Iran: Hopes, Achievements, and Constraints in Agricultural Biotechnology

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To take advantage of biotechnology, countries such as Iran need sufficient funds, biosafety regulations, intellectual property rights (IPRs), and policies on ethical and trade-related issues.

Considerable investments in human and financial resources are required for biotechnology research and development (R&D). Developing countries rely mainly on public funds for their research. As a percent of GDP devoted to science and technology, the investment ranges from 2-4 percent for industrial countries to up to 1 percent for developing countries. In Iran, the figure is less than 0.3 percent. Most of the investments in the industrial countries are made by the private sector, whereas in developing countries the private sector investment is negligible.

Investment is not only required for biotechnology R&D products, but also to prepare, ratify, and implement a sound regulatory framework to prevent risks to humans and the environment that may be associated with recombinant DNA technology. Biosafety regulations are needed to improve and introduce new genes from different sources into different species. There are concerns about the safety of the genetically improved organisms (GIOs). The public has some concerns about the broad application and release of GIOs in the environment. The magnitude of the deliberate field release of such organisms has intensified the need for biosafety.

There are only a few developing countries that have their own biosafety guidelines. Iran is one of those countries that have not yet put in place any guidelines. These countries will have to follow international agreements and treaties. Many developing countries do not have the financial and human resources to participate in the international debates that result in internationally approved agreements, so there is little or no input for some developing countries.

There is a need for strong protection in intellectual property rights (IPRs), including patents, plant breeders' rights, and trade secrets. For emerging countries to take advantage of biotechnology, they should have a sound policy on IPR that includes comprehensive patent and plant variety protection laws. Without strong IPRs, cooperation and partnership between the public and private sector is difficult. Many of the methods and products of modern biotechnology are owned by transnational companies in industrialized countries. Strong IPRs are needed to access these technologies and to build a research capacity inside the country. Upgrading and strengthening IPR laws is usually opposed in developing countries.

Agricultural Biotechnology in Iran

Human Resources

Iran has 339 scientists recognized as biotechnologists, and 141 are involved in agricultural research. Recently educated scientists (both in Iran and abroad) have a good knowledge of genetics and molecular biology, and have good laboratory skills in the application of molecular tools and DNA/protein technology.

The Iranian government has made a considerable investment in developing human resources and in training (both classical and non-degree training) scientists in biotechnology. There are now several hundred Iranian graduate students studying biotechnology abroad.

Iranian universities also have started to offer courses in biotechnology in different faculties. There are three major universities in Iran that offer MSc and Ph.D. degrees in agricultural and medicinal biotechnology. The capacity of these courses is, however, limited and cannot meet the demand for experts in this field.

Institutions

There are 46 institutes/centers in Iran involved in biotechnology (in whole or in part). They include a range of well developed and well equipped modern institutes. There are 19 institutes/centers in Agriculture and Natural Resources, 12 in Medicine, 8 in Basic Sciences, and 7 in Industry and Environment. These institutes rely mainly on public funds. Some are well funded and equipped with modern and advanced facilities, while others are fragile with limited resources. In addition to the public institutions there are several private companies active in biotechnology. These companies also rely on loans and support from government. In some cases joint ventures with foreign investors have been put in place. The companies are successful and their businesses are profitable.

Razi Institute. One of the most important applied R&D organizations in Iran, this Institute is under the Ministry of "Jihad e Sazandegi," with a current annual budget of about US$10 million. The institute has about 130 scientists, and a record of scientific achievement and innovation. It has been internationally recognized and designated as a Reference Organization/Laboratory in diagnostics. Razi was one of the first institutes in the world able to mass produce poliomyelitis vaccines.

