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SUMMARY - Turkey is one of the few countries having achieved self-sufficiency in agricultural productions. Biotechnologies have played a significant role in yield improvement. Research focuses on tissue cultures, mainly for plants, husbandry, agricultural technologies, phytopathology and pest control. The main objectives are yield improvement, conservation of genetic resources and control of diseases and pests. At present a total of fourteen stations are working on improving and multiplicating plants and controlling phytopathology, five stations are conducing research on artificial insemination (semen preservation) and eight stations are specializing in pest control in the Ministry of Agriculture, in Universities and private firms.

Key words: Biotechnologies in Turkey - Micropropagation - Tissue cultures - Secondary metabolites - Recombinant DNA - Protoplast fusion - Germplasm - Embryo transfer - Pest control - Virus.

RESUME - "La biotechnologie dans le domaine de l'agriculture, en Turquie". La Turquie est l'un des rares pays au monde autosuffisant en matière de production agricole. La biotechnologie y joue un rôle significatif dans l'augmentation des rendements. Les recherches sont centrées sur les cultures de tissus particulièrement en ce qui concerne les plantes, l'élevage, la technologie agricole, la phytopathologie et la lutte contre les ravageurs. Les buts les plus importants sont l'amélioration de la production, la conservation des ressources génétiques et la lutte contre les maladies et les parasites. Actuellement, au Ministère de l'Agriculture, dans les Universités et dans le privé, quatorze stations au total se consacrent à la multiplication, l'amélioration des plantes et la phytopathologie, cinq stations étudient l'insémination artificielle (conservation du sperme) et huit stations se spécialisent dans la lutte contre les parasites.

***Mots-clés** : Biotechnologies en Turquie - Micropropagation - Cultures de tissus - Métabolites secondaires - ADN recombinant - Fusion de protoplastes - Germoplasme - Transfert d'embryons - Lutte contre les insectes - Virus.*

Introduction

Biotechnology has a history that is as old as the history of civilization. Microorganisms that transform the sugar into alcohol, the milk into dairy products have provided the biotechnology applications to the service of mankind throughout the centuries. During the past century many antibiotics, enzymes and proteins were discovered and produced by using microorganisms. Genetic engineering included in the biotechnology concept, also has a long history. We are all aware of the selection of lines, (breeding by selection) crossing the parent lines with different characteristics according to desired specifications in the plants and animals. But, new interest and excitement on biotechnology is related to the discoveries of DNA in 1953 and the development of "Recombinant DNA or Gene Splicing in 1973". The application of biotechnology is based on very rapid and significant discoveries in biology, chemistry and physics, but particularly in molecular biology. Scientific instruments including computers over the last 2 or 3 decades helped to the current exciting development in biotechnology. It is very common to use the word biotechnology in combination with the word genetic engineering. The use of recombinant DNA technology for the improvement of higher plants has a great importance.

Biotechnology can increase production, decrease the production costs, improve the living standards of mankind, but on the other hand it affects negatively the

countries that are heavily dependent on agriculture and turns over the production power to the developed countries and even to the limited number of private sector organizations in these developed countries. But, it is obvious that all these developments shall establish their own balance and contribute significantly to our overall growth in Turkey.

The country or the community where something is invented, is the first to benefit from it. In a short period of time, however, innovations are definitely transferred to other regions, because boundaries cannot limit science and technology.

My country, Turkey, is not only self-sufficient in agriculture, but also one of the few net exporters of foodstuffs in the world. However biotechnology or the so-called science-power is regarded as an important means for the improvement of both agricultural and food production. This is because, this type of development will lower unit costs of production, reduce the time required for production and partially substitute some conventional factors and inputs.

Biotechnology in Turkey

The term "biotechnology" covers two groups of techniques for plants;

The first one is recombinant DNA, microbial and plant gene manipulations.

The second one is micropropagation, synthesis of secondary metabolites and protoplast fusion, anther culture which are used as a tool in breeding programmes.

The first group studies are very recent in Turkey. A new laboratory at the University of Çukurova, Adana, will be working on recombinant DNA and gene manipulations next year.

Besides the studies on plant biotechnology, there are some biotechnological researches and applications which include the following areas:

- Biotechnology for livestock
- Biotechnology on agricultural industries
- Biotechnology on insect and pest control

Institutions

PLANT TISSUE CULTURE LABORATORIES

The biotechnological research and applications have been used for the various aims at Universities, Research Institutes of the Ministry of Agriculture, Forestry and Rural Affairs and at some commercial companies in Turkey.

