Addressing Agricultural Development in Egypt; A National Program Perspective

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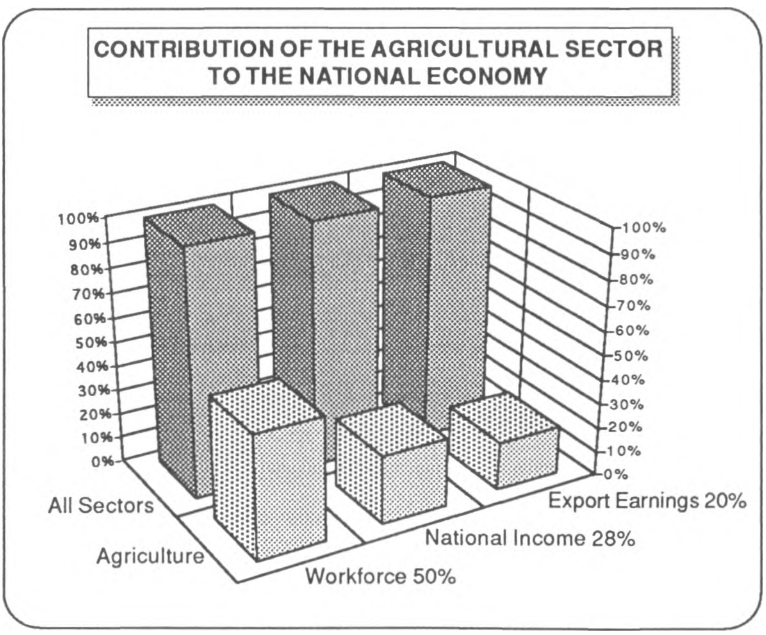
The challenge facing the world today is to provide food, fiber and industrial raw materials for an ever-growing world population without degenerating the environment or affecting the future productivity of natural resources. Meeting this challenge will require the continued support of science, research and education. A high demand for attention to these problems lies in developing countries where 90 percent of the world's population growth will take place within the next two decades.

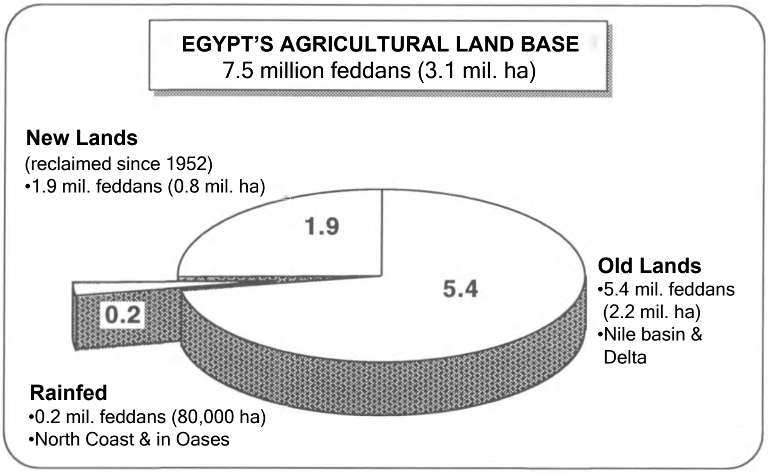
In Egypt, agriculture represents the spearhead of socioeconomic development: accounting for almost 28 percent of the national income, employing almost 50 percent of the workforce and generating more than 20 percent of the country's total export earnings (Figure 1). A limited arable

FIGURE 1



land-base (Figure 2) coupled with an ever-growing population with an annual birth rate of 2.7 percent are the main reasons for the ever-increasing food production/consumption gap. Egypt's population will grow to about 70 million by the year 2000 and swell to 110 million by the year 2025.