National Research Center for Genetic Engineering and Biotechnology (NRCGEB). This center was established in 1988 under the Ministry of Culture and Higher Education, and is involved in basic and applied research in biosciences, medicine, agriculture, and pharmacology, using the tools of molecular biology, genetic engineering, and biotechnology. NRCGEB holds practical and theoretical specialized workshops in biotechnology and molecular biology for specialists, researchers and graduate students. The center is currently located in a temporary site with a huge expansion project under construction. The new home for the NRCGEB is being constructed in a 15 hectare site 16 kilometers west of Tehran with 60,000 square meters of laboratory, library, pilot plant, and administrative buildings.

The center has a good record of achievements in medicinal biotechnology such as production of recombinant growth hormone for humans, and DNA vaccine production project for hepatitis B. It is relatively new in agricultural biotechnology research. Transformation of sugar beet and rape seed, promoter analysis of Psr3, production of salt tolerance in plants by T-DNA activation insertion mutagenesis, and gene isolation and characterization are some of the ongoing activities.

Biotechnology Center of Iran Research Organization for Science and Technology (IROST). IROST is a major research institute established in 1979. The Biotechnology Center of this organization was established in 1982. The Biotechnology Center is active in environment, medicine, agriculture, food biotechnology, and bioprocessing engineering. The center is well equipped with large and modern laboratories. The production of biological fertilizers and single cell proteins (SCPs) from agricultural by-products, production of lysine and giberrelic acid, on a large scale; alpha amylase, gluco amylase, gluco isomerase, pectinase, and many other enzymes on a laboratory scale, and application of bacterial and fungal agents in agricultural pest control, are some of the activities of the agriculture branch of the center.

The center has the Persian Type Culture Collection (PTCC), which is a large collection of microbes of interest to industry and agriculture.

One of the other outstanding achievements of this center is the industrial scale production and marketing of a *Bacillus thuringiensis* (Bt. M-H-14)-based insecticide for combating malaria in southern and eastern provinces of Iran.

Private sector. The private sector has started investing and has some activities in Iran in biotechnology in recent years. Rana Agro-Industry Corp. is one the pioneering private companies in this field. Rana was established in 1992. In a joint venture with a British company, Rana produces tissue culture-derived date palm and banana, with an expansion program for lage-scale production of other fruit trees and ornamental plants. During the Persian Gulf war, hundreds of thousands of palm trees were destroyed. These trees need to be replaced. Added to the plantlets required for plantation expansion projects and the replacement of older trees with the younger and more productive ones, there is an annual market for over 200,000 palm plantlets in the country. There is a huge demand and market in neighboring countries as well. Rana is currently producing about 100,000 plantlets per year. The company will have the capacity to produce 400,000 date palms or 6 million other plant varieties per year.

Cina Gene is the leading company in Iran producing and offering restriction enzymes and other enzymes used in molecular biology, PCR kits, DNA markers, plasmids and many other research items. Considering the lengthy and bureaucratic procedure of placing orders for these items from abroad, and considering the cost of shipment, the company has been welcomed by Iranian research institutes and universities.

Agricultural Biotechnology Research Institute of Iran (ABRII). The Agricultural Research Education and Extension Organization (AREEO) is an umbrella policymaking and funding organization under the Ministry of Agriculture, under which all the national agricultural research institutes are organized. AREEO supervises, among others, several crop-specific research institutes in Iran such as Rice Research Institute of Iran (RRII), Sugar Beet Seed Institute (SBSI), and Pistachio Research Institute of Iran (PRII). In addition there are several discipline specific research institute such as Seed and Plantlet Improvement Institute (SPII), Soil Water Research Institute of Iran (SWRII), and ABRII under AREEO. On behalf of these research institutes, AREEO has several international collaborating institutes and laboratories worldwide. It is one of the donors to the CGIAR, and has separate collaborative projects with its centers such as ICARDA, IRRI, CIMMYT, CIP, and ISNAR.

ABRII was established in 1980 as the Plant Biotechnology Department of SPII. It has recently been upgraded to the level of an independent institute. All biotechnology research activities of the research institutes under AREEO are supervised and monitored by ABRII. ABRII is government funded, with a current annual budget of about US$2 million, and has modern and advanced research facilities such as 10 large phytotrons, several greenhouses and controlled rooms, tissue culture facilities, radioisotope application facilities, and an optical room.

