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Place and Role of Biotechnologies in the Agricultural Research System of Egypt

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SUMMARY - Recent advances in the ability to isolate and manipulate genes and many other biotechnologies have provided agriculture with new and powerful tools to improve the productivity of plants, animals and microorganisms. Egypt has made a substantial effort towards the application of biotechnologies to agriculture. This effort is particularly important to Egypt because its economy is heavily dependent on agriculture. A major challenge to Egyptian agriculture is the generation of plants resistant to stress conditions, such as high temperature, salinity, drought, insect pests and pathogenic organisms. This paper describes the historical background of biotechnologies in Egypt. Next it outlines government policy aiming at unifying the efforts of Egyptian scientists and institutions in the field of biotechnology and cites examples of national institutions which have been developed for that purpose. Projects which resulted from international cooperation are also alluded to. Finally the paper indicates the areas of high priority in biotechnological research in Egypt.

Key words : Biotechnology in Egypt - Tissue Cultures - Disease-free plants - Variants - Genetic engineering - Somatic hybridization - Genetic transformation.

RESUME - "La situation et le rôle des biotechnologies dans la recherche agricole en Egypte". Des progrès récents concernant les possibilités d'isolement et de manipulation de gènes, et relatifs également à de nombreuses autres biotechnologies, ont permis à l'agriculture d'améliorer la productivité des plantes, animaux et microorganismes, au moyen de ces nouveaux et puissants outils. L'Egypte a fourni de grands efforts pour l'application des biotechnologies dans le domaine de l'agriculture. Ceci est d'autant plus important pour l'Egypte que son économie est hautement dépendante de l'agriculture. Le défi le plus important pour l'agriculture égyptienne est la création de plantes résistantes aux conditions adverses, telles que les températures élevées, la salinité, la sécheresse, les insectes ravageurs et les organismes pathogènes. Cet article examine le contexte historique des biotechnologies en Egypte. Il souligne ensuite la politique gouvernementale qui vise à coordonner les efforts des institutions et scientifiques égyptiens dans le domaine de la biotechnologie, et cite quelques exemples d'institutions nationales créées à cet objet. Des projets lancés sous les auspices de la coopération internationale sont également mentionnés. Finalement, les domaines hautement prioritaires en ce qui concerne la recherche sur les biotechnologies en Egypte sont indiqués.

***Mots-clés** : Biotechnologies en Egypte - Cultures de tissus - Plantes indemnes - Variants - Génie génétique - Hybridation somatique - Transformation génétique.*

Introduction

Biotechnologies are new techniques in the cellular and molecular biology utilized for improving the genetic make up and management of plants, animals and microorganisms. It is now widely recognized that the recent advances in the field of biotechnology can prove to be valuable for developing countries for expediting their developmental process.

By the turn of the century, the world population would have arisen from the present 5 billion to over 6 billion. To merely maintain the current consumption levels, an increase of 26% in the world's average grain yields would be needed. The bulk of this increase would be in developing countries. Integrated with conventional technologies, biotechnologies can play an important role in increasing agriculture yield and assuring food supply.

The emerging trends in the biotechnological research and development in industrialized countries suggest that appropriate biotechnologies may not be easily accessible to developing countries. The biotechnological revolution, therefore, poses an immense challenge before developing countries to help in bridging the gap between actual and potential yields.

Historical background

As early as 1982 Egypt had developed an interest, but not involvement, in modern biotechnologies. A national committee of genetic engineering and biotechnology was formed in the Egyptian Academy of Sci-ences. The goals were to identify the opportunities and constraints of the use of modern biotechnologies in solv-ing agricultural problems. In the same year, the Committee submitted to the UNIDO Secretariat a petition for the establishment of a regional center for genetic engineering and biotechnology within the framework of ICGEB to act as a focal point for the Middle East and North African region. Meanwhile, a survey was con-ducted for scientists who were either involved or planning to be involved in this field.

In 1984, at the University of Cairo, a committee was formed under the supervision of the Vice-President for Higher Education and Research for the purpose of establishing an institute of biotechnologies and genetic engineering. Interested professors from various faculties met regularly to discuss different plans and prospects. It was decided to hold an international workshop hosted by Cairo University. This did not materialize, however.

In 1985, there was a great awareness in the Egyptian scientific community of the vital importance and impact of biotechnologies on the economic development of the nation. Egyptian scientists were monitoring developments overseas, but little modern biotechnology activity was taking place locally at that time. The Egyptian National Committee for genetic engineering and biotechnology was represented in an international meeting sponsored by UNIDO to discuss plans for establishing an international center(s) for biotechnologies.

