News from CGIAR
Consultative Group on International Agricultural Research
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Women and Agricultural Technology—The Users' Perspective in International Agricultural Research

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The CGIAR, established in 1971, is an association of countries, international and regional organizations, and private foundations dedicated to supporting a system of agricultural research centers and programs around the world. The purpose of the research effort is to improve the quantity and quality of food production in the developing countries. The World Bank, the Food and Agriculture Organization of the United Nations (FAO) and the United Nations Development Programme (UNDP) are co-sponsors of this effort. The World Bank provides the chairman and secretariat of the Consultative Group. The Group is advised by a Technical Advisory Committee (TAC) whose secretariat is provided by FAO. The Group has 48 members, of which 38 are donors contributing about $180 million in 1985.

Center scientists and administrators met at Bellagio, Italy, in March to discuss how gender issues relate to the mandates of the international centers. Common concerns included how IARC research can address the needs of potential user groups and how the centers can utilize household level potential for technology adoption.

ISNAR and the Rockefeller Foundation co-sponsored an inter-center seminar on Women and Agricultural Technology at Bellagio, Italy, March 26-29. The purpose of the meeting was to encourage senior policymakers in the CGIAR system to: 1) determine the degree to which the centers' research programs consider the different categories of people who are potential users of IARC technology, or whose livelihood is influenced by its adoption; 2) recommend how centers can take into account household-level potential for technology adoption—especially women's roles in farm decision making and labor allocation; and 3) identify specific activities that could be used to test the seminar's recommendations.

The Rockefeller Foundation covered many of the associated costs of the meeting, including the use of their Bellagio Conference Center.

The following interview with ISNAR's Josette Murphy, a specialist in research evaluation, describes the origin of the meeting and its outcome.

(please see next page)

Why did the center directors decide to hold a meeting on women and agricultural technology?

The original recommendation for an inter-center seminar was proposed at IRRI's conference on Women in Rice Farming Systems almost two years ago. More generally, the centers are now addressing a broader array of research problems than they did during the early years of the CGIAR system, including problems encountered under less than optimum agronomic conditions. Research must address the needs of diverse groups of producers, many of whom have a fairly small margin of flexibility for adopting new technologies. The need to understand real farming conditions and the constraints under which diverse categories of producers, including women, must operate is being increasingly recognized by the centers. This affects the way that research problems are identified and the way that research design is carried out in both national and international organizations. The objectives of the meeting were to assess the centers' experience to date in serving diverse groups of producers—of which women are important subsets—and to discuss future approaches to research and how we can best cooperate with national research organizations.

Who uses the new agricultural technology developed by the centers?

The national research organizations. The participants emphasized that these organizations are the primary clients of the IARCs. The CGIAR impact study that's currently under way will specify which producers actually adopt IARC technologies.

Should we consider women as a separate category of users and beneficiaries of this technology?

No, women do not form a homegeneous group for development purposes. The variable of gender is relevant to development activities because in every society it influences the rights and obligations of individuals and their access to production resources, but several other variables need to be considered when defining categories of people for development activities. The social status of the household, its resources in terms of land, labor, capital, and education, and the diversity of its income-producing activities are examples of the variables that influence the situation of a particular woman in relation to technological change. Furthermore, women play multiple roles. For example, they participate in field work, control many processing activities, and are responsible for household tasks. The situation is too complex to be reduced to only a matter of gender, but gender-related issues do have a significant influence on technology adoption.

What are the consequences for agricultural productivity and family welfare if women's decision making is not adequately considered in the generation and use of new agricultural technology?

There are three key points here, each of which was addressed at the seminar. The first point is that women, in their roles as agricultural producers, food processors, traders, and family nurturers, influence household behavior and decisions in a number of ways. Even if a particular decision regarding technology is overtly made by the husband, his decision is usually influenced by factors other than agronomics. Cooking and processing qualities are good examples, as are relative prices and marketing opportunities, demands on family and hired labor, and consumption and cash needs. The choice of technological approach is based on more than the production process itself; it is based on the entire food and economic context of the household, and women play an active part in that choice.

The second point is related to how the contribution of women to household welfare can be disrupted through the introduction of well-intended technological change. Don't forget that in many countries there is a clear division in rights and obligations among the members of a household. Women usually have some personal source of income that they control and which, as a rule, they use to provide supplementary food to their children or to cover school costs. To deprive a woman of this income through a misconceived development effort is likely to deprive her children of food or schooling. This occurs quite often when the production of a cash crop is encouraged by promoting the use of improved technology through extension, credit, and marketing that is biased towards the male head of the household.

Finally, in many societies, women are a repository of information on local flora as well as traditional farming, storage and processing practices. Researchers lose potentially useful insights when they ignore women.

How do we define the needs of women who do not have an opportunity to communicate their needs?

