

### **III PRESENT STATUS OF AGRICULTURAL BIOTECHNOLOGY IN ASIA**

#### **A. Selected Country Experiences**

Several governments in Asia are committed to the use of modern biotechnology in agriculture. They have devoted significant human and financial resources to this policy over the past two decades. Some illustrations of current activities in selected countries are given below. Further details on individual countries are contained in Appendixes 3 to 10 and summarized in Table 3.1.

The PRC accords high priority to biotechnology to increase food production and improve product quality in an environmentally sustainable manner. The PRC has moved quickly to adopt new biotechnologies, particularly genetically modified crops. The country is rapidly increasing its expenditure on biotechnology R&D. Over 103 genes have been evaluated for improving traits in 47 plant species. New traits have been introduced and evaluated in field tests on rice, wheat, maize, cotton, tomato, pepper, potato, cucumber, papaya, and tobacco. A variety of traits have been targeted. They include resistance to diseases, pests, and herbicides, and quality improvement.

Approximately 50 genetically modified varieties have been approved for environmental release, or small-scale field testing in the PRC. A few new genetically improved varieties have been approved for large-scale commercial production. The most widespread are new pest-resistant varieties of cotton that are being widely cultivated by farmers. These were grown commercially by approximately 3 million farmers on approximately 500,000 ha in 2000. Several new products are in the pipeline for potential commercialization (Zhang 2000).

India has allocated large public resources toward human resources development and infrastructure in biotechnology. In the early 1980s, the Government of India created a Department of Biotechnology to promote the use of new biotechnologies in industry, medicine, and agriculture. Current R&D efforts in India are directed toward increasing agricultural productivity, bioremediation in the environment, medical and industrial biotechnology, and bioinformatics (Sharma 2000). R&D priorities in agriculture include new regeneration techniques for the rapid multiplication

of citrus, coffee, mangrove, vanilla, and cardamom. Cardamom yield has increased 40 percent through the use of tissue culture.

There is substantial private sector participation in biotechnology in India, for example, in the seed sector, the veterinary products sector, and bioinformatics linked with the booming information technology sector (Dhawan 2001). Further, organizations like the M.S. Swaminathan Research Foundation have developed innovative approaches such as the ADB-supported BioVillages program that is fostering the growth of new income-raising technologies. Emphasis is on developing small-scale bioindustries for women (Lakshmi 2001).

Indonesia has placed a high priority on biotechnology over the past 15 years. The Government has designated three National Biotechnology Centers to coordinate R&D in agriculture, medicine, and industrial microbiology. Applications of biotechnology to agriculture are primarily the responsibility of the Agency for Agricultural Research and Development (AARD). A National Committee on Biotechnology advises the minister in developing guidelines for government policy in the promotion of biotechnology. In recent years there has been an extensive training program within Indonesia and abroad to upgrade skills of scientists involved in biotechnological research. In the 1980s, a major World Bank loan of over \$100 million financed the creation of three inter-university centers for agricultural, medical, and industrial biotechnology. More recently, a current World Bank loan is financing facilities for agricultural biotechnology within AARD.

Crop improvement efforts using modern biotechnology started in Pakistan in 1985, when a training course was held on recombinant DNA. Work is now concentrated on chickpea, rice, and cotton. Field evaluation is hampered by lack of biosafety regulations. There is some private investment in R&D of agricultural biotechnology. The government controls testing, multiplication, distribution, and biosafety issues for genetically modified crops. Pakistan lacks firm policy and regulations regarding intellectual property rights (IPR) and patents involving biotechnology, and biosafety regulations for GMOs (Zafar 2001).

The Philippines began its modern biotechnology programs in 1980 with the creation of the National Institutes of Molecular Biology and Biotechnology in Los Baños, with a focus on agricultural biotechnology. In 1997, the Agriculture Fisheries Modernization Act recognized biotechnology as a major strategy to increase agricultural productivity. The Act provided a budget for agricultural biotechnology of almost \$20 million

annually for the next 7 years (4 percent of the total R&D budget). In 1998, the government funded these five high-level biotechnology research projects to develop

- (i) new varieties of banana resistant to banana bunchy top virus and papaya resistant to ringspot virus,
- (ii) delayed ripening papaya and mango,
- (iii) insect-resistant maize,
- (iv) marker-assisted breeding in coconut, and
- (v) coconut oil with high lauric acid content.

Nongovernment organizations (NGOs) and other groups concerned about the safety of GMOs have been vocal in the Philippines. This is affecting field-testing and commercialization of transgenic crops. Products in the regulatory pipeline include new varieties of insect-resistant maize and insect- and disease-resistant rice.