In 1986, a national policy and a research program in modern biotechnologies were established with collaborative linkages between scientists in the National Re-search Center, the Agriculture Research Center and the Egyptian Universities. Junior researchers were sent to Europe and USA to update their knowledge in the field. Moreover, a separate unit for genetic engineering and biotechnology was established at the National Research Center. Preliminary studies to transform colon bacteria to express plant and animal genes were conducted. The Egyptian Society of Genetic Engineering was established with the aim of unifying efforts in the field. An annual meeting discussing major research progress and presided by official dignitaries is a major activity.

In 1987 plant tissue culture laboratories were established or renovated at several places. The most up to date are : (1) at the Egyptian Major Crop Improvement Program (EMCIP) situated at the Agriculture Research Center, and (2) the development of the Agricultural Systems Project Laboratory situated at the College of Agriculture, University of Cairo.

Government policy, investments and international cooperation

1. National Agriculture Genetic Engineering Lab (NAGEL)

In April 1988, and under the umbrella of UNDP, a mixed group of Egyptian and foreign scientists, among whom were Van Montague, Richard Jones and Mohamed Ali, met in Cairo to discuss the development and implementation of the new biotechnologies in Egypt. The panel felt that the current agricultural dilemma of food consumption far outdistancing production capabil-ities provided a strong justification for the implementation of programs that allow a rapid transfer of technologies from industrialized countries. The experts believed that this is best served by establishing a National Agricultural Genetic Engineering Laboratory (NAGEL).

Three initial projects were proposed :

a. Micropropagation of virus-free minitubers of potato varieties ecologically suited for production in Egypt. At present, all seed potatoes used in the country are imported. Development of this capability would save approximately 16 million dollars annually.

b. Development of improved varieties of rapeseed *Brassica campestris* for increased production of edible oil using RFLP mapping. This technique can be used to organize the genetic diversity, predict combining ability to optimize yield and create genotypes with enhanced traits.

c. Genetic transformation of tomato for improvement of yield components, harvestability and market qualities. Tomato is the largest vegetable crop grown in Egypt and was chosen as a model system for Egyptian scientists to gain competence in biotechnologies and their application to crop improvement. This would enhance and facil-itate the future expansion of other crops.

In April 1990, a group of 7 scientists was appointed on a full-time basis to start executing the above-mentioned research projects. The appointees are all highly qualified Ph.D.'s, well trained in various aspects of biotechnology and are covering the areas of tissue culture, cytogenetics, molecular biology, protein engineering and recombinant DNA technology. They

were recruited from different universities and the Agricultural Research Center's laboratories. Temporarily, NAGEL is located in an eight room laboratory complex that occupies one floor of the EMCIP building at the ARC in Giza. Helping these scientists are 15 technicians who are holders of either B.S. or M.S. degrees.

NAGEL is headed by the Minister of Agriculture and Land Reclamation who is assisted by 6 executives among whom is the General Director of the Agricultural Research Center. The budget of NAGEL is about 1.5 million dollars and an equal amount of Egyptian pounds.

2. National Institute for Genetic Engineering and Biotechnology (NIGEB)

The Egyptian Academy of Scientific Research and Technology, which is responsible for planning and evaluating research in Egypt, realized the need for giving a greater impetus to the national activities in biotechnologies. Encouraged by the recommendations of UNIDO missions that visited Cairo in 1982 and 1985, the Acad-emy set to establish NIGEB. Designed to complement NAGEL, NIGEB will cover a wider area of research projects addressing the country's industry, medicine, environment, agriculture and basic sciences needs.

The estimated budget of NIGEB is about 7 million Egyptian pounds and 1.5 million dollars donated by UNDP. The permanent core staff of the institute will consist of a group of 10 - 12 Ph.D. level Egyptian scientists, supported by an equal number of research associates and technicians. For some of them, further training will be carried out in France (Pasteur), Belgium (Ghent), Germany (Max Plank), and England. This training will be covered financially through UNDP and expected grants from ICGEB and will hopefully start in October 1990. The first phase of the physical facilities of the NIGEB is expected to be completed in ten months. The intended 4 laboratories, offices, conference and lecture halls, library and other facilities will cover an area of 12,000 square meters. The building is situated in Helwan, a suburb of Cairo.

3. The University of Menoufiya

has, through scientific and financial aid from the German Government, established a Gene Technology Unit at the grounds of the College of Agriculture at Shebin Elkom. The actual cooperation between Cairo and Bonn start-ed in 1987 through a cultural agreement signed by the Egyptian Supreme Council of Universities and the Technological University of Darmstadt. In March 1987, a joint seminar was organized by Menoufiya University to discuss different aspects of genetic engineering. The German delegation consisted of 12 scientists and was headed by the German Minister for Scientific Research.