The background of biotechnological studies in Turkey goes back to about 1960's. The first study on the fixation of nitrogen was started in 1953 at the Microbiology Department, Faculty of Agriculture in Ankara.

Today, there are a number of laboratories applying tissue culture techniques as a part of their research programmes.

A plant tissue culture laboratory was firstly established at the Aegean Agricultural Research Institute (AARI), Izmir, 1977. Thereafter, others have followed it at Universities and other Research Centres. The names of all tissue culture laboratories present in Turkey and their objectives are listed in Table 1. As it is seen, six of them are within the Ministry of Agriculture, six laboratories are at the Universities, and three of them within commercial companies.

In addition to these institutions, it is intended to establish some more laboratories which will be possibly at the Vegetable Research Institute in Antalya and at the Agricultural Research Institute in Eskisehir. These laboratories will apply tissue culture techniques for breeding purposes.

LABORATORIES FOR ANIMAL HUSBANDRY

Agriculture and animal husbandry are the complementary parts of each other. For this reason, it is aimed at increasing the productivity in animal husbandry as in agriculture. Significant increases have been observed concerning the implications of biotechnology for livestock production, nutrition and health in the world. There are a number of areas where biotechnology has been applied and can improve animal production health. Two of these areas namely embryo transfer and sperm storage in liquid nitrogen have found more applications than others in Turkey. The embryo transfer has a great importance in animal husbandry. Studies on embryo transfer started in late 1970's at the Veterinary Faculty in Istanbul. At the same time, studies on freezing conservation of embryos have also started. Today, four veterinary faculties and two animal research institutes are working on this subject (Table 2). These two animal research institutes, belonging to the Ministry of Agriculture, have applied embryo transfer for two years in practice.

Five artificial insemination centres preserve the sperms by means of deep freezing and they are responsible for providing sperms of desirable races.

Table 1 - Tissue culture laboratories and their objectives in Turkey

ORGANIZATIONS	OBJECTIVES
A- MINISTRY OF AGRICULTURE, FORESTRY AND RURAL AFFAIRS	
1. Aegean Agricultural Res. Inst., Izmir (AARI)	-Micropropagation -Obtaining virus-free plants -Germplasm conservation -Breeding (somaclonal variation)
2. Ataturk Horticultural Res. Inst., Yalova (AHRI)	-Micropropagation -Obtaining virus-free plants
3. Olive Res. Inst., IZMIR (ORI)	-Micropropagation
4. Citrus Res. Inst., Antalya (CRI)	-Obtaining virus-free plants -Micropropagation
5. Grape Res. Inst., Manisa (GRI)	-Obtaining virus-free plants -Micropropagation
6. Plant Protec .Res. Inst., Adana (PPRI)	-Obtaining virus-free plants
B- UNIVERSITIES	
7. Dep. Horti., Fac. Agric., Izmir, Aegean Univ. (EU)	-Micropropagation
8. Dep. Field Crop, Fac. Agric., Izmir, Aegean Univ. (EU)	-Micropropagation -Breeding
9. Dep. Horti., Fac. Agric., Ankara, Ankara Univ.	-Micropropagation -Breeding
10. Dep. Horti., Fac. Agric., Adana, Çukurova Univ.(CU)	-Micropropagation -Breeding
11. Dep. Plant Prot., Fac. Agric., Adana, Çukurova Univ.(CU)	-Obtaining virus-free plants -Breeding
12. Dep. Biol., Fac. Sci-Lit., Diyarbakìr,Dicle Univ.(DU)	-Micropropagation
C- COMPANIES	
13. Bereket Seed Comp., (B.S.C.) Adana, Commercial Firm	-Micropropagation -Obtaining virus-free plants
14. Gardenia Ornamen. Plants Comp., Yalova, Commercial Firm	-Micropropagation
15. Pìnar Dairy Comp., Izmir, Commercial Firm	-Embryo culture transfer

LABORATORIES FOR INSECT CONTROL

Methods related to biotechnology include;

- Trapping systems (attractants)
- Repellents/deterrants
- Factors influencing development especially the Sterile Insect Technique (SIT) and related problems.

Eight plant protection research institutes have been organized to control *Ceratitis capitata* Wild., *Rhagolatis cerasi* L., *Dacus oleae* Gmel., *Prays oleae* Bern., *Cydia pomonella* L., *Synantheden myopaeformis* Borkh., by using the techniques mentioned above.