FIGURE 2



In recent years, only 15 percent of production for total agricultural commodity exports in Egypt has been exported which is indicative of the increased domestic demand due to increased population growth. Increasing the agricultural land base from 7.4 million feddans (about 3.1 million hectares[ha]) to 14 million feddans (about 5.8 million ha) cropping area would only satisfy 50 percent of the requirement for a current population of 59 million. To bridge the food gap and to fulfill the goal of self-reliance, expanding the land-base and optimizing agricultural outputs are urgently needed.

NATIONAL PERCEPTIONS

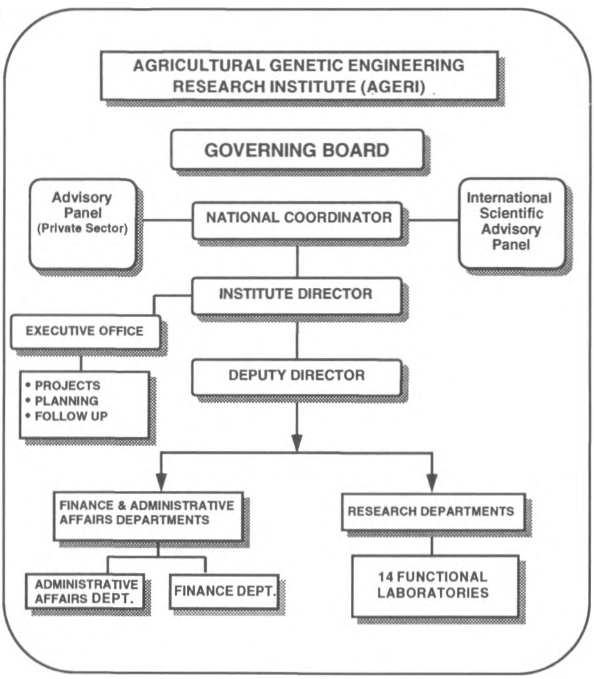
The government of Egypt is increasingly aware that it must use its own limited resources in a cost effective way. Failure to develop its own appropriate biotechnology applications and inability to acquire technology developed elsewhere could deny Egypt timely access to new, important advances that could overcome significant constraints to increased agricultural productivity.

A very significant contribution to increased food production could be achieved by protecting more of the crops currently grown from losses to pests, pathogens and weeds. The total loss of worldwide agricultural production ranges from 20 to 40 percent including both pre-harvest and post-harvest losses which occur despite the widespread use of synthetic pesticides.

It is in this area of crop protection that biotechnology, especially genetic engineering, could offer great benefits to the environment by replacing the present policy of blanket sprayings of crops with herbicides, fungicides and pesticides with plants that have a combination of genetically engineered resistance to pests and diseases. Thus, genetic engineering is very suitable to agriculture in the developing world since it is "user-friendly." If it is applied in a sensible manner, there can be no doubt that this technology is "green." One of the major targets is the production of transgenic plants conferring resistance to 1. biotic stress resulting from pathogenic viruses, fungi and insect pests and 2. abiotic stress such as non-favorable environmental conditions including salinity in the soil, drought and high temperatures. All these are major agricultural problems leading to deleterious yield losses in a large variety of economically important crops in Egypt.

The Agricultural Genetic Engineering Research Institute (AGERI) represents a vehicle within the agricultural arena for the transfer and application of this new technology. The original establishment of AGERI in 1990 was the result of a commitment to expertise in agricultural biotechnology. At the time of its genesis, AGERI was named the National Agricultural Genetic Engineering Laboratory (NAGEL). The rapid progress of its activities during the first three years encouraged the Ministry of Agriculture and Land Reclamation to authorize the foundation of AGERI (Figure 3) which is phase two of the national goal for excellence in genetic engineering and biotechnology. AGERI is now moving to adopt the most recent technologies available worldwide and applying them to address existing problems in Egyptian agriculture.

FIGURE 3



CAPACITY BUILDING

The physical location of AGERI is within the Agricultural Research Center (ARC). This not only facilitates an interface with ARC's ongoing research programs but also provides a focal point for biotechnology and genetic engineering for crop applications in Egypt.

