Commercial Production of Transgenic Cotton in Egypt

All the currently available transgenics in cotton belong to the upland type, and Egypt grows only *G. barbadense*. However, this does not mean that Egypt has not been able to make use of genetic engineering technology in cotton. In fact, genetic engineering programs started with the establishment of the Agricultural Genetic Engineering Research Institute in 1990, and Egypt has made significant progress in the development of transgenic crops since. A team of researchers/ biotechnologists at the Agricultural Genetic Engineering Research Institute of the Agricultural Research Center has been working for over ten years to develop its own systems to make use of modern technology. The team has been successful, and currently two transgenic crops are ready for commercial release: a potato engineered to resist infestation by tuber moth, and a squash resistant to a viral pathogen. Genetically engineered maize resistant to the stem borer may be the third transgenic crop to go into commercial production, provided field trials prove successful. Egypt has acquired already-developed transgenic maize technology from multinational companies, thus, it has not only relied on its own expertise, but has also been looking for additional ways to make use of new developments in genetic engineering. Egypt has also made significant progress in GE cotton.

Need for Biosafety Regulations

One of the significant limitations in the spread of genetic engineering to many countries—and particularly to developing countries, which are the main producers of agricultural goods—has been awareness about its usefulness as well as possible risks. Though the benefits of the GE technology may be highly significant and dominant over potential risks, ICAC has realized that there is a need to educate the public about both so that appropriate measures can be taken to avoid risks before damage actually occurs. Many countries have come to realize that in order to adopt the technology and before any biotechnology products are released, they first need to formulate regulatory requirements. Though GE cotton is grown on a commercial scale only in six countries, national biosafety systems have already been established in over fifty countries to evaluate proposed uses of genetic engineering and its products.

Egypt does not have many GE cotton products ready for use. But, considering the GE products available on the market from over 40 crops engineered so far, it is clear that they are so diverse that some would require a higher level of regulatory control than others. Whether it would be a low or a very strict regulatory process, the fact remains that countries' biosafety systems will serve as gatekeepers for the use of biotechnology in cotton and in all other crops and living organisms. General biosafety guidelines have been prepared by the Biosafety Information and Advisory Service of the United Nations Industrial Development Organization and are available on line at http://binas.unido.org/binas. Countries' national biosafety systems are intended to serve as mechanisms for ensuring the safe use of biotechnology application without imposing unacceptable risks to human beings or the environment, or unintended constrains to technology transfer.

Seed Industry

Egypt has 66 registered seed companies specialized in seed production of hybrid maize, sorghum, sudangrass forage, sunflower, some vegetables, clover and alfalfa. Over fifty companies are registered to import seed, while 148 companies have the required license to export seed from Egypt. The planting seed industry in Egypt started and flourished from the cottonseed industry. In 1922, the government of Egypt established a cottonseed production unit at the Ministry of Agriculture, which served as a basis for the initiation and establishment of the seed industry. From time to time, the unit expanded to include seed production of other crops. The status of the seed production unit was raised to a higher level within the Ministry in 1980. In

1993, when the Ministry started implementing free market economy policies, the seed industry was reorganized into two sub-sectors. Seed certification, quality control, marketing control and law enforcement activities were separated from commercial seed production.

The Agricultural Research Center of the Ministry of Agriculture and Land Reclamation has 17 research institutes/organizations, and the Cotton Research Institute at Giza/Cairo is one of them. The Cotton Research Institute has the primary responsibility of developing varieties. The Central Administration for Seed Testing and Certification, established in 1995, has the primary responsibility of seed quality control, legislation and policy enforcement. For the purpose of quality asurance, the Central Administration for Seed Testing and Certification also undertakes field and lab tests depending upon the status of the variety. Uncertified seeds are tested only under lab conditions.

Seed varieties developed by the Cotton Research Institute are handed to the Central Administration for Seed Production for commercial production and distribution. The Central Administration for Seed Production recommends to the Agricultural Research Center authorities the quantity of certified and registered classes of seed to be produced to meet the requirements of all farmers. The Central Administration for Seed Production contracts with elite growers to produce seed for various crops. The Central Administration for Seed Testing and Certification keeps a close watch during the seed multiplication process and works in collaboration with the respective breeders and the Central Administration for Seed Production, and makes sure that all requirements for maintaining seed quality are properly followed.