Biotechnological activities

During the last 15 years, we have achieved several successful results in both scientific research and practical applications.

Biotechnological techniques mainly in vitro techniques have been utilized in the following areas of agriculture:

- Plant propagation,
- Plant improvement,
- Plant germplasm conservation,
- Obtaining disease-free plants.

As mentioned before, the names and objectives of plant tissue culture laboratories in Turkey were given in Table 1.

Institutions according to their plant subjects and objectives are summarized in Table 3.

In Vitro Techniques in Plant Propagation

In vitro propagation is a convenient term for the process of multiplying plants vegetatively by means of tissue culture.

The majority of economically important and horticulturally desirable plants are generally propagated vegetatively in order to preserve the characters of individual cultivars. In spite of modern improvements in conventional techniques of propagation, many plants are slow or difficult to multiply. The potential of vegetative propagation has been increased by the application of tissue culture methods. The rates of multiplication are much faster with the application of tissue culture methods than with conventional propagation methods. Also, by using tissue culture techniques, propagation problems are largely removed from plants which were previously considered difficult or impossible to propagate.

There can be a danger of extinction of some plant species in nature. Species of the *Orchidaceae* family in Turkey are one of typical examples, because a lot of *Orchis* species are grown wild in nature throughout Anatolia. Some drugs and chemicals are being extracted from their corms. These corms in nature can raise only one daughter plant in one year. To save the *Orchis* species from extinction, tissue culture techniques have been employed to raise plants.

The frequency of using *in vitro* techniques for purposes of propagation is higher than in other application fields.

Table 2 - Institutional working on embryo transfer and artificial insemination

Faculty of Veterinary	- Istanbul University, Istanbul
Faculty of Veterinary	- Selcuk University, Konya
Faculty of Veterinary	- Ankara University, Ankara
Faculty of Veterinary	- Uludag University, Bursa
Livestock Research Inst.	- Ministry of Agriculture, Konya
Livestock Research Inst.	- Ministry of Agriculture, Lalahan
Artificial Insemination Inst.	- Ministry of Agriculture, Ankara
Artificial Insemination Inst.	- Ministry of Agriculture, Istanbul
Artificial Insemination Inst.	- Ministry of Agriculture, Izmir
Artificial Insemination Inst.	- Ministry of Agriculture, Samsun
Artificial Insemination Inst.	- Ministry of Agriculture, Adana

Research subjects and practical applications on micropropagation concerning various institutions are listed in Table 3. As it can be seen, 25 different plant species (12 fruits, 7 ornamentals and 6 vegetables) have been used in micropropagation studies.

The number of institutions working on micropropagation is nine. Three of them belong to the Ministry of Agriculture, four of them are various faculties and there are two commercial firms as well.

IN VITRO TECHNIQUES IN PLANT IMPROVEMENT

Tissue culture is becoming an important focus for breeding programmes in Turkey. Although, it is not used routinely for breeding programmes yet; tissue culture technology offers the potential of speeding up breeding procedures by making small plants available for testing in laboratory.

As known, tissue culture techniques are used in two ways for plant breeding. The first one is using protoplast culture, cell culture, gene transfer which are used directly for breeding. The second way is to shorten the breeding cycle by using some techniques as embryo culture, ovule culture, anther culture and rapid clonal propagation. So far, the second group applications have been used in Turkey.

Research subjects and practical applications regarding in vitro breeding in the various institutions are listed in Table 4.

As it is seen, anther culture studies have been concentrated on tobacco, potato, sunflower and on some vegetables such as pepper and eggplant.

Table 3 - Plant propagated by micropropagation techniques and applying institutes in Turkey

PLANT NAME	EXPLANT TYPE	INSTITUTIONS
Lilium cvs	Bulb scale	AARI
Freesia cvs	Soft stem piece	AARI
Rose cvs	Shoot-tip	AARI,AHRI
African violet	Leaf	AARI,EUAF
Ferns	Runner tip, spores	AARI,BSC,GOPC
Plum rootstocks	Shoot-tip	AARI
Plum cvs	Shoot-tip	AARI
Grape (*V.vinifera*)	Shoot-tip, meristem	AARI,GRI AUAF,DUSLF
Pomegranate	Shoot-tip	AARI
Quince	Shoot-tip	AARI
Tea (*Camellia sineusis*)	Shoot-tip	CUAF
Pistachio	Shoot-tip	DUSLF
Strawberry	Shoot-tip floret tissue	AARI
Cauliflower	Shoot-tip floret tissue	AARI,AUAF
Cucumber	Shoot-tip, stem piece	AARI,EUAF
Tomato	Meristem	AUAF
Garlic	Meristem	AUAF
Berries	Meristem	AUAF
Almond	Shoot-tip	CUAF
Artichoke	Shoot-tip	CUAF
Walnut	Shoot-tip	AUAF,AHRI
Olive	Shoot-tip	ORI
Potato	Meristem	AARI,BSC,EUAF
Spathyllum	-	BSC
Orchis	Embryo	AARI

For abbreviations, see appendix.