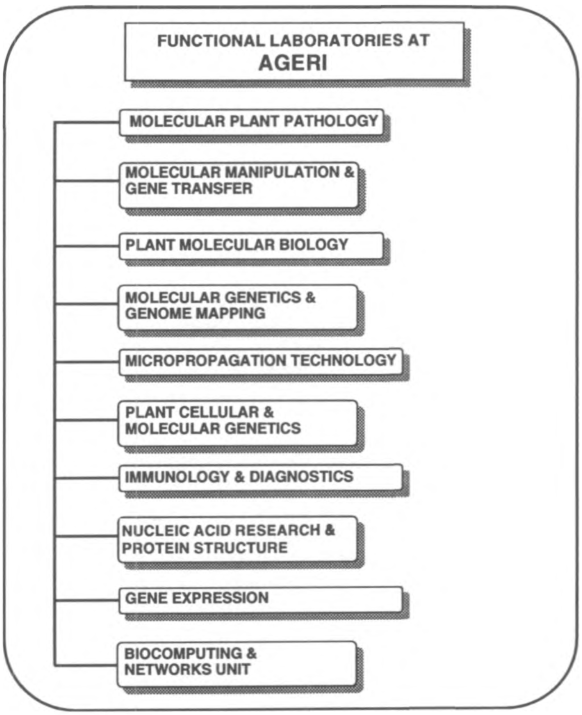
AGERI has upgraded the existing laboratory on its premises and has used two floors to house the project for a total net area of 1116 square meters (m^2) consisting of 14 modernly equipped laboratories (Figure 4); a BioComputing and Networks Unit, a central facility; a preparation/washing facility; and a supply repository.

• The recently completed controlled-environment chambers (140 m^2) are used to host transgenic plant material for acclimatization.

• A fiberglass greenhouse (307 m^2) has been recently added to AGERI's property.

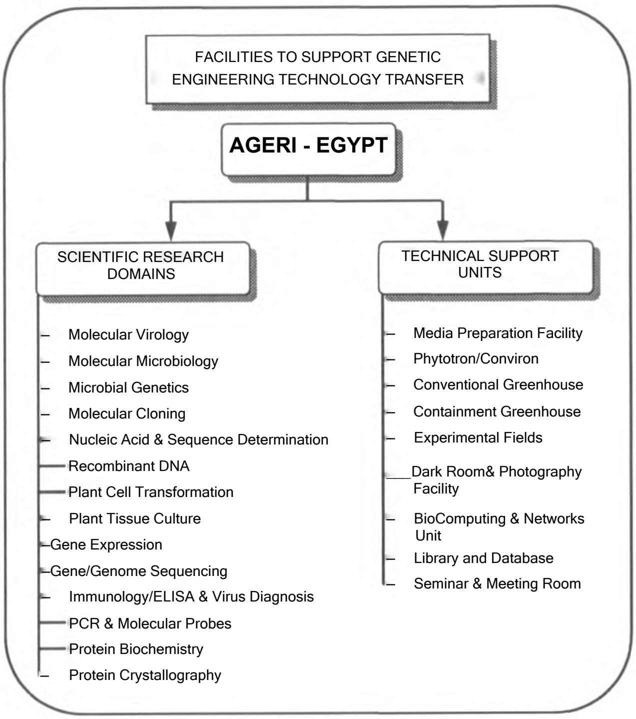
• A containment greenhouse (412 m^2), consisting of eight units, three laboratories and a headhouse which will comply with biosafety and USDA/APHIS-EPA (U.S. Department of Agriculture/Animal Plant Health Inspection Service-Environment Protection Agency) regulations, is now under construction. This greenhouse will host various lines of locally-produced transgenic plants with new traits. Also experiments dealing with testing the level of gene expression in transgenic plants will take place in this modern facility.