In many of the poorer countries small farmers do not have effective channels to communicate their needs, whether they are male or female. It is the researchers and development experts in national, and sometimes international organizations, who assess these needs through direct studies of the rural situation or who deduce them from the statements of administrators and politicians. Data collection and analysis for problem identification and the definition of constraints is often a necessary first step in research. In the past, data collection efforts have sometimes been misleading because they focused on men. To fully understand how decisions are made and under which priorities and constraints the household operates, it is essential to get information from the various people involved, including women. In some cultures this may require hiring both female and male field workers, but it does not necessarily increase the overall size of the work force required. The most important step in ensuring that women's needs are properly defined is right at the beginning, when a research project is being designed. If researchers are aware that women influence technology adoption, whether or not they actually participate in production, then research plans and appropriate data collection procedures can be designed. As a consequence of the need for appropriate information and the importance of placing production decisions in a broader social and economic context, the social sciences become an integral part of research. National programs must continue to

perform most of this location-specific research, including problem identification.

What efforts have the centers made to integrate women's roles into research objectives or to analyze women's needs successfully?

Each center was asked to write a paper describing past and current activities that take into account the diversity among producers and other beneficiaries of technology and, more specifically, activities related to women. The papers show that many activities are under way that focus on, or take account of, the needs of women. These include agronomic studies and analyses at the farm level and household, regional and national studies that include economic and social issues. These activities are often initiated when a center broadens the scope of its interests to include the storage and processing characteristics of its target crops. The studies provide location-specific data with immediate applications. More important, they contribute to the development of methodologies and procedures which other organizations can adopt—a principal role of international centers. Areas of experience and expertise vary across centers, and clearly there are logical divisions of labor with regard to both actual research and methodology development.

What were the key issues discussed at the meeting?

I've already mentioned the importance of placing production in its broader economic and social context and the need to use data that highlight rather than blur the diversity among client categories. A key issue that we discussed was the respective and complementary roles between international and national organizations. The participants emphasized that IARC clients are the national research organizations, and that the centers are involved at the farm level primarily through their counterparts in national programs. The need for strong national organizations was reaffirmed. In matters related to women, a major role prescribed for the CGIAR centers is to inform and sensitize national policymakers and researchers to the issue and to demonstrate the production consequences of inappropriate policies, research, or extension decisions. The participants discussed the diversity in mandate and approaches among the centers and recognized the support between the commodity centers and centers such as IFPRI and ISNAR. The participants also discussed the benefits from an interdisciplinary approach to problem identification and research implementation and the need for more contacts and exchange between scientists working on similar issues in the various centers.

Were recommendations made for future actions?

A statement of conclusions reached by the participants will be formally presented at the June 1985 meeting of the Directors-General. The statement affirms the relevance of women's issues to development and research, and it highlights the diversity among women producers and other beneficiaries of technology. It discusses the complementary nature of national and international research efforts, emphasizing the need for strong national research organizations and for client-oriented research planning.

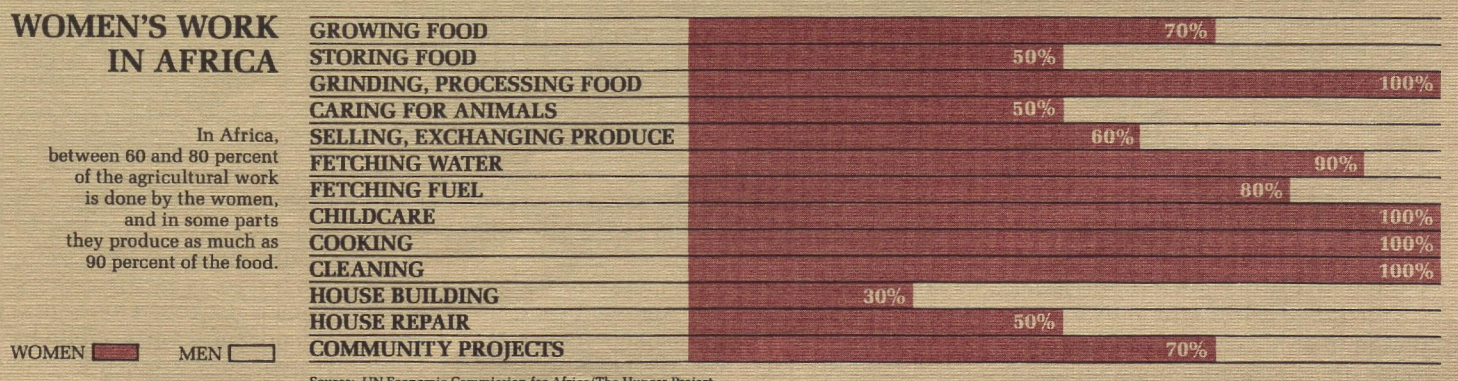
The statement includes some suggestions for research design, development of research procedures, dissemination of findings, and training within the IARCs, but it was left to each center to decide exactly what it needs to do under its mandate and how it should go about doing it. Reporting and other administrative requirements were not included to avoid artificial isolation of the issue. We should remember that a research program does not have to include the word women in its title to be appropriate to their needs. Researchers should aim at integrating gender-related issues into the mainstream of development and research strategies at all levels—design, implementation, testing and evaluation—because it makes good technical and economic sense.