Mass production of uniform and disease free plants. Efficient protocols have been established for mass production of date palm, cherry, apple, banana, potato mini tuber, and sugarcane through tissue culture at ABRII. Hundreds of hectares of these tissue culture-derived plants are being grown in Iran, and demand is increasing dramatically due to their good performance and farmer satisfaction. ABRII's facilities were not designed for large-scale production of tissue culture-derived plants, so new greenhouses and tissue culture rooms with higher capacity are under construction. In addition, we are transferring our experience and the protocols to large-scale private-sector contractors and government-owned private companies. One successful example is the technology transfer of the tissue culture of Karoon Sugarcane Agro-Industry Company.

Haploid Breeding

We are currently incorporating different methods of haploid breeding in our plant improvement programs at ABRII, particularly anther culture and maize X wheat crosses. Seventy-nine double haploid (DH) lines of wheat were produced using wheat X maize technique from four crosses at F1 and F3 stages. Eight promising lines with high yield (up to 10 metric tons/hectare) and enhanced resistance to yellow rust and leaf rust were selected.

Enhancing resistance to biotic and abiotic stresses. Agricultural products constitute Iran's main export items after oil. Iran, however, is also one of the major food importing countries. The import of rice, for example, has increased dramatically in the last 20 years, partly because of population growth (from 19 million in 1956 to 60 million in 1996).

In 1998 Iran imported 1.3 million metric tons of rice, making it one of the largest rice importing countries in the world. More food will be required by the year 2010, considering the limited available land for agriculture, and limited supply of water in Iran. With an average annual rainfall of 240 mm (compared to the 860 mm average annual rainfall in the world), Iran is categorized as one of the dry regions of the world. Major expansion of the area under rice cultivation is not possible. Rice is susceptible to several insect pests including striped stem borer, the major insect pest of rice in Iran, causing estimated crop losses of up to 20 percent. There is no known resistance source in the world collection of rice germplasm maintained at IRRI. In collaboration with IRRI, a synthetic cryIA(b) gene was introduced to Iranian aromatic variety Tarom Molaii using a biolistic approach. The molecular analysis showed the stable integration of the gene into a single locus expressing at a high level (Ghareyazie and others 1997). Bioassays indicated enhanced resistance against four different pests of rice up to the 6th generation (unpbulished data).

Combating salinity problem. About 15 percent of Iran's land area is covered by salt-affected soils. Salinity and drought are the main causes of reduced agricultural productivity. There are increasing lands where none of the known crop plants can be economically cultivated. Breeding for salinity tolerance was not effective in producing crop varieties that can tolerate extreme salinity. Plant physiologists in ABRII are hoping to improve the agronomic characteristics of wild species for cultivation in salt-affected soils. Iran is considered as the center of origin for many crop plants, ornamentals, and fruit species. It is estimated that more than 10,000 plant species with high intraspecifc genetic variation exists in Iran. A large collection of seeds of crop varieties of different species including wheat, barley, rye, rice, pea, melon, grape, and many other important plants and their wild relatives is being maintained in Genetic Resources and National Germplam Center under SPII. We have collected several wild species of both Graminaecea and Poaceae families from extremely salt affected lands covered with salt crystals. In addition to improving their agronomic characters for animal fodder, we are interested in determining their salt tolerance, potassium transport and their osmotic adjustment mechanisms. We are attempting to isolate and characterize the candidate gene conferring additional tolerance in these varieties. In an attempt to increase the tolerance of rice cultivars to salinity a manitol-1-phosphate dehydrogenase gene was transferred to an Iranian rice variety. The stable integration and Mendelian inheritance of the gene was assured by molecular analysis. The increased level of manitol in transgenic rice is under investigation. Greenhouse experiments, however, did not show significant increased salinity tolerance when compared with control plants. Protein analysis will tell us whether the gene has been silenced, or if the approach was (increasing the manitol level) inappropriate. The same gene is also being introduced to Iranian elite wheat cultivars.