Thailand is focusing on the applications of biotechnology to traditional foods, fruits, and export commodities such as shrimp. R&D priorities are to increase production and reduce production cost on crops such as rice, cassava, sugarcane, rubber, durian, and orchids. An early success in Thailand has been the development of new molecular diagnostics for the diagnosis and control of virus diseases in shrimp. These diseases cost the shrimp export industry over \$500 million in lost production in 1996. The development and commercial use of the new diagnostics prevents the loss of an estimated 20–50 percent of annual production, a saving of at least \$100 million per year.

There are also active agricultural biotechnology programs in Bangladesh, Malaysia, Nepal, Sri Lanka, Singapore, and Viet Nam.

## **B. Regional and International Programs**

### **1. International Agricultural Research Centers**

International R&D programs using modern biotechnology are being conducted by the international agricultural research centers (IARCs), particularly the International Rice Research Institute (IRRI), International Maize and Wheat Improvement Center (CIMMYT), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), International

Livestock Research Institute (ILRI), and International Service for National Agricultural Research (ISNAR). The Center for International Forestry Research also uses biotechnology in the characterization of forest diversity in its Asian program. The International Center for Living Aquatic Resources Management is using new technologies in the improvement of fisheries and aquaculture systems. ILRI is initiating a program on Asian livestock improvement. The CGIAR centers invest approximately \$30 million per year in modern biotechnology. Further details of the way the IARCs use biotechnology in their crop improvement programs are given in Appendix 11.

## **2. ISNAR Biotechnology Service**

The ISNAR Biotechnology Service (IBS), with Japanese support, has been assisting selected Asian countries in developing human resources for managing biotechnology research programs or institutions. IBS has developed specialized courses to enhance the capacity and competency of managers, focusing on strategy building, priority setting, managing biosafety and regulatory aspects, resource generation and deployment, product delivery, and information sharing as well as the establishment and management of linkages.

## **3. International Service for the Acquisition of Agri-biotech Applications**

The International Service for the Acquisition of Agri-biotech Applications (ISAAA) is brokering public-private sector partnerships to facilitate technology transfer. It has current regional projects to increase the productivity of maize, papaya, and sweetpotato. ISAAA is also establishing a new Asian knowledge center for crop biotechnology, based in the Philippines, in partnership with CAB International and the Southeast Asian Regional Center for Graduate Study and Research in Agriculture. Its purpose is to make available timely and balanced information on the risks and benefits of crop biotechnology to interested parties in Asia. In doing so, it aims to provide training and study tours highlighting experiences not only in research but also with biosafety and intellectual property issues.

## **C. Activities of Funding Agencies**

The major external sources of assistance for agricultural biotechnology in the Asia/Pacific region are ADB, Australia, the Rockefeller Foundation, the United Nations, the United States Agency for International Development (USAID), and the World Bank.

### **1. Asian Development Bank**

ADB has made several strategic and innovative investments in agricultural biotechnology over the past decade. These investments have been in the form of loans and technical assistance projects.

#### **a. Components of Agriculture and Science and Technology Loan Projects**

Several governments have requested ADB financial support for human resource development, laboratory facilities, and equipment for agricultural biotechnology programs. These programs have been integrating new applications of biotechnology into their conventional agricultural R&D programs. The applications include the use of new molecular diagnostics for pests and diseases and MAS for crop and livestock breeding. Such components are being supported under ongoing ADB projects in the Philippines, Sri Lanka, and Thailand (Table 3.2). ADB has provided other loans and grants in closely related areas such as in integrated pest management in cotton under the Cotton Development Project in Pakistan.

#### **b. ADB Regional Technical Assistance Projects**

ADB has provided regional technical assistance grants for the development of the three regional crop biotechnology networks over the past decade (Table 3.2). The networks are the Asian Rice Biotechnology Network (ARBN), initiated in 1993, the Asian Maize Biotechnology Network (AMBIONET), initiated in 1998 and the recently established Asian Semi-Arid Crops Network. These networks have been influential in developing capacity to use new techniques in crop breeding for the major cereal crops (rice, maize) and the crops important in the semi-arid regions (sorghum, pigeonpea, and groundnut). The networks are managed by three IARCs (IRRI, CIMMYT, and ICRISAT) that work with national re-