Bellagio: Issues for the CGIAR Centers

The Bellagio conference signaled the beginning of a system-wide dialogue on the subject of women and agricultural development. While the meeting dealt primarily with the concept of "user perspectives" rather than women *per se*, numerous issues were raised that could help the CGIAR centers to gear research to the needs of female farmers and consumers.

Why Women: One of the key issues at Bellagio was whether development agencies should designate women as specific users of technology. Although several of the participants pointed out that women should not be considered as a target group, the importance of women in the agricultural sector was commonly acknowledged.

Estimates presented at the conference show that women grow much of the food produced in developing countries and that they are crucial to the support of poorer households. In many instances they also serve as farm managers who are re-



Source: UN Economic Commission for Africa/The Hunger Project

sponsible for the choice of crops that are grown, the use of farm labor, and the purchase of inputs.

Priorities: Consideration was also given to the question of how international centers can direct research toward female constituencies. Priority areas include the assessment of women's participation in agricultural field tasks, analyses of how researchers can best meet the needs of female farmers and consumers, and studies aimed at identifying sex-specific needs. The last point, it was said, could be carried out through network building, the inclusion of women staff and trainees in on-farm research programs and by evaluating gender-related incentives for technology adoption.

Negative Impact: The participants also examined the possibility that improved technology can have a negative impact on women, particularly in the area of employment.

While several examples were cited, the discussion showed that the issue is essentially one of balance. For example, two center representatives noted that research had shown that the use of chemical herbicides in their region could lead to higher rates of female unemployment, and thus a decision was made at their center not to study or promote herbicides. Subsequent research, however, revealed that in many instances farmers who failed to use herbicides could not take advantage of improved technologies that would ultimately lead to higher productivity.

"The challenge," one participant stated, "lies in integrating technology, work opportunities, and extension services in a mutually supportive way so that both men and women can play productive and mutually profitable roles in agriculture."

Programs: At present, many of the centers are focusing on these issues by collecting primary data. IFPRI, for example, has conducted a number of studies to assess government policies that emphasize the substitution of cash crops for food crops. The thrust so far has been to identify shifts in household budgetary control and the time available to women for child care and nutrition.

Similar studies are being conducted to guide center research programs in the development of new technologies. CIAT reported that

Women in Agriculture . . .

CIP

WORLD BANK

While circumstances vary, women play a critical, though often unacknowledged role in agriculture.

IITA

In addition to their responsibilities as homemakers, in many countries women form the bulk of the farm labor force and in some instances are credited with producing 90 percent of all food crops.

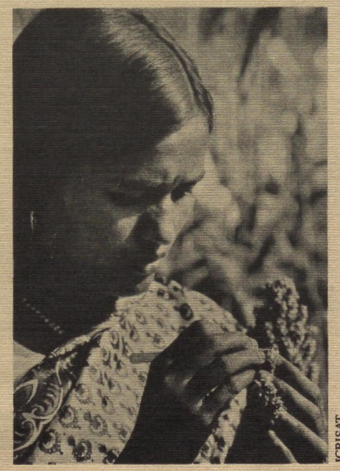
CIAT

Women also play a key role as purveyors of food stuffs. Once a field has been harvested, they are often responsible for transporting and marketing the crop.

WORLD BANK

IITA

International centers are now acknowledging the role of women in agriculture, and are drawing upon their experience to determine the thrust of future research. One study highlighted at Bellagio showed that many women are experts on local flora, seed production and procurement, harvesting, storage and processing.



ICRISAT

Women are also playing direct roles in center research and policymaking. Many IARCs are now addressing the gender factor by tapping the expertise of women staff members and trainees.

surveys have been used to identify characteristics that might influence women farmers and consumers to adopt improved bean cultivars. Along the same lines, an in-house study at IRRI showed that some of the institute's agricultural machinery is too heavy for women to operate and that efforts may be needed to modify the equipment.

Gender-related topics are also receiving attention at center symposia and workshops. Recently, women's issues have been featured at a number of conferences, including a special roundtable discussion held at IITA's May workshop on banana and plantain production. Other IITA initiatives include attempts to increase the number of women who attend the institute's training programs and an expansion of the gender-related references available in the IITA library.

Sensitization: While each of these programs has a role to play in addressing women's issues, a number of participants pointed out that international centers should also attempt to influence institutional attitudes about women.