All the seed needed to grow cotton in Egypt comes from locally developed *G. barbadense* varieties only, and is produced in coordination with the Cotton Research Institute, the Central Administration for Seed Testing and Certification and the Central Administration for Seed Production, under the overall administrative supervision of the Ministry of Agriculture and Land Reclamation. The breeders at the Cotton Research Institute, who are experts in identification of varieties, are responsible for producing breeder's and foundation seed. Foundation seed is the basis for producing registered and certified seed. Breeder's seed is produced separately but sometimes the same field may be used to produce foundation, certified and registered seed. Within a field, the central part may be designated for producing foundation seed, assuming that no outcrossing has occurred in this part of the field and, subsequently, certified and registered seed may be produced from the outer parts of the field.

Planting Seed Produced in Egypt – 2000/01

Category	Quantity in Tons	% of Total
Breeder's Seed	150	1
Foundation Seed	1,110	6
Registered Seed	4,068	24
Certified Seed	11,974	69
Total	17,302	

The Cotton Research Institute is one of the oldest establishments in agricultural research. The institute was established in 1915, even before the seed production unit was established within the Ministry of Agriculture. The institute started as a breeding station and has turned into a main research facility on cotton research in the country by accommodating many other disciplines. But the main emphasis is still on breeding new varieties and producing breeder's and foundation seed. Other disciplines serve as support to the mainstream work of the institute. A separate institute on plant protection (mainly insects), a diseases institute and genetic engineering institutes take care of the respective disciplines, but physiology, agronomy and fiber quality are housed within the Cotton Research Institute. Breeders get support from allied disciplines and train inspectors and supervisors from the Central Administration for Seed Testing and Certification and the Central Administration for Seed Production in the proper identification of different varieties. The Cotton Research Institute has six research stations that are used not only for varietal trials, but also for the production of breeder's seed. The station at Sakha in the Delta region serves as the main center for production of breeder's and foundation seed.

Seed Rate and Varieties

Cotton in Egypt is planted on ridges and virtually all is dibbled by hand. Usually, 10-12 seeds are used per dibble and hills from the center are spaced at 50 centimeters from each other. Plants are ultimately thinned to about two plants per spot. A high number of seeds per dibble, and close spacing between rows increases the need for a higher seed rate, but the seed actually used per hectare is even higher than the required rate. Seed from *G. barbadense* varieties usually has less fuzz compared to upland and diploid cultivated types, and planting seed was not delinted in Egypt prior to 1995. The average seed rate used in Egypt ranges from 80-100 kgs per hectare. The main reason for the application of a higher seed rate is just a tradition to avoid any chances of getting a low plant stand and low yields. Without going into details about how much seed should be used per hectare to obtain an optimum plant stand and to achieve the target yield, the fact remains that a higher seed rate definitely increases the need to produce more planting seed than actually required.

Area Under Different Varieties in Egypt - 2000/01

Variety	Area in %
Giza 70	14
Giza 80	13
Giza 83	11
Giza 85	14
Giza 86	21
Giza 88	2
Giza 89	24

There are at least ten other countries that produce *G. barbadense* on a significant area. These countries grow a limited number of varieties every year. But in Egypt, the number of varieties permitted for commercial production is proportionally much higher

compared with other countries growing similar types of cotton, which gives farmers flexibility to grow a variety of their own choice better suited for their soil and production practices. On the other hand, a high number of varieties adds to the uncertainty of which variety to grow on what area. Due to a much wider choice, farmers keep switching among varieties, multiplying the doubts of how much seed of each variety is necessary to produce next year. Thus, as a precaution, seed of most varieties is produced in higher quantities than the actual amounts used by farmers. This not only increases the cost of seed production but also lessens the efforts of the concerned agencies for strict quality control at various stages of quality monitoring, like in the field, in ginning and in handling.