**Table 3.1: Status of Agricultural Biotechnology**

Country	Key Institution	Research Area
People's Republic of China	Institute of Biotechnology Research, Chinese Academy of Agricultural Science, China National Center for Biotechnology Development	Disease and insect resistance; tolerance for abiotic stress; product quality in rice, cotton, maize, wheat, and vegetables
India	Department of Biotechnology, Ministry of Science and Technology	Coordination of nationwide biotechnology activities; R&D in biofertilizers and bioinsecticides; nitrogen fixation; immunodiagnostics; genetic engineering; embryo-transfer  Crops: rice, maize, cotton, citrus, coffee, mangrove, vanilla, and cardamom
Indonesia	Agency for Agricultural Research and Development, Center for Biotechnology Research and Development	Coordination of agricultural biotechnology; R&D in rice, cassava, maize, cotton, soybean; tissue culture; mycorrhiza; rhizobium; genetic engineering; biodiversity
Malaysia	National Biotechnology Directorate; Ministry of Science, Technology and the Environment	Tissue culture, embryo transfer; genetic engineering; value-added products; feed, edible fungal protein; diagnostics; biomass conversion  Crops: rice, papaya, orchid, chili, rubber, and oilpalm
Pakistan	National Institute for Biotechnology and Genetic Engineering, Center of Excellence in Molecular Biology	Biopesticides, biofertilizers; molecular breeding; genetic engineering for crop improvement  Crops: rice, cotton, and chickpea
Philippines	National Institute of Molecular Biology and Biotechnology	Nitrogen fixation; biofuel, food fermentation, antibiotics, diagnostics; plant cell culture; high value added products; genetic engineering  Crops: rice, maize, coconut, mango, and papaya
Thailand	National Center for Genetic Engineering and Biotechnology	Coordination of biotechnology; biocontrol; DNA fingerprinting; genetic engineering  Focus: rice, shrimp, cassava, dairy cows, fruits, and vegetables
Viet Nam	Institute of Biotechnology, National Center of Natural Science and Technology	Plant tissue culture; insect and disease resistance; tolerance for abiotic stress; genetic engineering  Crops: rice, maize, potato, sweetpotato, cassava, soybean, sugarcane, and cotton

Sources: Zhang (2000), Sharman (2000), Dart et al (2001), Nair and Abu Bakar (2001), Zafar (2001), de la Cruz 2000), Tanticharoen (2000), Tuong-Van Nguyen (2000).

**in Some Asian Countries, 2000**

<b>Biosafety Mechanism</b>	<b>Achievement</b>
Biosafety regulations on GMOs approved in 1996	Transgenic cotton is grown over an area of 500,000 ha. About 50 genetically modified varieties have been approved for environmental release or small-scale field testing
Biosafety guidelines for transgenic seeds, plants, and plant parts developed	Field testing of some promising transgenic crops in progress
Biosafety guidelines and labeling regulations developed	Field testing of transgenic crops in progress
National Biosafety Law has been drafted, but it has yet to be approved by the Government	Good progress in developing transgenic rice, papaya, banana, orchids, pineapple, oilpalm, and rubber; field testing of papaya has been approved
Biosafety guidelines and regulations are being prepared	Concentrated mostly on traditional biotechnology
Biosafety guidelines for contained use and release of GMOs developed. Commercialization guidelines ready for approval	Field testing of transgenic crops in progress
Biosafety guidelines for laboratory and field trials developed	The application of biotechnology to develop new molecular diagnostics for diagnosis and control of virus diseases in shrimp has been successful; some transgenic crops (tomato, papaya, chili, pepper, and cotton) are undergoing field testing
Biosafety guidelines and regulations are being prepared	Still in the early stage of modern biotechnology development

**Table 3.2: Summary of ADB-Funded**  
(\$'000)

Loan/ RETA No.	Project	EA
A. RETA		
1. RETA 5331	Establishment of Plant Biotechnology Research and Training	ICRISAT
2. RETA 5510	Establishment of the Asian Rice Biotechnology Network	IRRI
3. RETA 5667	Asian Rice Biotechnology Network – From Products to Impact	IRRI
4. RETA 5766	Application of Biotechnology to Maize Improvement in Asia	CIMMYT
5. RETA 5812	Asian Rice Biotechnology Network: Achieving Impact and Sustainability	IRRI
6. RETA 5945	Rapid Crop Improvement for Poor Farmers in Semi-Arid Tropics of Asia	ICRISAT
B. Loans		
1. 791-PAK	Cotton Development	MINFAL
2. 1535-SRI	Science and Technology Personnel Development	MOST
3. 1698-THA	Agriculture Sector Program	MOF
4. 1740-PHI	Grains Sector Development Program	MOF and DOA

ADB = Asian Development Bank, CIMMYT = International Maize and Wheat Improvement Center, DOA = Department of Agriculture, EA = executing agency, ICRISAT = International Crops Research Institute for the Semi-Arid Tropics, IRRI = International Rice Research Institute, MINFAL = Ministry of Food, Agriculture and Livestock, MOF = Ministry of Finance, MOST = Ministry of Science and Technology, R&D = research and development, RETA = regional technical assistance.