Dr. Swaminathan noted that a starting point would be to sensitize officials at key development and funding agencies. Specific steps, he said, might include formal consideration of women's issues at the Centers' Week, the development of research priorities and strategies by TAC, and the coverage of gender-related topics in the terms of reference of the quinquennial reviews panels. He also suggested that each center develop an interdisciplinary working group to analyze pertinent issues and to help orient research strategies and priorities.

He cautioned, however, that impact would be limited unless similar attempts were made to address the issue directly to national research systems. "These mechanisms of interaction between scientists in national programs and their counterparts in the IARCs," he said, "should be fully utilized in the move for achieving a greater degree of understanding on the issues. . . ."

The proceedings of the Bellagio meeting—***Women and Agricultural Technology: Relevance for Research*** (Volume I) and ***Experiences in International and National Research*** (Volume II)—will be available from ISNAR in July.

AWID Honors Swaminathan

Dr. M. S. Swaminathan, Director General of IRRI, received the Association for Women in Development Award for "outstanding contributions to the integration of women in development" at the Association's April meeting in Washington. In accepting the award for Dr. Swaminathan, Dr. C. Jean Weidemann of the Midwest Research Institute quoted from Swaninathan's address to the Bellagio meeting, part of which is excerpted below.

"It is essential that IARCs avoid a *laissez faire* approach (to women's issues) and move *positively and aggressively* in the direction of assisting women dependent upon agriculture for their well-being. This is particularly important in the context of the increasing emphasis placed by IARCs on attending to the problems of ecologically handicapped farming areas and economically disadvantaged farm families. *It is precisely in such situations that the value of women's labor and income to household happiness and survival is immense.*

How can IARCs help in generating greater opportunities for flexible and productive employment when most of them are not concerned with post-harvest technology and the off-farm employment sector?

An effective way of responding to this challenge is to capitalize upon IARCs single most important asset, namely access to diverse scientific institutions and political systems. By the very nature of their functioning—through networks, cooperative programs, monitoring tours, symposia and conferences, and training activities—IARCs exert an influence on national research systems which far exceeds their budget or scientific capability and infrastructure. They have equal access to the knowledge and material pool in developed countries. They can hence lead a *positive movement* of helping women, particularly (those) belonging to small farmer and landless agricultural labor families, through the organization of workshops which can help to compile a portfolio of research and training tasks for each major farming system and getting interested laboratories and scientists, both in developed and developing countries, to adopt specific tasks. In addition, they can set an example in involving women scientists to a greater extent in all aspects of technology development and dissemination.

While action on the above lines is feasible and should be taken, *it is important to recognize that science is not a magic wand with which sex inequalities in workload and economic returns can be made to vanish.* This should be emphasized clearly as otherwise false hopes will be aroused about the capacity of science and technology to remove deep-seated social maladies.

In the ultimate analysis, it is only the concern, commitment and concerted action of national agricultural research systems and policymakers that can lead to meaningful results in imparting a users' perspective in research priorities and strategies. The major role of IARCs should be to trigger a self-propelling and self-replicating pattern of involvement of NARS in R&D efforts designed to give equal attention to the needs of men and women farmers and agricultural labor. *Prospects of external funding should not be the main motivating factor for the participation of NARS in networks or studies in this field.* There are numerous examples to show that involvement without conviction and commitment leads to the collapse of bilateral or multilateral donor-aided programs when the external input is withdrawn. Enduring benefits will result only when a proper blend of political will, professional skill, and people's participation is achieved within each country."

New TAC Member

Dr. Ibrahim Nahal has been appointed to TAC for a two-year period ending December 1986. Dr. Nahal, an expert in the fields of ecology and forestry, is presently the Rector of the University of Aleppo, Syria. He previously served as a Senior Regional Advisor to the UN Environment Program and as a Visiting Scientist at the Institut Nationale Agronomique de Paris.

ACIAR President Named

Professor John Dillon has been appointed President of the Policy Advisory Council of the Australian Centre for International Agricultural Research (ACIAR) and Chairman of the Centre's Board of Management. He succeeds the late Sir John Crawford.

Like Sir John, Professor Dillon has a deep interest in the activities of the CGIAR. He heads the ICRISAT board, is a member of CIAT's board and is the Chair of the CGIAR's Board Chair Group for 1985. He has also played a significant role in several external reviews and in 1981 led a review of farming systems research at the CGIAR centers.

New Publications

CIAT

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EDUCATION AND FERTILITY

There is a correlation between how much schooling a woman receives and the number of children she has.

SELECTED DEVELOPING COUNTRIES	TOTAL FERTILITY* AMONG WOMEN	
	NO SCHOOLING	7 YEARS SCHOOLING OR MORE
COLOMBIA	7.0	2.6
COSTA RICA	4.5	2.5
LESOTHO	6.2	4.8
MEXICO	8.1	3.3
PAKISTAN	6.5	3.1
PHILIPPINES	5.5	3.8
SENEGAL	7.3	4.5
SUDAN	6.5	3.4

*Total fertility is the average number of children born to each woman.