Main Goals of GE Cotton in Egypt

There are many GE upland cotton programs in the world. In addition to the work of private companies, many countries have also initiated their own specific programs according to their needs. However, the Egyptian program is the only major program on *G. barbadense* in the world. Genetic engineering of cotton in Egypt has the following main goals in general:

- *G. barbadense*, like the upland varieties, is also affected by insects. One of the main areas of research in Egypt is the development of transgenic cotton resistant to insects.
- Characterization of salt, drought and heat stress-tolerant genes and the development of transgenic cotton varieties possessing traits that offer tolerance to abiotic stresses.
- Molecular and biochemical characterization of cotton fiber initiation and development in Egyptian cotton.
- Identification and characterization, and sequencing of gene families responsible for fiber length and strength traits in Egyptian cotton.

Significant progress has already been made to develop Egyptian cotton resistant to insects, particularly bollworms. Efforts are underway to verify the synthetic Bt toxin gene(s) and work is continuing for the transformation and regeneration of transgenic cotton plants expressing accumulated synthetic Bt gene(s). The regenerated transgenic plants resistant to insects are being tested under greenhouse conditions and soon will be offered for testing under field conditions for insect damage tolerance.

Regarding tolerance to various kinds of stress, Egypt has developed cotton tolerant to drought. Heat and salt stress tolerance are also within achievable targets. Stress tolerant transgenic cotton is also at greenhouse and confined field-testing stage.

The effect of plant growth substances (auxins, gibberellins and cytokinins) on in vitro fiber initiation and development has revealed interesting results. Regulation of gene expression controlling late fiber growth development in fertilized ovules is being studied, and molecular and biochemical characterization of Egyptian cotton fiber initiation and development seem possible. However, work regarding identification and characterization of genes responsible for fiber length and strength is still at initial stages.

National Biosafety System

Egypt is one of the first developing countries that have designed criteria for safe handling, large scale testing and commercial release of genetically engineered crops. Egypt established a national biosafety system as early as 1993. The Biotechnology Service of the International Service for National Agricultural Research (ISNAR) undertook a study along with two other collaborators from the U.S. to assess the impact of genetically engineered crops being released in Egypt, and also reviewed the biosafety policies and procedures associated with the introduction of GE crops. ISNAR has published the results of the study in the form of a report titled "Analysis of a National Biosafety System: Regulatory Policies and Procedures in Egypt," in September 2000.

In 1992, the Agricultural Genetic Engineering Research Institute of Egypt (AGERI) and Michigan State University started a collaborative project called the Agricultural Biotechnology Support Project (ABSP), supported by the U.S. Agency for International Development (USAID). ABSP required Egypt to have an adequate mechanism for biosafety review. Egypt's national biosafety system was formally instituted by the Ministry of Agriculture and Land Reclamation in 1995.

The Egyptian biosafety system involves several ministries, departments and government agencies in the process of importation, exportation, local production and release of GE products. The National Biosafety Committee (NBC) is the final authority in the release of GE products and its main responsibilities, among others, include the formulation and implementation of guidelines for safe handling and commercialization of GE products. NBC also has the mandate of coordinator with national and international organizations working in the same field. NBC provides training and technical advice in the relevant fields. It is the responsibility of NBC to keep up with developments in the field and, accordingly, update guidelines for the effective implementation of regulations and safety of the environment and living organisms. NBC is comprised of three subcommittees specializing in (1) agriculture: dealing with crops; (2) environment: dealing with biopesticides, biofertilizers, etc.; and (3) health: dealing with pharmaceuticals, human and veterinary vaccines.