In addition, integrated laboratory equipment worth one million marks was given as a gift to the Egyptian Government. At this laboratory at the grounds of the College of Agriculture, a one month training course was offered in November 1988, with a nucleus of 30 trainees from different disciplines, 8 German and an equal number of Egyptian experts. Subjects such as gene cloning and plasmid technology were discussed and experiments were conducted. This encouraged the Egyptian party to hold another training course in November 1989 which was financially supported by UNESCO and supervised by CAIRO MIRCEN. The gene technology unit of Menoufiya University, which enjoys a good reputation in the field, is soon going to include an advanced laboratory for molecular biology worth 1.5 million dollars donated by the United States Agency for International Development (USAID) in Cairo.

4. Institut Français de Recherche Scientifique pour le Développement en Coopération (ORSTOM)

This is another example of international cooperation. An agreement was signed between the Egyptian Government represented by the University of Cairo and the French Government represented by ORSTOM in 1988. The 250,000 francs building was opened unofficially in July 1989 and was completed and officially inaugurated in April 1990. Another 500,000 French francs have been spent to equip four laboratories.

Six experts are assigned at the ORSTOM unit, three from each party. Although they are mainly interested in entomovirology, the unit is encouraging and cooperating in executing research in different aspects of genetic engineering and biotechnologies. In November 1989, ORSTOM offered a training course in molecular biol-ogy. A mission headed by Professor J. Weil from Strasbourg instructed 20 Egyptian trainees for two weeks.

Aspects of Major Priority and their Relation with Classical Disciplines

In the agricultural sector, a great deal of attention has been focused on biotechnologies because of their great potential for developing countries. For a variety of reasons, these countries -including Egypt- fear that they may be excluded from development. One reason is the law protecting intellectual property, inventions and

even living organisms. Genetic engineering patents held by foreign private companies can lead to a monopoly in the cultivation of certain plant species.

Integrated with conventional plant breeding, biotechnologies can play an important role in increasing agricultural yield and thus ensuring food security. Biotechnologies can help in bridging the gap between actual and potential yields through enhancement of the efficiency of photosynthesis, rapid multiplication of elite plants and accelerating the pace of breeders to overcome barriers of sexual incompatibility.

In planning sophisticated research for a developing country, there is a special need to take into account (1) the economical aspects of that country and (2) the time factor in order to ensure that the research has some practical use. Priority considerations should be given to *main food crops* preferably in collaboration with the relevant international agricultural research centers.

As for priorities for the application of genetic engineering methods, *the use of RFLP* has high priority as molecular markers to increase genetic transfer of genes controlling growth, maturity and quality. *Somatic hybrid-ization* has a particular research priority since it will provide a means of overcoming existing crossing barriers. There is a need for a great deal of research in this area in order to broaden the range of combinations of species with the specific aim of transferring resistances from wild forms. Somatic hybridization requires elaborate laboratory equipment, however. It will take considerably longer time to develop *genetically transformed crops*. Priority objectives for the latter are: improving the protein quality of major crops, improving stress tolerance, and extending pathogen resistance.

Concluding remarks

Egypt is endowed with a wealth of qualified scientific manpower resources. It should be noted that biotechnologies in Egypt are a responsibility of three ministries which carry out agriculture research activities*. These are the Ministry of Agriculture and Land Reclamation, the Ministry of Scientific Research and Technology, and the Ministry of Education. Egyptian universities, who fall under the authority of the Ministry of Education, are involved in different aspects of biotechnologies executed by major colleges of agriculture. Examples are: staff members at the Department of Genetics, College of Agriculture, University of Cairo who are interested in transferring the ICP gene from Bacillus into cotton plants to induce resistance to cotton leaf worms. Moreover, haploid techniques have been successfully started at the same department for annual species such as wheat. Available results from the use of anther culture point out a clear acceleration of breed-ing. There are, however, some difficulties with legumes. This is an area which requires more research.

One of the first laboratories in Egypt that is involved in selection for somaclonal variation is at the Agronomy Department, Al Azhar University. Primary aims are selection for salt, temperature and drought tolerance in maize and wheat. Research projects in this field can be implemented in the national research centers providing there is appropriate cooperation.

The above-mentioned projects not only have an impact on national productivity, but also represent a spectrum of increasingly complex scientific challenges. They require multidisciplinary scientists trained in Egyptian and foreign universities and biotechnology contacts. Performance on these projects will create a base for future laboratory expansions, addition of new goals as well as establishing scientific collaboration and linkages between national and foreign experts.

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* The role of the private sector in carrying out biotechnological research is negligible. An exception is one firm that established a tissue culture laboratory for micropropagation of fruit trees.