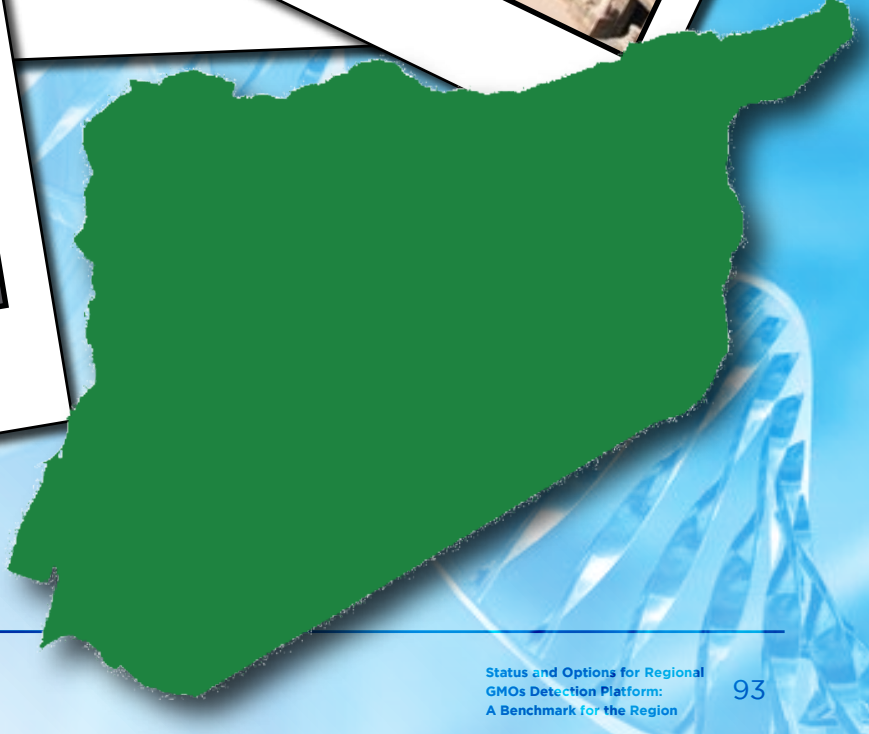
Syria

Dr. Ahmad Abdul Kader

General Commission for Scientific Agricultural Research (GCSAR)



3.4. Syria

Current Status of Biotechnology applications in Syria

Introduction

Syria has a total area of 185,180 km2 distributed as follows: Forests (461 thousand ha), cultivated land (13759 thousand ha), with average of 0.79 ha per person. Cultivated land presents 33.4% of cultivated area as follows: Permanent crops 6%, pastures 60.6%. The total irrigated area in Syria is about one million hectares (24.6%). About 30% of Syria's total land area is cultivated, but only 10% of it is irrigated. The total population of 18 million, with an average growth rate of over 3.29%. The population in the Syrian Arab republic is expected to reach 32.5 million by the year 2025.

On the other hand, since biotechnology is considered as a tool with enormous potential for overcoming some of the constraints to increase agricultural production, therefore, governments need to develop strategies, polices and legal frames for integrating modem biotechnology into agricultural research. In pursuit of these aims, Syria, like other countries, has already started to alter public and private research and teaching institutions to these ends and is looking for developing vigorous research programs. The Governments of Syria has recognized that it has to reap the benefits of modern biotechnology under close monitoring. Indeed, the integration of biotechnological methods into production systems and scientific research plans is considered of high priority in Syria to keep pace with worldwide advancement in modem biotechnology procedures for the final end of ensuring sustainable food security and surplus production for exportation. Furthermore, a key area in facilitating application of plant biotechnology program is an effective transfer of technology system which require a good training and qualification system and a good agricultural system where implementation and application of the technology is possible and desirable. However, since the facilities in National Research Institutes are insufficient for competitive up-to-date research and there is a dramatic shortage or properly trained scientists and technicians in this modern field, it is therefore of high priority to cooperate with international organizations for capacity building in all aspects of biotechnology and biosafety and also for developing vigorous research programs.