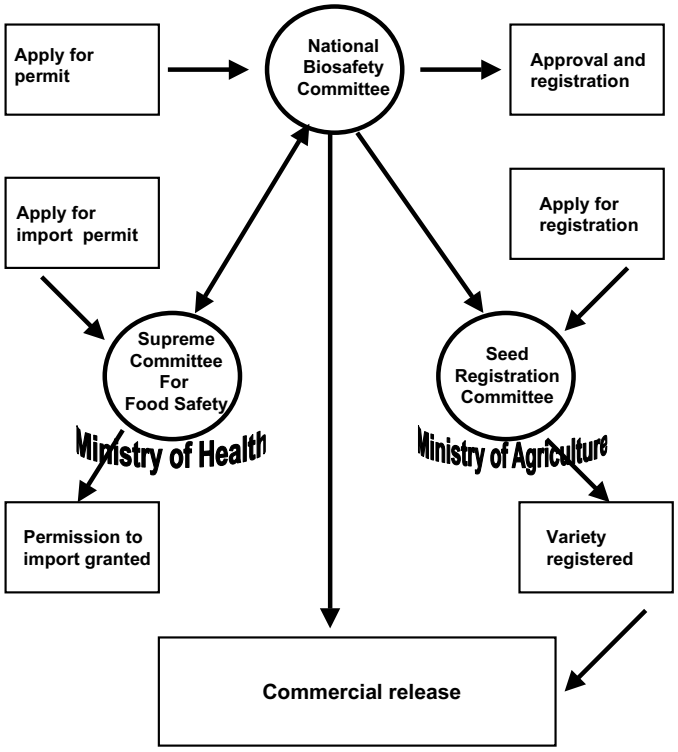
Under the guidelines established at the national level, every national institution working with the process involving recombinant DNA technology is required to establish an Institutional Biosafety Committee. The Institutional Biosafety Committee not only adheres to the national guidelines but also assembles appropriate institutional guidelines in line with national standards so that all possible research risks are covered. Thus, the institutional committees make sure that plans and programs are available for adoption in case of accidental spills and personnel contamination. The institutional committees are comprised of experts in different techniques used in genetic engineering

of organisms, policies and applicable laws and biological safety.

Standard application forms are submitted to NBC for approval and release of a GE product. NBC usually appoints a principal investigator for a more critical review, who submits a report to the full committee after consultation with members of the concerned discipline subcommittee. Applicants are required to indicate what information on the application is confidential, such as plasmid maps, exact genetic change, technique used in developing the GE product, or any other information specified by the applicant. NBC has the right to either issue a permit or discard the product as unfit for commercial release in Egypt. However, permission to import a GE product is granted by the Supreme Committee for Food Safety of the Ministry of Health.

Though national biosafety guidelines were drafted in 1994 and made public in 1995, procedures for commercialization of GE products were established in 1998. The Supreme Committee for Food Safety of the Ministry of Health ensures the safety of the food aspect of any GE product and, similarly, other issues related to products like pharmaceuticals, etc., are taken care of by other ministries/departments. The Environmental Affairs Agency of the Ministry of Environment ensures environmental protection laws. The role of the three main committees is shown in the diagram below. The Central Administration for Seed Testing and Certification is responsible for testing and registration of GE varieties but would act only if a variety has been allowed for growth on a commercial scale by the NBC.

Commercial Release of GE Plants in Egypt



More Recent Changes

When commercial production of GE crops became popular, and it became clear that products made from GE crops were going to move frequently across countries and regions, the government of Egypt reconsidered its policies. In 1997, the government prohibited the import of any foodstuff produced through GE technology unless confirmed safe. A certificate from the country of origin confirming that seed was not produced from untested GE plants must accompany all imported GE seed/products. This means that only products which have been approved in the exporting country and found safe can be imported into Egypt.

The fine-tuning of the policies, procedures and protocols has been undertaken to improve the release of crop varieties, including cotton. The objective is to include GE crop varieties in addition to conventionally bred varieties of all crops developed locally. Varieties can be released as "open and general" or they can be "exclusive release." If periodical reviews indicate that proper requirements are not followed or applied, the permits for exclusive release can be revoked.

In 1999, the government decided to include fingerprinting as a requirement for registration of all crop varieties. The objective was to confirm identity during the registration process and for subsequent use as a reference.

Some changes have also been made with regard to intellectual property rights, particularly within institutes and the Agricultural Genetic Engineering Research Institute. Under the rules, the Institute will hold all rights and title but will release intellectual property rights to inventors.

For more details on the revisions, refer to the report published by the International Service for National Agricultural Research.