grant universities. Joint ventures between universities and the private sector are also becoming more numerous.

India has one of the largest public agricultural research systems in the world, led by the Indian Council of Agricultural Research (ICAR). It employs more than 20,000 scientists, of whom approximately 12,000 are engaged in research full time. In the developing world, only Brazil and China have comparable levels of expenditure and professional staff.

More funds for research

Yet India's investment in agricultural research is less than half of that of developed countries. To be competitive in the world economy of the 21st century, India will need to allocate more funding for research and improve the effectiveness of its agricultural research institutions and extension programs.

Increasingly scarce water supplies are also going to require improvements in water management and price reforms in supplying water for irrigation and power. Marketing and trade policies also need to be liberalized to exploit growing

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Farmers near Khandera village in Dadri, Uttar Pradesh, examine a no-till seeder, a new way of planting wheat that does not require plowing.

The USAID-supported work on introducing no-till agriculture in India shows that farmers are willing to adopt new technology once they understand how it will benefit them.

opportunities for marketing of high-value livestock products, fruits and vegetables.

With limited scope for expansion of farmed land, the main sources of agricultural growth will be enhanced productivity, profitability and competitiveness. There will also need to be a shift from resource- and input-based agricultural growth to knowledge- and science-based growth. In this paradigm shift, the dissemination of knowledge and innovations plays a critical role. The USAID-supported work on introducing no-till agriculture in India shows that farmers are willing to adopt a new technology once they understand it and how it benefits them.

Looking ahead

The key factors affecting agriculture in the 21st century will be the application of biotechnology and information technologies, as well as the globalization of markets, knowledge, education and consumer preferences. To be competitive, agriculture will have to produce value-added products that meet food safety regulations, be environmentally sustainable and respond to the increasing demand for higher quality. Agriculture development will also have to ensure a balance between food security and conservation of natural resources.

Current and planned collaboration on agriculture between Indian and American scientists and universities suggests that knowledge-based research and new technologies will bring practical solutions to help Indian farmers and attract greater private investment.

M.S. Swaminathan, known as the father of India's Green Revolution for his contributions in plant breeding, favors the genetic modification of crops as a way to increase yields. "The way ahead lies in harmonizing organic agriculture and the breeding methods based on the new genetics," he says, despite his interest in organic farming. Perhaps the genetic modification of crops taking place now may be the next stage in the process of developing new high-yielding varieties that Swaminathan bred and introduced to India more than 40 years ago.

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Genetically Engineered Eggplant

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Much of India's 500,000 hectares of eggplant—also known as aubergine or baingan *in Hindi—is destroyed by an insect, the fruit and shoot borer, and heavy spraying poisons the crops. U.S. and Indian agriculture universities have developed a gene that produces bacteria that is toxic to the insect, but not to humans or animals.*

Eggplant is one of the most important vegetables grown in Asia. It is the most-consumed, and most-sprayed, vegetable in India, where it is grown on more than 500,000 hectares, making it one of the main sources of cash for many farmers. Unfortunately, much of the eggplant in India is destroyed by the insect known as the fruit and shoot borer. To control this pest, farmers often have to spray the crop with hazardous pesticides (up to 80 times), increasing their costs of production and poisoning their crop, to the extent that farmers often won't eat their own produce.

USAID's Agricultural Biotechnology Support Project II, under a unique collaborative agreement, has worked with U.S. land-grant universities, U.S.-based seed companies, Indian research institutes, Indian state agricultural universities and private seed companies to develop varieties of eggplant resistant to the fruit and shoot borer. These biotechnological advances have been brought about by genetically engineering eggplant to contain *Bacillus thuringensis*, or Bt gene. This is a species of bacteria-producing proteins which are toxic to the fruit and shoot borer, but not harmful to animals or humans. It will greatly reduce pesticide use and improve yields (by reducing pest damage), which will increase farmers' income. Growing Bt eggplant could reduce crop protection costs by 50-80 percent and result in gains of more than $400 per hectare.

Innovative models of public-private partnerships like the one that has led to the development of Bt eggplant can be advantageous for all parties: the public sector, which obtains access to proprietary technologies and scientific innovations and product development investments; the private sector, which can reduce the cost of technology approval processes; and farmers, who receive new transgenic seeds at affordable prices.

The first genetically modified eggplant hybrid seeds, likely to be commercialized this year, will be distributed to farmers through private seed companies, thus triggering the growing of food crops developed using biotechnology in India. —D.M.