Syria gives major importance to building capacity in biotechnology to keep pace with the recent developments in this field, considering it a priority to improve agricultural production to be self-sufficient with surplus for export. Syria has formulated Biosafety guidelines since 2001. Nevertheless, as a developing country, Syria lacks the technical and financial capacity for comprehensive implementation of the priority

action plan for capacity building in Biotechnology. Domestic funds are limited. The international cooperation in biotechnology is also limited. Syria always attaches importance to this area for which a series of policies, regulations and strategies have been established. A number of management approaches and technical measures have been taken to develop biotechnology programs at the national institutes. Nevertheless, due to the difficulty of purchasing important equipments and chemicals and the limited available financial resources, the input from the government cannot meet the actual demand. The input needs to be increased and more resources need to be obtained from home and abroad. Syria has already started to incorporate biotechnology increasingly in their agricultural research programs. Therefore, in the recent years, there has been a steady development of agricultural biotechnology capacity in Syria where human and financial resources allocated to biotechnology R&D are increased. The government is gradually building a strong scientific base in agricultural research and biotechnology. The national research institutes are encouraged to be actively involved in bilateral and international collaborative research programs in diverse fields of agricultural biotechnology. Although the conventional agricultural research capacity is moderately strong, the trend now is to develop a strong biotechnology capacity in several areas. The public agricultural research programs have had substantial success in promoting rapid agricultural growth.

On the other hand, in Syria, the marketing and management of biotechnology products are virtually absent, as is the critical mass required raising public awareness and so far, there is no regulation to control introduction and handling of biotechnology products. However, such regulations and ministerial decision are underway and will be enacted very soon.

The Ministry of Agriculture and Agrarian Reform (MAAR) has the mandate for biotechnology research development and all aspects related to introducing, handling, import and export of GMOs, while the Ministry of Environmental Affairs together with the Ministry of Agriculture are responsible for monitoring the impacts on the environment in coordination with the Syrian National Biosafety Committee (SNBC).

On the other hand, Syria is considered as a center of origin biodiversity for many crops, feeds and fruit trees (wheat, barley, lentil, chickpea, olive, almond, pear, plum, pistachio, etc). It is one of the few nuclear centers where numerous species of temperate-zone agriculture originated thousands of years ago, and where their wild relatives and landraces of enormous genetic diversity are still present.

Syria has ratified the convention on Biodiversity (CBD) and has established a supreme council for biodiversity and genetic resources in the Syrian Arab Republic, which has the main responsibility to plan and program for the conservation, management and sustainable use of biodiversity and genetic resources of plants and animals. Syria also joined Cartagena protocol on Biosafety on April 1st 2004 and entered into force on June 30 th 2004. The Ministry of Environment is in charge of implementing the protocol. It is therefore imperative to have the necessary legislative, administrative and policy instruments in place to minimize risks to the environment and human health that might emerge from applications of modern biotechnology. Syria has also established its NBC and formulated biosafety guidelines since 2001. Additionally, a draft of biosafety law is under discussion.

Syria has already made actions needed to create, enhance and improve the competence and problem-solving capacities of the research and academic institutions in the country to carry out its allotted functions and achieve its objectives by applying modern biotechnology techniques for the final aim of sustainable agricultural production and modernizing Syrian agriculture. A great attention is given to strengthening and development of both human resources and the institutional and infrastructural capacities in biotechnology to be able to cope with new developments and applications of biotechnology as they arise, with emphasize to achieve safety in biotechnology, through establishing its own biosafety guidelines and regulations as well as effective control of introduction and handling of GMOs/LMOs in the country.

1. Plant biotechnology

Most biotechnological work in Syria is in the areas that have direct economical return such as in the field of agriculture. Several universities have recently established programs in biotechnology or genetic engineering for graduates and undergraduates. Although scientific research in modern plant biotechnology in Syria began more recently, researchers are now applying the advanced biotechnology tools to the field of plant science. Scientists in biotechnology laboratories are working on the improving plant propagation and multiplication of major horticultural crops and fruit trees using tissue culture techniques as a tool to facilitate conventional methods of plant breeding.