Source: *World Development Report 1984*, The World Bank/The Hunger Project

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To purchase publications, contact the centers or Agribookstore, IADS Operations, Inc., 1611 North Kent Street, Arlington, VA 22209, USA.

Calendar

CGIAR Activities

October 28-November 1	International Centers' Week, Washington, DC

TAC Activities

October 21-26	38th TAC Meeting, Washington, DC

Seminars, Symposia and Workshops

July 1-6	CIP	Tunisia Potato Tuber Moth Seminar
July 1-10	CIP	Philippines Rapid Multiplication Techniques Course
July 4-10	CIAT/CIP/IITA	Workshop of the Caribbean Network of Root and Tuber Crops, Guadeloupe
July 7-27	IBPGR	Training Course on Temperate Fruit Crops Germplasm, University of California, Davis, USA
July 8-12	IITA	IITA/UNDP Dissemination and Transfer of Technology Workshop
July 11-13	CIP	Philippines Technology Transfer: Seed Potato Production Training Workshop
July 15-19	CIAT	Workshop on Seed Technology Research and Training
July 22-26	CIP	Philippines Potato Production Course
July 22-26	IITA	West African Root Crops Workshop, Accra
July 22-26	ICRISAT	Fourth Regional Workshop on Sorghum and Millet Improvement in Eastern Africa, Soroti, Uganda
July 28-30	ISNAR/FAO/ ICARDA	Conference of the Association of Agricultural Research Institutions in the Near East and North Africa Region, Damascus
August 5-7	IITA	Tissue Culturalists Meeting
August 5-9	CIAT/IRRI	International Rice Conference for Latin America
August 5-23	IBPGR	Training Course on Genebank Management, N.Y. State Agricultural Experiment Station, Cornell University, Ithaca, N.Y., USA
August 6-8	IBPGR	International Symposium on Southeast Asian Plant Genetic Resources, Jakarta
August 6-8	IBPGR	Workshop on *Triticeae*, Washington, D.C.
August 8-9	CIAT	Rice Breeders' Workshop, Central America and Mexico, Villavicencio, Colombia
August 12-16	IITA	Mass Media and Food Production in Eastern and Southern Africa, Nairobi
August 12-30	CIP/CIAT/IITA	Nigeria Tissue Culture Techniques and Propagation Course
August 21-26	ICRISAT/WMO	Workshop on Agrometeorology of Groundnut, Niamey
August 25-30	IITA/IBSRAM	International Conference on Land Clearing and Post Clearing Management, Sumatra, Indonesia
August 26-30	CIMMYT	Winter Wheat Workshop
September 2-6	IRRI	Agricultural Engineering Workshop
September 2-6	ILCA	Conference on Matching Livestock Feeding Systems to Resources
September 2-27	ISNAR/MAMC	Workshop on Agricultural Research Management, Mananga, Swaziland
September 2-October 4	CIAT	Regional Course on Cassava Research for Production for South Asian Countries
September 9-13	ICARDA	FABA Bean Nile Valley Project Coordination Meeting, Sudan
September 9-13	IITA	Regional Workshop on West African Farming Systems Network, Dakar
September 11-23	CIP	Burundi Potato Storage Course
September 16-19	ILCA	ILCA Workshop on Potentials of Forage Legumes in Farming Systems in Sub-Saharan Africa
September 16-20	IITA	EEC/SAFGRAD/IITA HYVT Project Maize and Cowpea Workshop, Cotonou
September 16-28	IRRI	Farming Systems Social Economics Research Monitoring Tour and Workshop
September 29-October 1	IRRI	Salinity Workshop, Pakistan
September 30-October 4	IITA	Soybean Workshop
September 30-October 4	ILCA	Conference on Small Ruminants in African Agriculture

CGIAR

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CIMMYT: Centro Internacional de Mejoramiento de Maiz y Trigo.
P.O. Box 6-641, Londres 40, Mexico 06600, D. F. Mexico
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Telex: 383-1772023 CIMTME

CIP: Centro Internacional de la Papa.
Apartado 5969, Lima, Peru
Telephone: 350266
Telex: 25672 PE

IBPGR: International Board for Plant Genetic Resources.
Via delle Terme di Caracalla, Rome 00100, Italy
Telephone: 5797
Telex: 843-610181/610127 FAO I

ICARDA: International Center for Agricultural Research in the Dry Areas.
P.O. Box 5466, Aleppo, Syria
Telephone: 50465/51280
Telex: 924-331206

ICRISAT: International Crops Research Institute for the Semi-Arid Tropics.
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Telephone: 262251
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•PRESS RELEASE•

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Bioengineering of Crops Could Help Feed the World

Crop Increases of 10-25 Percent Possible

Interviews are available with Ismail Serageldin, World Bank Vice President for Environmentally and Socially Sustainable Development, and scientists on the World Bank panel on biotechnology. Please call 703-820-2244 to schedule a time.