Source: Asian Development Bank (various documents).

**Projects in Biotechnology**

<b>Approval Date</b>	<b>Grant/Loan Amount (\$'000)</b>	<b>Remarks</b>
29 Apr 1989	1,250	A well equipped biotechnology laboratory was established at ICRISAT
21 Nov 1992	900	An Asian Rice Biotechnology Network covering several Asian countries was established
9 Jan 1996	850	Further support to rice biotechnology was provided
29 Dec 1997	1,400	An Asian Maize Biotechnology Network covering some Asian countries has been established
22 Oct 1998	1,000	The third phase of rice biotechnology research is supported by ADB
17 Oct 2000	1,200	High-yielding varieties of groundnut, chickpea, and sorghum will be developed using marker-assisted selection
30 Sep 1986	66,100	Loan savings used to strengthen biotechnology R&D of cotton in Pakistan
11 Sep 1997	20,000	Part of the loan was used to expand science and technology personnel development and to strengthen the biotechnology research agency in Sri Lanka
23 Sep 1999	300,000	Some of the local currency of the loan was used to strengthen the biotechnology R&D in Thailand
24 Apr 2000	100,000	Part of the loan is being used to support rice biotechnology research in the Philippine Rice Research Institute

search institutes to implement the programs on rice, maize, and semi-arid crops.

A recent evaluation of ADB's research investments through the international centers reported favorably on the achievements of the rice and maize biotechnology networks, and recommended further support for this type of research cooperation.

The networks provide a platform by which countries and the IARCs can collaborate in the use of the new tools of functional genomics to identify genes that control important traits such as drought and salinity tolerance. This will speed up the breeding of crop varieties with these characteristics that have been difficult to address through conventional breeding. There will be increasing opportunities for cooperation between the networks, as more knowledge is gained on the commonality of genes between species and their control.

### **Box 3.1: Asian Rice Biotechnology Network**

The rice growing countries in Asia recognized in the early 1990s that biotechnology could provide powerful new tools for rice improvement. These tools included tissue culture, wide hybridization, molecular markers, and genetic engineering. The ARBN was initiated in 1993 to provide a vehicle for collaborative research in these areas with universities and national rice research institutes.

The objectives of ARBN are to (i) promote human resource and infrastructure development for biotechnology at selected national agricultural research systems (NARSs) institutes through joint research and training coordinated by IRRI, and (ii) generate biotechnology tools and products for use by NARSs through IRRI research and infrastructure development.

ARBN was established with funds provided by ADB and the German Government's *Bundesministerium für Technische Zusammenarbeit*, which has been supporting IRRI's development of biotechnological products of direct use to NARSs. ADB supports research and infrastructure development at NARSs with additional funding for training and shuttle research by NARSs scientists at IRRI.

**Box 3.2: Asian Maize Biotechnology Network**

Member countries of AMBIONET are PRC, India, Indonesia, Philippines, and Thailand. The network was established in 1998 with financial support from the ADB. AMBIONET emphasizes developing molecular markers for specific traits and using them in the selection of new maize varieties. The goals of AMBIONET are to:

- increase the scientific capacity of Asian maize and biotechnology programs to ensure higher, more stable, and more sustainable maize productivity for farmers in Asia, and thereby help meet the region's rapidly growing demand for maize;
- develop sustainable, environmentally friendly, and natural resource conserving maize production systems;
- empower national programs to effectively use modern biotechnology for maize improvement;
- strengthen the ability of national programs to identify and overcome the key production constraints faced by maize farmers in the region; and
- generate and distribute improved maize cultivars, and implement improved crop management strategies, in collaboration with existing national program personnel, and by using facilities and other resources more effectively to avoid duplication; and ensuring the long-term sustainability of integrated maize and biotechnology research programs in participating countries.