A high priority is to obtain virus-free plants utilizing tissue culture techniques. The technique is currently applied to potato, banana, citrus, apple, cherry and many other species at the Ministry of Agriculture (GCSAR and GOSM). A large-scale propagation of potato is currently being carried out in Aleppo (GOSM). The utilization of protein markers using A-PAGE and SDS-PAGE electrophoresis techniques in establishing fingerprints of major cereal and other crops for identification purposes is also practiced. The use of RAPD , AFLP, SSR techniques in genetic diversity studies and as a tool in marker-assisted selection in mutants resulting from breeding programs for some important crops is also being done. The development of in vitro technique for microtuberization is also developed. Furthermore, the development of doubled haploid in barley is also being studied at AECS. Experiments on genetic transformation has also been started at some institutes in Syria, mainly GCSAR and AECS.

Traditional biotechnology is being used in Syria such as in food production. Plant tissue culture attracts much attention from the public sector where many laboratories have been established some 10 years ago. Animal and human cell culture is mainly centered on medical and veterinary applications. In vitro fertilization and embryo culture is starting in some fertility clinics. In addition, there is high interested research and limited production of immunological diagnostic kits and animal vaccines. Other commercial productions of biotechnology in Syria include some agricultural input particularly for plant protection where the state has initiated production of alternatives to chemical pesticides by commercializing bio-pesticides for control of plant diseases and pests using natural enemies. So far, there are no GMOs produced, neither commercialized in Syria. Syria has not yet established specific laws that regulate biotechnology and Biosafety. However, active steps in this direction are underway. There is an increasing public interest in Syria about the rapid biotechnological advances and their socioeconomic implications and possible impact to the environment. But there is some confusion including in the media, about the nature of the new advances and how they were produced.

Syria is therefore striving to building up capacities in all disciplines of biotechnology so that to keep pace with the developments of biotechnology applications in agriculture. Laboratory facilities and equipments for upstream of biotechnological research already exist at a number of institutions in Syria, including GCSAR AECS, GCBT and at the Universities in Syria. However, Biotechnological R&D institutions in the country should be strengthened by equipping them with state-of-the-art infrastructure, centralized facilities, highly-trained human resources, and information and communication facilities and by fostering public-private partnerships.

Cooperative programs in biotechnology present in Syria are either bilateral national or multilateral international. Most of these programs are still ongoing, while some others have already been completed. Some other cooperative proposals are also under consideration and discussion. Other programs, however, are approved or signed but still not started yet.

1.1. Modern biotechnology applications in Syria include:

- **Molecular biology techniques** for different purposes such as Genome mapping, identification and characterization (fingerprinting) of species and genetic resources, genetic diversity and germplasm evaluation, as well as for breeding purposes.
- **Genetic transformation** of plants for producing crops tolerant to biotic and abiotic stresses, but it still in its early stages of development as can be seen in the next paragraph reveling the activities of the institution involved in biotechnology in Syria.
- **Tissue cultures** (Organs cultures, embryo culture, haploid cultures....) is used widely in many institutes for different purposes including: -

  – Multiplication of difficult- to- propagate species by traditional methods.
  – Producing virus- free plants.
  – Multiplication of introduced plants.
  – Germplasm conservation.
  – Obtain mutations carrying desired characters.
  – Obtain secondary products with biological effect in the laboratory.

1.2. Animal and veterinary biotechnology

Faculty of Veterinary Medicine at Albaath University is interested in biotechnology application in animals such as embryo transfer and fingerprinting of animals. It has established Molecular Biology laboratory with some work is being applied at limited scale for teaching purposes.

At the Ministry of Agriculture, Directorate of Animal health a diagnosis of animal diseases such as avian influenza virus (bird flu) is conducted using biotechnological methods.

Production of animal vaccines is also done and distributed to the animal breeders for free. Also, fingerprinting of Alawas local sheeps is being done in cooperation between Aleppo University and GCSAR.

1.3. Microbial/ Industrial biotechnology

In Syria, Microbial and industrial or traditional biotechnology is used for different applications including:

- Brewing industry: such as wine and Arak industry using some yeasts as Saccharomyces.
- Beer industry: the main rule of biotechnology is the selection of suitable yeast races «Saccharomyces cervisiae».
- Yeast production: depends on offering suitable conditions growth and propagation of Saccharomyces species on Malus resulting from sugar industry and selecting preferred races of yeasts after subsequent treatments starts with primary planting of yeast on sterilized media with suitable conditions of pH and temperature.