FIGURE 4



For the establishment of a core nucleus of biotechnology in Egypt, AGERI is adopting the most recent technologies available worldwide and applying them to address existing chelanges in Egyptian agriculture (Figure 5). This includes employing the BioComputing & Networks Unit which is an information center supporting the research activities at AGERI. Services provided by the unit include providing worldwide networking capabilities to access databases and biotechnology information centers located abroad, as well as providing a forum for discussion of technical issues with experts from all over the world through the e-mail facility. The unit provides electronic literature search on CD-ROM and maintains a software library to meet the biocomputing and publishing needs of the institute.

FIGURE 5



HUMAN RESOURCES DEVELOPMENT

One of many vital contributions AGERI has accomplished is the identification and recruitment of a collective group of 17 senior scientists of high scientific accomplishment and work ethic. Each one is a vital link in the program's goals for crop improvement. The senior scientists have institutional affiliations and disciplines within Egypt as well as their scientific responsibilities within AGERI. They are representatives and active faculty members from six Egyptian universities as well as various national agricultural research centers. They work at

AGERI on a joint-appointment basis which maximizes their interaction between the academic and research domains. Their high level of international training, in conjunction with their enthusiasm to invest their talents into AGERI's biotechnology programs, is an encouraging addition toward Egypt's agricultural technology development.

Another vital contribution of AGERI has been its role as an interface between the international scientific community and Egypt. Once AGERI became fully commissioned, the research and post-doctoral education components of the project commenced. Various seminars and conferences have been held at AGERI with highly qualified international consultants. Numerous study tours (40) have taken both senior scientists and junior assistants of AGERI to various international biotechnology centers in Europe, North America and Asia to attend conferences or training courses. During the years 1993-1994, another 20 missions to different parts of the world took place.

Condensed, short courses and seminars concentrating on vital basics of biotechnology have been held by members of our local staff. Educational activities have been promoted as a result of this linkage and cooperation with international researchers and laboratories. Opportunities have been supplied for the exchange of genetic probes, DNA libraries and vectors. Such contacts with centers worldwide have been encouraged and initiated to facilitate meaningful interactions. Training courses conducted at AGERI include:

• An international training course on the use of RFLP's (restriction fragment length polymorhisms) and PCR (polymerase chain reaction) for crop improvement, November 1991.

• A regional training course on the application of PCR and ELISA (enzyme-linked immunosorbent assay) in plant virus diagnostics, May 1992.

• A course in modern methods in microbial molecular biology, April 1993.

• A regional training course on tissue culture and micropropagation in plants with special emphasis on date palm, May 1994.

RESEARCH AND SCIENTIFIC COLLABORATION

AGERI has been successful in attracting funds to sponsor its research from the following international organizations:

• United Nations Development Program (UNDP) as a co-funding agency which supported the initial research at NAGEL, currently AGERI.

• A cooperative research agreement between AGERI and the Agricultural Biotechnology for Sustainable Productivity (ABSP) project based at Michigan State University, USA, which is funded by the U.S. Agency for International Devlopment (USAID) in Cairo under the National Agricultural Research Project (NARP). This activity will allow interaction between AGERI's scientists and researchers from a number of eminent American Universities, i.e., Michigan State University, Cornell University, University of California and the Scripps Research Institute. Moreover, other ongoing USAID funded research is collaboratively executed with the University of Maryland, University of Wyoming , University of Arizona and the USDA/ Agricultural Research Service (ARS), Beltsville, Maryland, USA.

• Recently, the International Center for Agricultural Research in the Dry Areas (ICARDA), located in Aleppo, Syria, has contracted AGERI for conducting research on their mandated crops.

The projects carried out at the Agricultural Genetic Engineering Research Institute (AGERI) (Figure 6) are based on the concept of maintaining a program that is focused on the problems of Egypt. The immediate objectives are to develop and deliver transgenic cultivars of major economically important crops in Egypt. Therefore, the most recent and successful genetic engineering technologies are used to address this need.

