Recent Development in Agricultural Biotechnology in Egypt

M. A. Madkour[1]

Abstract

Increase in agricultural production is now widely recognized as a necessary precondition for rapid industrial and overall economic growth in most developing countries.

In Egypt, a positive transition in the reform of the agricultural sector is now underway for an effective liberalization of this vital sector which controls almost 50% of the country's economy. The strategic goals of the agricultural sector include:

- Optimizing crop returns per unit of land and water consumed
- Bridging the food gap and achieving self-reliance
- Expanding foreign exchange earnings from agricultural exports.

It is therefore evident that biotechnology and genetic engineering will play a leading role in increasing agricultural production and productivity.

The use of genetic engineering tools can help dramatically in reducing the dependence on pesticides and agrochemicals known to be hazardous to the environment. It can also lead to the production of transgenic plants conferring resistance to major diseases as well as to prevailing environmental stress.

This paper describes the establishment of the first research and development facility in agricultural genetic engineering in Egypt, namely the Agricultural Genetic Engineering Research Institute (AGERI). The goals of AGERI in the agricultural community can be highlighted as follows:

- To advance Egyptian agriculture using biotechnology and genetic engineering capabilities available worldwide to solve contemporary problems of Egyptian agriculture.
- To broaden the research and development (R&D) capabilities and scope of the agricultural research centers in the public and private sectors.
- To expand and diversify the pool of highly qualified trained professionals in the area of biotechnology and genetic engineering.
- To provide opportunities for university-trained professionals, researchers, and private venture companies to cooperate in agricultural genetic engineering.
- To promote opportunities for private sector development.

The paper will also deal with examples of major problems in the agricultural sector where genetic engineering is expected to play a leading role in finding solutions. The current status of biosafety in Egypt related to field testing of genetically modified plants will also be highlighted.

The challenge facing the world today is to provide food, fiber, and industrial raw materials for an ever growing world population without degrading the environment or affecting the future productivity of natural resources. Meeting this challenge will

[1] Agricultural Genetic Engineering Research Institute (AGERI)
Giza, Egypt.

require the continued support of science, research and education. there is a deep concern about these problems in developing countries, where 90% of the world's population growth will take place within the next two decades.

In Egypt a limited arable land base coupled with an ever growing population with an annual birth rate of 2.7% is the main reason 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. In recent years, only 15% 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 acres to 14 million cropping acres would only satisfy 50% of the requirement for a current population of 60 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.

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 can overcome significant constraints to increased agricultural productivity. The strategic goals of the agricultural sector include:

- Optimizing crop returns per unit of land and water consumed.
- Bridging the food gap and achieving self-reliance
- Expanding foreign exchange earnings from agricultural exports.

Biotechnology and genetic engineering offer major tools to enhance agricultural production. This essential character is underscored by the fact that agriculture represents the spearhead of socio-economic development : accounting for almost 30% of the national income, employing almost 50% of the workforce and agricultural commodities generating more than 20% of the country's total export earnings. This modern trend in research offers new approaches to agricultural sustainability whereby human requirements may be met and tackled, while the environment would become improved rather than destroyed.

The Agricultural Genetic Engineering Research Institute (AGERI), has been established as 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 of 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, as the second phase of the national goal for excellence in genetic engineering and biotechnology. AGERI (formerly NAGEL), is now aiming at the adoption of the most recent technologies available worldwide and at applying them to address existing problems in Egyptian agriculture.

One of AGERI's major targets is the production of transgenic plants conferring re-

sistance to:

a) biotic stress resulting from pathogenic viruses, fungi and insect pests and
b) biotic stress such as unfavorable environmental conditions including salinity, drought and high temperatures.

All these are major agricultural problems leading to severe yield losses in a large variety of economically important crops in Egypt. AGERI has based its project on the concept of maintaining a program that is focused on the problems of Egypt. The immediate objectives are to develop and release transgenic cultivars of major economically important crops in Egypt. Therefore, the most recent and successful genetic engineering technologies are used to address this need.

The activities of AGERI will insure forefront crop biotechnology in Egypt during the coming decades by training the next generation of high caliber scientists. They are dedicated to the production of a widening array of elite crop cultivars and biotechnology-based products, i.e. products which are tailored to Egyptian agriculture's quest to maximize production efficiencies with scarce resources of water and arable lands, to reduce environmental degradation and to reduce production risks to the farmer. These efforts will make agrosystem production more economically successful as well as environmentally and socially acceptable.