1.4. Other approaches Biotechnology and genetic improvement.

Genetic improvement has been with used for centuries. People used plants, animals and microorganisms in many ways to support agriculture, industry and other activities. Scientists tried to invest all ways to contribute in the increasing of yield and improve the nutrition situation of people by using all techniques from selection-breeding to genetic engineering and its application in agriculture and medical researches. Some techniques used for genetic improvement are reviewed hereunder.

Selection and breeding:

Historically, this technique has relied upon the natural processes of sexual reproduction and selection of features that are part of the variability inherent in nature. it depends on cross-breeding in the same species or between species or genera.

The success of breeding depends on the good selection of parents and the mechanism of crossing. This method is widely distributed in Syria in plants and animals, i.e. field crops (wheat, barley, lentil and chickpea), cotton, vegetables (cucumber, tomato, potato, onion, melon and water melon). Most of the authorities are interested in cross breeding and selection such as the General commission for Scientific Agricultural Research (GCSAR), Atomic Energy Committee (AECS), ACSAD, IPGRI and ICARDA. Also, Syria introduced different species of vegetables (tomato, potato, cucumber, cabbage…) and fruits (Pear, Apple, Almond and Apricot). In animal field, there are many successful experiments on livestock such as cows and goats…….

Mutations:

It is the frequent change in the genetic material which causes an alteration of the sequence of protein. Mutation is inherited from generation to generation and considers as the main resource of all genetic variations. We have two types of mutations:

Spontaneous mutations:

They occur as the result of normal cellular operations or random interactions with the environment. Such mutations are rare event and depend on the physiology biochemistry of cells. Since the discovery of mutation scientists have studied the mechanism of controlling mutations and the ability too induce new genetic characters using certain compounds.

Induced mutations:

They occur as a result of using certain compounds called mutagens. Two types of mutagens are used; Radiation and chemical compounds. Plant breeders invested mutations in different experiments, but in animals the using of mutation is quite rare. In Syria, mutations are used in different treatments to produce new varieties or landraces of fruit trees and crops using induced mutations. i.e. GCSAR produced new landraces of soybean using radiation mutagens, also AECS produced potatoes resistant for abiotic and biotic stresses and sterile mails of some pests such as Cydia pomonella. Many varieties produced by spontaneous mutations are widely distributed in Syria such as apple varieties (Stark rimson and Top red) and Orange (Abo sorra).

2. Physical facilities dealing with Biotechnology in Syria:

Institutions involved in biotechnology in Syria

The key institutes involved in biotechnology in Syria include the following:

- Ministry of Agriculture and Agrarian Reform (MAAR) represented by:
  - General Commission for Scientific Agricultural Research (GCSAR)
  - General Organization for Seed Multiplication (GOSM)

- Atomic Energy Commission of Syria (AECS)
- Ministry of High Education:

  - Faculties of Agriculture at: Damascus-, Aleppo-, Tishreen-, ALU-Bath- Univ.,).
  - Faculties of Science at: Damascus-, Aleppo-, Tishreen-, ALU-Bath- Univ.).
  - Faculty of technical engineering , Aleppo University.
  - Faculty of Veterinary Medicine (ALU-Bath Univ.)
  - Faculty of Petroleum and chemical engineering (ALU-Bath- Univ.).
  - Faculty of Pharmacy ((Damascus Univ, Aleppo Univ.,)
  - Faculty of Medicine (Damascus Univ, Aleppo Univ.,)
  - General Commission of Biotechnology (GCBT)

- Scientific Studies and Research Center (SSRC)
- Ministry of Health
- Arab Center for Studies of Arid and Dry Areas (ACSAD)
- International Center for Agricultural Research in the Dry Areas (ICARDA).

- Private Sector :
  - Green House Company.
- Scientific Council for Pharmaceutical Industry (SCPI).

The details on the current status of national capacities and infrastructure in biotechnology and biosafety in these institutes are shown as follows:

2.1. Ministry of Agriculture and Agrarian Reform (MAAR)

General Commission for Scientific Agricultural Research (GCSAR)

The General Commission for Scientific Agricultural Research (GCSAR) is an independent commission that belongs to the Ministry of Agriculture and Agrarian Reform (MAAR). Funding is from the government. Its main tasks are to conduct scientific research in the following areas: field crops, horticulture (vegetables, under-cover cultivation, ornamentals, fruit trees), cotton research, pesticides, plant protection, live stock production, natural resources, food industry, socio-economic studies and biotechnology.