Callus (indirect somatic embryogenesis), shoot (direct somatic embryogenesis) and cell culture techniques are used to increase the somaclonal variations. These techniques are being applied to tomato, potato, lemon and sour orange to select resistant lines to some diseases or to select high quality lines (Table 4).

The frequency of hybrid can be increased greatly, if hybrid embryos are rescued using the embryo culture technique. Embryo resulting from wild crosses and crosses between species or genera often fail to grow, but it can be rescued by growing them by special tissue culture method. Embryo culture technique has been applied to produce viable hybrid plants from the sterile crosses between two tomato species (*Lycopersicon peruvianum x Lycopersicon esculentum*) with the aim of introducing disease resistance genes.

Furthermore, embryo cultures are used to shorten the duration of breeding programmes. For instance, it is possible to save nearly 20-50 days in one generation in tomatoes.

Table 4 - In vitro techniques utilized in breeding programmes, and plant species, and institutions applying these techniques in Turkey

CULTURE TYPE/ PLANT NAME	OBJECTIVE	INSTITUTIONS
Anther culture Pepper	- To improve F1 hyb. resistance to *Phytophtora Capsici*	CUAF
Anther culture Eggplant	- To improve ratio of haploid plants from anther culture	CUAF AUAF
Gynogenesis Watermelon-Muskmelon	- To improve parthenogenetic haploid embryos	CUAF
Anther culture Pepper	- To determine the best method for obtaining haploid plants	AUAF
Embryo culture Tomato	- To determine the convenient stage for embryo culture, to use in breeding programmes - To increase the frequency of hybrids from sterile crosses	AUAF
Anther culture Tobacco	- To improve new lines suitable for the conditions of Aegean Region	EUAF
Anther culture Tobacco	- To improve new lines for Southern East Region of Turkey	DSLF
Anther culture Potato	- To determine the best method for obtaining haploid plants	EUAF
Anther culture Tobacco	- The influence of different Fe and sucrose concentration levels on being (existence) haploid	EUAF
Anther culture Tobacco	- To observe the earliness and chemical characteristic of dihaploid plants	EUAF
Anther culture Sunflower	- To determine the best method to obtain haploid plants	EUAF
Callus culture Tobacco	- To determine the best growth medium to improve doubled haploids	EUAF
Callus-cell culture Sour orange	- To select resistant lines to *Phytophtora citrophtora* from somaclonal variations	CUAF
Callus-cell culture Lemon	- To select resistant lines to *Phoma tracheiphila* from somaclonal variations	CUAF
Callus-cell culture Potato	- To select high quality lines from somaclonal variations	AARI
Protoplast culture Citrus	- To determine the best method	CUAF
Callus-cell culture Tomato	- To select resistance lines to Fusarium oxysporium sp.lycopersici	CUAF

IN VITRO TECHNIQUES IN PLANT GERMPLASM CONSERVATION

Tissue culture has a great potential as a method to conserve germplasm, particularly in case of vegetatively propagated crops.

The conservation of plant genetic resources is important as much as their survey, collection and evaluation. Because it is observed that local and primitive varieties, close relatives and wild types of different plant species are lost in Turkey. Replacing the high quality varieties, different plant pests and diseases, various climatic factors, natural disasters are reasons for this situation. Therefore, a great importance is given in survey, collection, evaluation, conservation of plant genetic resources in the last 25-30 years.

As known, vegetatively propagated plants (clonal plants) can be conserved in the following forms;

-Field collection
-Screenhouse/glasshouse maintenance
-Buds/Scions storage
-Seed storage
-Pollen storage
-*In situ* germplasm preservation
-*In vitro* storage

None of these methods is completely sufficient. For example, field collection and bud/scion storage are convenient for active collection, but risky for base collection.