AGERI has upgraded the existing research facilities on its premises and has used two floors to house the project, for a total net area of 1,116m^2, consisting of 14 laboratories with modern equipment, a Biocomputing and Networks Unit, a central facility and a supply repository. Moreover, a fiberglass greenhouse (307m^2) has been added on to AGERI's property. The controlled environmental chambers (140m^2) are used to host the transgenic plant materials for acclimatization. A biocontainment greenhouse (600m^2), complying with the biosafety and EPA (Environmental Protection Agency) regulations, has been in operation since September 1995. In this greenhouse, experiments dealing with the degree of gene expression in transgenic plants are being conducted.

One of the many major contributions of AGERI is the identification and recruitment of a selecteted group of 17 senior scientists with a high level of scientific expertise and work ethics. Each one is a vital link in the program's goals for crop improvement. The senior scientists have institutional affiliations within Egypt in addition to their scientific responsibilities within AGERI. They are representatives and practicing 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 communities. Their high level of international training in conjunction with their enthusiasm to invest their talents into AGERI's biotechnology programs is an encouraging addition to the cause of Egypt's agricultural technology development.

Another major 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 were initi-

ated. Various seminars and conferences have been held at AGERI with highly qualified international consultants. Numerous study tours (60) have taken both senior scientists and junior assistants of AGERI to conferences and training courses.

Moreover, condensed, short courses and seminars concentrating on basic aspects 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 provided for the exchange of genetic probes, cDNA libraries and vectors. Such contacts with centers worldwide have been encouraged and initiated to promote meaningful interactions. Senior scientists have made an impact on the educational quality of young researchers at AGERI through their affiliation and teaching activities in Egyptian universities.

Egypt should assume a leading role in transferring these agricultural technologies to Middle Eastern and Northern African countries, targeting the research, training and interactive institutional activities. AGERI will provide the foundation for sustainable agricultural production, thus realizing the food security of the region and other benefits of biotechnologies.

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

The successful implementation of these projects would build a national capacity within Egypt for the sustainable production of crucial crops to the economy and a safer cleaner environment.

Examples of these projects are as follows :

1. Genetic engineering of potato resistant to major viruses in Egypt (PVX, PVY, PLRV); production of transgenic tomatoes resistant to geminiviruses such as Tomato Yellow Leaf Curl Virus (TYLCV), introduction of virus resistance in squash and melon against Zuccini Yellow Mosaic Virus (ZYMV) and finally production of transgenic faba bean conferring resistance to Bean Yellow Mosaic Virus (BYMV) and Faba Bean Necrotic Yellows Virus (FBNYV).

2. Engineering of insect-resistant plants with *Bacillus thuringiensis* crystal protein genes. *B.t.* genes are used for the transformation of cotton, maize, potato and tomato plants to confer a resistance to their major insect pests.

3. Genetic engineering for fungal resistance using the Chitinase gene concept for the development of transgenic tomato and faba bean expressing resistance to fungal diseases caused by *Fusarium* sp., *Alternaria* sp. and *Botrytis fabae.*

4. Enhancement of the nutritional quality of faba bean seed protein by the successful transfer of the methionine gene to faba bean plants.

5. Cloning the genes encoding for important economic traits in tomatoes, faba bean and cotton, especially those related to stress tolerance (i.e. heat shock proteins and genes responsible for osmoregualtion).

6. 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.

7. Developing efficient ELISA-based 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. As an example, the cultivation of Egyptian *B.t.* transgenic cotton, resistant to major insect pests, would result in substantial savings of the US$50 million spent annually on the purchase of imported pesticides. Mapping of rapeseed oil 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 US$33 million per annum in the import of seed potatoes.

The goals of AGERI in the agricultural community can be summarized as follows:

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

2. Broaden the Research and Development capabilities and scope of the agricultural research centers in the public and private sectors (i.e., initiation of new program areas and application to a wider array of crop species).

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

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

5. Promote opportunities for private sector development.

6. Achieve the desired level of self-reliance and self-financing within AGERI to mobilize the funds necessary for the running costs of laboratories.