GCSAR supports both basic and applied research in the agricultural sciences including **agricultural biotechnology**. GCSAR is considered the main research center that is involved in utilizing biotechnology and in the introduction of new trends in biotechnology in Syria. One of the main goals of GCSAR is to contribute to the promotion of biotechnology R & D in the areas of agricultural biotechnology. As part of this objective, GCSAR is striving to improve and develop knowledge and expertise in biotechnology and genetic engineering; and, to achieve this purpose, GCSAR established in early 2003 Biotechnology Department as independent department belonging directly to the director general.

MAAR in cooperation with the SNBC and Ministry of Trade and Economic (directorate of Food Supply) is responsible in assessing the safety of agricultural products derived from biotechnology, including plants, animal feeds, biofertilizers, and animal vaccines. It is the responsibility of MAAR to keep pace with the technology as it develops and evolves.

- **Infrastructure of Biotechnology Department (PBIO) at GCSAR**
  Biotechnology department was established at GCSAR in 2003. It has 6 laboratories as follows:
  - **3 Tissue culture laboratories as follows :**
    - the central one is at GCSAR headquarter in Douma which was established in 1993,
    - one at Aleppo Research Center established in 2006, and
    - the third lab is at Latakia Research Center established in 2008.

- ◊ **2 Molecular Biology labs. as follows:**
  - one at GCSAR headquarter in Douma established in 2003 and the other
  - Aleppo Research Center established in 2005.
- **1 Genetic Engineering laboratory** at GCSAR headquarter in Douma established in 2005.
- **Divisions** of the Biotechnology Department:
  1. Plant Tissue Culture and Micropropagation Division (3 laboratories)
  2. Genetic Engineering Division. (1 lab.)
  3. Molecular Biology Division. (2 labs.)
  4. Biosafety Division.

Plant Tissue Culture and Micropropagation Division:

The Plant Tissue Culture Laboratory (PTCL) was established in 1993, and belongs now to the Biotechnology Department.

Tasks:

- Developing methods of In vitro micropropagation for the most economically important crops.
- Production of doubled haploid plants for breeding purposes.
- Establishment of a gene bank for the micropropagated plants.
- Genetic Engineering Division.

Tasks:

- Genetic transformation of plants for biotic and abiotic stresses via gene transfer methods for the most economically important crops.
- Crop improvement using biotechnological techniques.
- Genetic analysis for GMOs

Molecular Biology Division:

Tasks:

- Characterization of crops via biochemical and molecular marker techniques such as: Microsatellite, AFLP, RAPD, markers, etc.
- Marker-assisted selection.
- Genetic diversity studies.

Biosafety Division:

Tasks:

- Establishment of institution biosafety committee
- Follow-up and enforcement of Syrian biosafety guidelines
- Implementing Ministerial Decisions on regulating importation, handling and release of GMOs into the environment.
- Follow-up the latest developments of global biosafety issues related to GMOs.

GMO detection

Equipments available: Facilities for Molecular Biology, genetic engineering Tissueculture,suchas:PCR,Ultradeepfreezers,Spectrophotometers,Microfuges, Gel Electrophoresis (for DNA and Protein analysis), Gel Documentation Systems, Incubators, Ovens, Laminar Flow cabinets,Autoclaves, Microscopes, electroporator, Hybridization oven, Tissue culture rooms.

- **Access to consumables, reagents and supplies:** is not easy, but can be managed ant it takes long time.
- **Access to information:** is available through the internet central hall for all employees and also the departments for the researchers.
- **Web site address:** www. gcsar.gov.sy
- There is also a central library with thousands of books and journals.

Funding Resources: The Funding of the agricultural Research including biotechnology is from the government Also, some funding from international programs come from EU and many other bodies (such as AvH, DAAD, United Nations Educational, Scientific and Cultural Organization).

Human Resources: The following table shows the specialization of human resources at the Ministry of Agriculture.

Table 1. No. of human resources involved in Biotechnology at the MAAR.