**2. Australian Government**

Over the last 15 years, ACIAR has entered into more than 100 biotechnology R&D partnerships with at least 10 Asian countries in support of more than 600 active or completed projects. The emphasis of this work has been on developing diagnostics and vaccines for a large suite of diseases of tropical livestock, with some recent work on fish and shrimp being undertaken. Most of these projects have been implemented through government programs, but NGOs are becoming increasingly involved. Molecular marker methods for identifying disease-resistant genes and prolificacy in livestock have also been developed. Several projects on biotechnology for rumen manipulation have been carried out.

Crops and forestry work has focused on development of diagnostics for diseases (viral, fungal, mycoplasma, and bacterial) and contaminants in tropical crops, and the application of biofertilizers, bioremediation technology, and biofumigants. Molecular markers have been developed for the improvement of cereals and tree species. In cooperation with IRRI, attempts are being made to develop apomixis systems for rice. Tissue culture methods for micropropagation and conservation of several species, including sweetpotato, taro, tropical fruits, coconut, green tea, and tree species such as mangrove are being developed.

Eight of ACIAR's current or completed projects have included aspects of plant genetic engineering, with target crops being cereals and pulses, groundnut, and several tropical fruits. Target characters include virus resistance and quality defects related to ripening processes. These collaborative projects were developed at the request of the Asian countries, which fully approved regulatory procedures. ACIAR also provides core funding to many CGIAR and other IARCs, a proportion of which is applied to biotechnology R&D.

Australian support has been provided through AusAID for an Association of Southeast Asian Nations (ASEAN)/Australia regional biotechnology network, mainly concerned with food, microbial, and industrial biotechnology. AusAID also supports the characterization and conservation of genetic resources of taro and forest genetic resources in the South Pacific. AusAID has supported several biotechnology seminars. A major seminar in 1989 at the Australian Academy of Sciences on the potential of agricultural biotechnology in international development reported on the outcomes of a joint study cosponsored by AusAID, ACIAR, ISNAR, and the World Bank (Persley 1990a, 1990b).

In the area of human resources, the Crawford Fund has sponsored several master classes in biotechnology for senior policymakers over the past decade.

### **3. The Rockefeller Foundation**

Operational from 1984-1999, the Rice Biotechnology Network sponsored by the Rockefeller Foundation was very active and successful in the region. The program's two objectives were to (i) to create biotechnology applications to produce improved rice varieties suited to developing country needs, and (ii) to train scientists in developing countries to use the techniques and adopt them to their own objectives. A network of about

200 senior scientists and 300 trainee scientists from all the major rice producing countries of Asia and a number of industrialized countries participated. The program was funded at approximately \$5 million per year for 15 years.

Another outcome of the program was the development of promising new technologies for the control of rice pests and diseases and improving the nutritional quality of rice. The work is being continued by national governments, ARBN, and IRRI to do the field evaluation and distribute new rice varieties in Asia.

The Rockefeller Foundation presently concentrates its biotechnology programs in Asia on drought tolerance in rice and maize. It is also examining innovative means of dealing with access to technologies and IP issues.

#### **4. United Nations Agencies**

The Food and Agriculture Organization (FAO) is giving high priority to biotechnology within its Asia/Pacific regional programs (FAO 2000). During 1989-1993, the United Nations Development Programme financed the establishment of biotechnology centers in eight countries (PRC, India, Indonesia, Republic of Korea, Malaysia, Pakistan, Philippines, and Thailand) to share rDNA techniques in animal improvement, embryo transfer, and disease control. In 1994 the United Nations Industrial Development Organization (UNIDO) established an International Center for Genetic Engineering and Biotechnology in New Delhi, India, to assist Asian countries in the applications of biotechnology to important crops of the region.

#### **5. United States Agency for International Development**

The USAID is supporting applications of biotechnology through bilateral activities in several countries, including India, Indonesia, and Pakistan. USAID is also providing specific support for biotechnology applications within the programs of IARCs. This includes support for research by IRRI on improving the nutritional quality of rice by increasing its vitamin A and iron content, and support for research by the Tata Energy Research Institute on the development of *golden* mustard.

## **6. World Bank**

The World Bank has supported the development of infrastructure and human resource development for biotechnology in several Asian countries over the past 15 years. This support has come through loans in the agricultural sector, science and technology, and education. There are currently substantial components for biotechnology within agricultural technology projects in India, Indonesia, and Pakistan. The Inter University Centers for Biotechnology in Indonesia were built with a \$150 million loan in the 1980s. The Republic of Korea also used World Bank loans to develop its infrastructure in biotechnology. The World Bank is also one of the main financial supporters of CGIAR centers. The centers invest about 10 percent of their total annual budget of \$340 million in the applications of biotechnology.