FIGURE 6

Research Fields at AGERI p

Discipline	Potato	Tomato	Cotton	Maize	Fava	Cucurbits
Virus Resistance	y	y			[illegible]	/
insect Resistance	y	y	y	y		
Stress Tolerance		y	y		/	
Genome Mapping		y		y		
Protein Engineering					/	
Fungal Resistance		y	y	y		

These projects also represent a spectrum of increasingly complex scientific challenges which require state of the art technologies of genetic engineering and gene transfer. Gene manipulation techniques such as cloning, sequencing, modifications, construction of genomic and cDNA libraries, and plant regeneration in tissue culture are just a few examples of the cellular and molecular biology methodologies that are utilized for the production of transgenic plants.

The successful implementation of these projects would build a national capacity within Egypt for the sustainable production of crops crucial to the economy and a safer, cleaner environment. Examples of projects carried out at AGERI are:

• Genetic engineering of a potato resistant to the most important viruses in Egypt (PVX, PVY.PLRV); production of transgenic tomatoes resistant to geminiviruses such as tomato yellow leaf curl virus (TYLCV); introducing virus resistance in squash and melon against zuccini yellow mosaic virus (ZYM V); and the production of transgenic fava bean conferring resistance to bean yellow mosaic virus (BYMV) and fava bean necrotic yellow virus (FBNYV).

• Engineering of insect-resistant plants with *Bacillus thuringiensis (Bt)* crystal protein genes. *Bt* genes are used for the transformation of cotton, maize, potato and tomato plants to resist their major insect pests.

• Genetic engineering for fungus resistance using the Chitinase gene concept for the development of transgenic maize, tomato and fava bean expressing resistance to fungal diseases caused by *Fusarium sp., Alternaria sp.* and *Botrytis favae.*

• Enhancing the nutritional quality of fava bean seed protein by the successful transfer of the methionine gene to fava bean plants.

• Cloning the genes encoding for important economic traits in tomatoes, fava beans and cotton, especially those related to stress tolerance (i.e., heat shock proteins and genes responsible for osmoregulation).

• Mapping the rapeseed genome in order to develop cultivars adapted to the constraints of the Egyptian environment and thus securing a good source of edible oil.

• Developing efficient diagnostic tools for the identification and characterization of major viruses in Egypt.

These projects are relevant for Egyptian agriculture since they reflect a significant positive impact on agricultural productivity and foreign exchange. To illustrate, Egyptian Bt transgenic cotton, resistant to major insect pests, would result in substantial savings of the U.S. $50 million spent annually on the purchase of imported pesticides. Mapping of rapeseed genome has a potential to substantially reduce the 400,000 tons of edible oil which is imported into Egypt annually. Similarly, transgenic potato varieties resistant to selected viruses and insect pests would prevent the expenditure of approximately U.S. $33 million per annum in the import of seed potatoes. The goals of AGERI in the agricultural community can be summarized as follows:

• Advance Egyptian agriculture using biotechnology and genetic engineering capabilities available worldwide to meet contemporary problems of Egyptian agriculture.

• Broaden the research and development (R&D) capabilities and scope of the agricultural research center in the public and private sectors (i.e., initiation of new program areas and application to a wider array of crop species).

• Expand and diversify the pool of highly qualified trained professionals in the area of biotechnology and genetic engineering.

• Provide opportunities for university trained professionals (e.g., faculty, researchers and teachers), the Ministry of Agriculture's professional researchers, and private venture companies to cooperate in agricultural genetic engineering research.

• Promote opportunities for private sector development.

• Achieve the desired level of self-reliance and self-financing within AGERI to mobilize the funds necessary for maintaining laboratories.

Figure 7 highlights the role that AGERI is seeking to fulfill in Africa and the Middle East as an emerging center of excellence for plant genetic engineering and biotechnology. AGERI will act as an interface between elite centers and laboratories from the international scientific community and research centers, universities and the private sector in Egypt, the Middle East and Africa. The major goal is to assist and provide the mechanism for proper technology transfer to benefit their relevant agriculture mandates.

FIGURE 7