	Ph. D	M. Sc.	B. Sc.	Technicians/others
Plant Tissue Culture	7	5	10	10
Genetic Engineering/ Transformation	7	1	-	-
Molecular Biology	5	3	-	2
Microorganisms /Microbiology	3	-	-	-
Phytopathology/ Biotechnology	3	2	5	5
Animal Physiology	2	-	10	5
Food Science	2	3	10	5
GMO detection	-	1	-	-

2.2. At Aleppo Research center also, there is 2 laboratories, these are:

- Molecular biology laboratory
- Tissue Culture laboratory

These two labs. were established in 2005 and are affiliated to the biotechnology department in GCSAR headquarter in Douma.
The facilities of Tissue culture and Molecular Biology are available.
The human resources are included in the calculations shown in the a.m. table.
All other information regarding access to chemicals, internet, etc. are similar to that of the Biotechnology department.

2.3. Building in Biotechnology at GCSAR

At the scientific capacity level, new scientists have already joined the staff of biotechnology at GCSAR, while others are going to complete their qualification (Ph.D.) in specific fields of biotechnology and start their activities afterwards. New training opportunities are being offered to existing employees. Over a three- four years period, there will be new staff to deal exclusively with biotechnology, including scientists and other experts.

2.4. GMO detection:

Since Syria is considered as a center of biodiversity for many crops, feeds and fruit trees, therefore, there is increased interest and public awareness to protect and preserve biodiversity from uncontrolled or illegal introduction of GMO material into the center of origin of such crops. GMO detection using PCR techniques and other methods of GMO detection is currently being conducted. A few personnel at GCSAR are trained in some techniques of GMO detection.

M. Sc. student from the department of biotechnology is conducting her thesis on GMO detection from samples collected from the local market. It is expected to defense her thesis in the second half of this year 2009.

An IBC has already been established at GCSAR to review in-house biotechnology research prior to submission to the NBC. Biosafety Officer has also been designated at the institute.

For capacity building purposes, GCSAR participates in workshops or conferences related to biosafety and biotechnology.

Biotechnology techniques:

GCSAR has a small pool of highly educated scientists competent in different fields of modern biotechnology techniques including molecular biology, genetic transformation, plant tissue culture, as well as in Biosafety.

Capacity building in biotechnology is considered by authorities of high priority. Training programs in biotechnology in Syria are at the forefront of international scientific joint research projects in fields covering agricultural biotechnology and biosafety. The main activities are capacity building including training of scientists and strengthening of national institutions to increase their efficiency. Some organizations are offering opportunities for M.Sc and Ph.D as well as Post¬doctoral scholarships in different fields including biotechnology, these include:

- **DAAD**, M.Sc and Ph.D scholarships in different fields including biotechnology, e.g. at Hannover University (Germany): A few Syrian students (from GCSAR) have been awarded such scholarships in biotechnology.
- **AvH** (Germany, Post-doc fellowships): One fellowship has been awarded to Syrian personnel at GCSAR in biotechnology with further support with some biotechnology equipments as donation to GCSAR for developing the infrastructure and research capacity.
- **IDB** (Saudi Arabia, Ph.D and Post-doctoral scholarships): Many Syrian students have been awarded such scholarship in biotechnology.
- **EU** (Tempus program): MSc program on biotechnology run at Damascus University funded by the EU, started in Sept. 2005. A few students from GCSAR are enrolled in this MSc program.
- **TWAS**: has granted GCSAR for equipment and chemical donation.
- **EU:** Within the framework of some EU funded projects, capacity building through training and exchange visit is taking place.

Existing Biotechnology Linkages to the the national, and international entities:

Cooperative programs present in Syria are either bilateral national or multilateral international. Most of these programs are still ongoing, while some others have already been completed. Some other cooperative proposals are also under consideration and discussion. Other programs, however, are approved or signed but still not started yet.

The Funding of the international programs come from EU and many other bodies (such as AvH, DAAD, United Nations Educational, Scientific and Cultural Organization (UNESCO), JICA or IDB.

The Personnel involved in these programs are B.Sc, M.Sc and Ph.D holders. Some programs support infrastructure development through purchasing of laboratory equipments and include training and exchange visits for capacity building purposes.