Bioengineered crops -- changing the nature of plants by adding or removing DNA -- could improve food yields by up to 25 percent in the developing world and help feed the 3 billion people to be born over the next 30 years, says a report by a top-flight scientific panel convened by the World Bank and the Consultative Group on International Agricultural Research (CGIAR).

Genes can be inserted into the major food crops, including rice, corn, wheat, potatoes, cassava and others to make them resistant to pests and diseases without the need for chemicals, or make them resistant to drought, cold, heat and other hostile conditions. Genes can also be inserted to increase the food content of crops -- increasing the amount of starch in potatoes and protein in rice, for example, says **Bioengineering of Crops**, a report prepared for the World Bank and CGIAR.

"The challenge of feeding an additional 3 billion human beings, 95 percent of them in the poor developing countries, on the same amount of land and water currently available, requires a dramatic transformation of rural economies and intensified agriculture," says Ismail Serageldin, Chairman of CGIAR and World Bank Vice President for Environmentally and Socially

Sustainable Development, who commissioned the panel that wrote the report. "All possible tools that can help promote sustainable agriculture for food security must be marshaled, and biotechnology, safely deployed, could be a tremendous help in that fight."

By far the greatest proportion of current research in crop biotechnology is being conducted in industrial countries on the crops of economic interest in those countries. In the European Union, almost 2,000 biotechnology research projects are underway, at least 1,300 of them using plants.

About 40 percent of field trials being conducted in **developing countries** are for virus resistance. Twenty-five percent of the trials are for crops modified for herbicide resistance, and another 25 percent are for insect resistance, with the balance for product quality, fungal resistance or agronomic traits.

Agricultural bioengineering has been made possible by the swiftly increasing abilities of scientists to extract and manipulate DNA (deoxyribonucleic acid) which makes up the genes of all living things. The transfer process involves cutting the desired gene out of a chromosome (string of genes) of a particular plant, animal or bacteria, and putting that gene into a plant cell; the genetically modified cell is then regenerated to produce a 'transgenic', or genetically modified plant. The modified plant passes the new gene onto its progeny.

"Biotechnology raises many ethical, safety and patenting issues," says Nobel Prize winner Henry W. Kendall, chairman of the panel, as well as chair of the Union of Concerned Scientists. "This conference is bringing the best scientific and intellectual talent to address the issues of safety, and confront all perceived and real risks with a view of devising a sensible, scientifically based strategy for the safe use of biotechnology."

Top scientists in the field, international organizations and concerned citizen groups will discuss the latest developments in bioengineering and to assess risks of the process, in a conference, **Biotechnology and Biosafety**, to be held in Washington Oct. 9-10. Other scientists attending, besides Kendall, will be Werner Arber of the International Council of Scientific Unions, Nobel Prize winner in medicine and physiology; Christopher Somerville, of the Carnegie Institute of Washington; Rita Colwell, President of the Biotechnology Institute, University of Maryland; and Po Tien, Director of the Molecular Virology and Bioengineering Department, Chinese Academy of Sciences.

The conference is sponsored by the World Bank, CGIAR, the U.S. National Academy of Sciences, the American Association for the Advancement of Science, the Smithsonian Institution, the International Council of Scientific Unions, the Third World Academy of

Sciences, the Food and Agriculture Organization, the United Nations Educational, Scientific and Cultural Organization, the United Nations Industrial Development Organization, the United Nations Development Programme, the United Nations Environment Programme.

"It is striking that so many distinguished organizations have agreed to cosponsor this conference," says Prof. Kendall. "The results of this conference should carry weight both by the quality and eminence of the participants as well as the scope and breadth of the co-sponsors."

CGIAR, a consortium of 16 international research centers, has traditionally functioned by promoting free access to genetic materials and research results. CGIAR will be challenged in this new era of patented proprietary research to find ways of intensifying its work for promoting, through research, sustainable agriculture for food security in the developing countries.

Current and Potential Contributions of Bioengineered Crops

Bioengineered crops are being introduced into the United States and other industrialized countries -- for example the Flavr Savr tomato is one of the first genetically engineered plants to receive approval from the U.S. Food and Drug Administration. The fruit ripening characteristics of this variety were modified to provide a longer shelf life.

Genetically engineered crops with improved pest and disease resistance, such as cotton, are also close to the U.S. market. Rice varieties with enhanced virus tolerance should be available to American farmers within a few years.

By the year 2000, annual farm sales of biotechnology-derived products are likely to total some $10 billion, with 70 percent based on seeds and 30 percent on veterinary and other products. Some $1 billion a year is spent on global research and development in agricultural biotechnology.