Isolation and characterization of high affinity potassium transporter genes from rice. We are interested in potassium transport mechanism for its putative involvement in salinity tolerance. It has been documented that the capacity to maintain a high [K+] /[Na+] in shoots is correlated with salt tolerance in several crop plants including rice. In collaboration with IRRI in a German/BMZ-funded project, we isolated and characterized a high affinity potassium transporter gene from a salt tolerant variety; Pokkali, and a slat sensitive variety IR 29 (Ghareyazie and others 1999). An additional high affinity potassium transporter gene from a different family was also isolated and is being characterized at ABRII. There is no report of the availability of any complete gene of this kind (including its promoter). The promoter analysis is being carried out at ABRII to determine the factors affecting the expression of these proteins. Attempts are being made for isolation and characterization of other genes of agronomic importance including candidate genes involved in pathogen resistance.

Application of Molecular Markers

Application of molecular markers such as isozyme and random amplified polymorphic DNA (RAPD) to study genetic diversity and germplasm management is a routine practice in ABRII and other institutes. About 1000 accessions from Iranian rice germplasm have been characterized in collaboration with RRII and IRRI. Using restriction fragment length polymorphism (RFLP), and PCR-based DNA markers including amplified fragment length polymorphism (AFLP), RAPD, sequence tagged sites (STS), and PCR-based RFLP. Three groups were distinguished among Iranian rices. These are indica and japonica and varieties that are genetically distinct from both indica and japonica types, indicating the varieties probably evolved independently within the country (Ghareyazie and others 1995). Classification of wheat germplasm and fingerprinting walnut and olive trees are some of the ongoing projects at ABRII. Molecular markers have been used to tag quality related genes such as aroma (in collaboration with IRRI) and gelatinization temperature (gt) at RRII (Nematzade 1995; Alavi and others 1999). Mapping QTLs for salinity tolerance genes is one of the ongoing projects at ABRII.

Constraints

Human resources. Most developing countries are suffering from similar constraints. There has always been a move of senior scientists from developing to industrial countries. The public sector (even the private sector) in most of the developing countries cannot offer salaries comparable to industrial country companies. Developing nations spend considerable amounts on education and training, but they often do not benefit from it. In Iran, the trend has been more promising in the past few years. More scientists are returning home and the number of specialized and qualified scientists in universities and research institutions is increasing significantly. In spite of this positive trend, agricultural biotechnology R&D is still suffering from the shortage of senior scientists.

Insufficient funding. Lack of money for science has been another common problem for most developing countries. Iranian agricultural research institutes do not receive sufficient support and contributions from foreign sources. There have been some positive moves by government, however, to increase funding for agricultural research, and agricultural biotechnology in particular. Nevertheless, currently funding is not considered as the top problem in agricultural biotechnology research and development in Iran.

There is a lack of a biosafety regulatory framework in Iran. In addition to the risks associated with the irresponsible deployment of GIOs, it creates problems in legally acquiring and safely releasing products of biotechnology.

There is also a serious lack of protection of IPRs in Iran, and little or no capacity in protecting national IPR at the international level.

Hopes

The establishment of the National Council for Scientific Research under the presidential office has raised hopes among the scientists in Iran. This council is a planning and priority-setting and granting council that receives scientific advice from 11 commissions. Biotechnology, agriculture, and soil and water commissions are the three related to agriculture. Some of the promising developments are: inclusion of both agriculture and biotechnology among the top priorities at the national level for funding and support; identifying the research priorities for funding in both agriculture and biotechnology commissions; submission to Majlis of the draft to ratify the "breeders' rights law"; preparation of a biosafety draft for ratification; full support of the President's administration to biotechnology; and the scientific achievements by both private sector and the public institutions.

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