Tissue culture methods have been used for rapid propagation, elimination of pathogens, genetic manipulations at various Universities and Research Institutes for many years in Turkey. But the research on the storage of tissue-cultured plants is done only at the Aegean Agricultural Research Institute, in Izmir. This institute is also the Centre of the National Plant Genetic Resources Projects. Therefore, a lot of work is done in the field of in vitro storage besides the main purpose.

Under this project, seven different fruit and grape genera are kept in orchards for conservation purposes. Since keeping this material in field can be risky, the in vitro method can be used as an alternative method.

Conserved material may be mainly divided into two groups at *in vitro* genebank,

- *In vitro* base collection: These collections are for long term conservation. Cryopreservation should be used for this aim.

- *In vitro* active collections: These collections are for short and medium-term periods. Minimal growth conditions can be used for this aim.

So far, some research on minimal growth conditions has been carried out with grape accessions. Some grape cultivars and rootstocks can now be stored up to 4 years in dark and +5 C.

IN VITRO TECHNIQUES FOR OBTAINING DISEASE-FREE PLANTS

Tissue culture or thermotherapy or a combination of both are the only practical methods for eradicating viruses from vegetatively propagated species. Meristem tips are the most effective explants for the production of virus-free plants for a wide range of economically important crops.

Psorosis, tristeza, stubborn, exacortis, xyloporosis are the most important viruses in Citrus and they cause important economic losses. To solve this problem the National Program has been carried out since 1986. The aim of this program is to obtain virus-free, true-to-type plants from all citrus cultivars grown in Turkey. Shoot tip grafting is used in this program.

It is aimed to release strawberry cultivars free from aphid-borne and nematod-borne viruses. This program started in 1989 at the Aegean Agricultural Research Institute (AARI), Izmir.

Other programmes for obtaining virus-free plants connected with grape, potato and chrysanthemum cultivars are presented in Table 5.

Table 5 - Plants obtained as disease free plant and relevant institutions

PLANT NAME	INSTITUTIONS
Citrus	CRI,APPRI,CUAF
Strawberry	AARI,CUAF
Grape	GRI
Chrysanthemum	AHRI
Potato	AARI,BSC

FUTURE BIOTECHNOLOGICAL ACTIVITIES

It is aimed to focus the biotechnological activities on the following areas:

- To obtain studies on micropropagation related to the plants having propagation problems (ornamental plants, fruit trees etc.)

- To conduct research on other plant species (vegetables and field crops) for obtaining haploid plants by androgenesis and gynogenesis

- To start recombinant DNA studies on some vegetables and field crops for the resistance to frost, bacteria and for obtaining high aminoacid content etc.

- To make more studies on protoplast culture and somatic hybridizations

- To use biotechnological methods routinely in breeding programmes instead of conventional methods

- To increase the number of programmes aimed at obtaining disease-free plants

- To do more research to increase the application of in vitro techniques for plant germplasm conservation

- To transfer more recent technologies from other advanced countries regularly

- To take part in some joint projects with other countries

- To train scientists, either in Turkey or abroad

- To try to obtain more financial support to establish new laboratories or to increase present capacity.

INVESTMENTS

The following organizations have given support to set up the present laboratories and to perform activities.

- Ministry of Agriculture, Forestry and Rural Affairs
- Various Faculties as Agriculture, Veterinary, Biology
- TUBITAK (Turkish Scientific and Research Council)
- YOK (High Education Council)
- NATO Science for Stability
- CENTO Technical aid
- FAO
- Giessen University, Federal Republic of Germany
- Commercial Firms.

The total number of research workers is not more than about 120, which is insufficient for Turkey. Some of them have been trained abroad.

Usually, biotechnological applications are faced with some difficulties and technical problems. To overcome these, we need some more support and collaboration from developed countries. Further joint projects can be useful.

Appendix

The abbreviations used in Tables

AARI	=	Aegean Agricultural Research Inst. IZMIR
AHRI	=	Ataturk Horticultural Research Inst. YALOVA
GRI	=	Grape Research Institute - MANISA
ORI	=	Olive Research Institute - Bornova/IZMIR
CRI	=	Citrus Research Institute - ANTALYA
APPRI	=	Plant Protection Research Institute - ADANA
EUAF	=	Aegean University Agricultural Faculty - IZMIR
AUAF	=	Ankara University Agricultural Faculty - ANKARA
DUSLF	=	Dicle University Science-Literature Faculty - DIYARBAKIR
CUAF	=	Çukurova University Agricultural Faculty - ADANA
BSC	=	Bereket Seed Company - ADANA
GOPC	=	Gardenia Ornamental Plant Company - YALOVA