Most of the bioengineering research carried out for developing countries to date has been to lay the groundwork for future crop transformation, but improvements in crop yields could come rapidly. The crops being researched include:

Rice: The Rockefeller Foundation's support for rice biotechnology should begin to pay off in two to five years in the form of new varieties available to some Asian farmers, the report says. In China, rice varieties produced through another form of biotechnology are now being grown on thousands of acres by farmers in rural areas near Shanghai.

"It is likely that efforts to improve the rice yield in Asia through biotechnology will result in a production increase of 10 to 25 percent over the next 10 years," the report says. "The increase will come from improved hybrid rice systems in China; from rice varieties transformed with genes for resistance to pests and diseases in other countries, which will increase average yields by preventing crop damage, not by increasing yield potential."

Corn (or Maize): Corn yields in developing countries may also be increased by biotechnology if genes useful in tropical countries are discovered in the course of corn research underway in the United States, the report says. Developing world scientists would be most interested in improving the protein quality and oil content of corn.

Potatoes: Some success has been demonstrated in increasing the starch content of the potato through genetic manipulation, which holds the hope of a significant increase in production potential from the same amount of potato plants in a field of the same size.

Potatoes are basically water and starch, but the starch content, which carries most of the food value, is less than 20 percent, versus more than 60 percent for corn. Scientists believe that if the process can be perfected, it can also be applied to other root and tuber crops crucial to the developing world, such as cassava, yams and sweet potatoes.

Pest and Disease Resistance: Prospects for incorporating pest and disease resistance into developing country crops are more favorable than prospects for increasing yields. Insect and disease problems are much simpler to address, and much of the effort in biotechnology is focused on these problems.

Agricultural intensification, through improving the productivity and income of the millions of small holder farmers in the developing world, is central to reducing poverty, protecting the environment and increasing food security. Without intensification, the forests will be chopped down, the hillsides will be colonized, the soils will be eroded and the waters will be dissipated. How to intensify is the question. Biotechnology is only a small part of the answer, but a potentially important part.

The U.S.-based company Monsanto has given Mexico without cost the genes that confer resistance to important potato viruses, and trained Mexican scientists in plant transformation and other skills needed to make use of the genes. The transformed potatoes are now being field-tested in Mexico.

Monsanto has also worked with the U.S. Agency for International Development (USAID) and the Kenya Agricultural Research Institute to develop and donate a similar virus control technology to Kenya and Indonesia for virus control in the sweet potato.

"These cases, however, are fairly few," says Mr. Serageldin. "We have to seek more ways of cooperation between researchers in industrialized countries and farmers in the developing world."

Herbicide Resistance: Scientists are trying to make crops that are resistant to herbicides, which kill weeds. Weeds are one of the main constraints to crop yield increases in developing countries. If herbicide-resistant crops are developed and planted, environmentally-safe herbicides could be used to kill weeds threatening the fields but would not harm the crops. A major value would be much less use of environmentally-unsafe herbicides.

Drought Resistance: Drought is a major problem for nearly all crop plants in the developing world, and the prospect of a "drought resistance gene" has excited many scientists. However, plant scientists recognize that many traits, and therefore many genes, contribute to drought tolerance or resistance: long, thick roots; thick, waxy leaves; the ability to produce viable pollen when under drought stress; the ability to recover from a dry period. Some of these traits can undoubtedly be controlled genetically, but little progress has been made thus far in identifying the genes that control them.

Oils: Biotechnology has also been used to change the proportion of fatty acids in soybeans, and to modify the composition of canola oil.

The Need for Bioengineering -- Increased Food Production

Currently, some 1 billion people around the world go hungry each day, half of them suffering from severe malnutrition.

Population in the developing world is 4.6 billion and is expanding at 1.9 percent a year, a rate that has been decreasing somewhat in the past decade. The least developed nations are growing at 2.8 percent a year. If they continue to grow at this rate, their population will double in 24 years. Currently, about 87 million people are added to the world's population each year.

In 1961 the amount of cultivated land supporting food production was 0.44 hectares per capita. Today it is about 0.26 hectares per capita, and based on population projections, it will be in the vicinity of 0.15 hectares per capita by 2050.

The rate of expansion of arable land is now below 0.2 percent a year and continues to fall. The bulk of the land best suited to rainfed agriculture is already under cultivation, and the land that is being brought into cultivation generally has lower productivity.

Erosion has made a billion hectares, or nearly 2.5 billion acres, of soil unusable for agriculture in recent decades. Asia has the highest percentage of eroded land, nearly 30 percent, but in all major regions the percentage exceeds 12 percent. It is estimated that 17 percent of all land under cultivation was degraded by human activity between 1945 and 1990.

"There are just two ways to increase food production -- put more land under cultivation, or increase yields," says Mr. Serageldin. "Clearly, the only realistic alternative humanity now has is to boost yields on available land. This will require many things other than biotechnology, but biotechnology will be a crucial part of expanding agricultural productivity in the 21st century."

Risks of Bioengineering

The major risks and objections to bioengineering include:

Inadvertent Consequences: Some critics have said that plants could be changed in unforeseen ways that would not be known until it was too late to reverse the process. Global research, however, has already worked to protect people, as when a company wanted to use a desired gene from the Brazil nut to put into the soybean, to increase the value of soybean protein for chicken feed. However, research demonstrated that this gene was the same gene that triggers allergic reactions to Brazil nuts in many people. Even though the company believed that the chickens would not be allergic and that humans would not have been affected by the chicken products, there was concern that the altered soybeans might accidentally get into the food chain. Because of that fear, the company voluntarily dropped the project.

Ethics: Private companies in the United States and other countries can patent genes that they manipulate in the test tube, but many non-government organizations, some international organizations and some governments object, arguing that no forms of life should be "owned."

"While patent protection is necessary to get the private sector involved in this research and development, we must find ways to handle public goods and the needs of the poor around the world," says Mr. Serageldin. "New modes of partnership will have to be worked out."

Herbicide tolerance: Some critics of bioengineering have raised the possibility that, for example, herbicide-tolerant squash could cross with its wild relative in southern climates, a

weed, and produce a herbicide resistant weed that could not be killed and would therefore grow without any form of control.

Loss of biodiversity: Said to be a consequence of growing genetically uniform plants [developed through genetic engineering]. This is also an issue raised with modern crop varieties developed through conventional means.

Food Safety: Many people are concerned that if they eat fruits or vegetables that are resistant to bacteria, it could kill all bacteria in their stomach, harming the digestive process. No scientific evidence supports such fears.

Cutting choices for vegetarians: Some vegetarians have said they do not want to eat vegetables that contain animal genes, because the food would not be a purely plant product.

"We must not dismiss the fears and concerns of people about the possible risks of the new technologies," says Mr. Serageldin. "But we must not allow diatribes to shackle progress either. We need processes of consultation and scientific evidence to guide our actions. This conference is one effort at generating a consensus approach to a difficult subject."

Conclusions and Recommendations

The panel's recommendations: very high priority must be assigned to the expansion of agriculture and to increased production of food in the developing world. It is critically important that increases in food production outpace population growth. Damaging agricultural practices must be replaced with lower impact, sustainable activities so that global capacity to produce food does not decline.

Because DNA technology is so powerful, it has the ability to make significant positive or negative changes in agriculture. Bioengineered crops are not in principle more injurious to the environment than traditionally bred crops. The panel recommends:

1. The World Bank should direct attention to the need for liaison with and support of the developing world's agricultural science community. A specific and urgent need is the training of developing world scientists in biotechnology methods so that each nation will have a cadre of scientists to assist it in setting and implementing its own policies on biotechnology research and biosafety.

2. The World Bank should identify and support high-quality research programs whose aim is to exploit the favorable potential of genetic engineering for improving the lot of the developing world.

3. The World Bank should support the implementation of formal, national regulatory structures in its client nations by seeing to it that these structures retain their vigor and effectiveness through the years and by providing scientific and technical support to the client nations as requested.

4. The World Bank should support, in each developing country, the deployment of an early warning system to identify any troubles that may arise and to introduce improvements in adapting new strains.

5. The World Bank should increase its support of research in biotechnology and related areas at international agricultural research centers because these centers are currently in the best position to ensure that high-quality, environmentally sustainable agricultural products and processes are developed and transferred to developing countries.

6. The World Bank should continue to give high priority to all aspects of increasing productivity in developing world agriculture while encouraging the necessary transition to sustainable methods.

Besides DNA agriculture, the panel says that the developing world needs:

o Increasing priority on conventional plant breeding and farming practices;
o Ensuring that adequate energy and water become available and that procedures for their efficient use are made known and adopted;
o Ensuring the introduction of modern means of controlling pests, including the use of integrated pest management systems, safe chemicals and resistant crops.
o Supporting the transition to sustainable activities and the reduction of waste and loss in all elements of the agriculture enterprise;
o Ensuring that the changes in agriculture will provide the employment opportunities that will be needed in the developing world.

"Because we do not want to proceed in this controversial area without the best scientific advice, we were grateful to Prof. Kendall and his colleagues to have reviewed the evidence and given us the advice they have," says Mr. Serageldin. "Together with the results of this conference, their

advice will inform the Bank's work on supporting the development and safe use of biotechnology in developing countries, for the benefit of the poor and the environment."

* * *

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Peter H. Raven: Director, Missouri Botanical Garden. Professor of botany, Washington University. Home secretary, National Academy of Sciences. Many awards, including the Japan International Prize for Biology, and jointly received the Sasakawa Prize, the Volvo Prize and the Prize of the Institute de la Vie.

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