3. General Organization for Seed Multiplication (GOSM)

Directorate of Tissue Culture at GOSM, (Aleppo), MAAR

GOSM at Aleppo has established plant tissue culture laboratory with greenhouses in 1988 to produce mainly virus free potato by meristem culture on a large-scale to cover the market needs of potato seeds/ microtubers. Also, in the last few years, a state-of-the-art tissue culture and molecular facility supported by the Japanese Government, JICA. GOSM is producing elite potato tubers for farmers for more than ten years ago.

Tissue culture activities are being achieved, in collaboration between the General Organization for Seed Multiplication (GOSM) of MAAR and Aleppo University, with a great success. "Banana plantlets and potato elite tubers", free from virus diseases have been produced on large scale for farmers which are of high economic value. Furthermore, tissue culture of the "date palm" has also reached a satisfactory achievement. Other plants is also being micropropagated at GOSM.

4. Atomic Energy Commission of Syria

Department of Molecular Biology and Biotechnology (MBB): Established 1999

Infrastructure: 15 well- equiped Labs. (area of 3000 m2) with Molecular Biology, genetic engineering Tissue culture, facilities such as: DNA Synthesizer, Sequencer, Gene gu, DHPLC for mutation detection, PCR, Ultra deep freezers, Spectrophotometers, Microfuges, Pulse Field Gel Electrophoresis, Gel Documentation Systems, GC, HPLC, TLC, Vertical Horizontal, Homogenizers, Radio Chemical Counting System, Incubators, Ovens, Flow Cytometry, Laminar Flow, Autoclaves, Microscopes, Cytogenetics

Workstation:

- **Access to consumables, reagents and supplies:** is not easy, but can be managed ant it takes long time.
- **Access to information:** is available through the internet for all employees There is also a central Library: with 659 Books in biology, 1562 Books in Agriculture, 1822 books in Medicine as well as more than 200 Journal titles (70 in biology, 132 in agriculture and 51 in medicine) and over than 125 thesis and thousands of articles and reports. Internet and intranet access available to researchers and employees. Website: www.aec.org.sy

The Department of Molecular Biology and Biotechnology at the Atomic Energy Commission of Syria consists of seven divisions specialized in various agricultural and medical disciplines. Work on plant tissue culture started in 1990 where many research projects have been done on crop plants including potato, tomato, garlic, carrot and some medicinal plants. Protoplast culture has been used for genetic transformation by DNA uptake. Molecular biology work started in 1999 to benefit from molecular marker technologies in plant biodiversity studies and to characterize fungal pathogens. Studies have been done to characterize pistachio, almond, olives, wheat, and other plants.

Plant transformation is still at the beginning where some crops such as potato, tomato, and cotton are being transformed with marker genes using gene gun and Agrobacterium. In the animal research field, research is being done to study karyotype of farm animals such as Ox or laboratory experimental animals (rats and mice). Molecular tools are being used for the characterization of pathogens and for the production of mono antibodies for diagnostic purposes. Molecular work is also underway to identify and locate the gene responsible for male sterility in insects using FISH techniques.

All Laboratories are classified according to biosafety guidelines established by the Syrian National Biosafety Committee. There are three levels of biosafety in the department:

- Biosafety level I: Work that doesn>t involve pathogens to lab workers such as plant tissue culture and transformation.
- Biosafety level II: Work involving human genetic studies analysis which requires blood samples taken from humans.
- Biosafety level III: Work on Brucella bacteria.

The department of Molecular Biology and Biotechnology conducts several cooperative projects with national and international institutes such as the universities, ministry of agriculture, ICARDA, IAEA, and ICGEB. The department consists of 7 divisions:

1. Plant Biotechnology Division
2. Microbiology and Immunology
3. Plant Pathology
4. Toxicology and Biochemistry.
5. Entomology
6. Mammalian Cell Biology
7. Genetics Human

Objectives of the department:

1. Promotion of Biotechnology and related sciences and technologies in Syria through coordinated research programs CRP.
2. Establishment of new ties and collaboration with other countries.
3. Holding joint theoretical and practical workshops and training courses.
4. Initiation of bilateral and multilateral research projects.
5. Understanding the molecular basis of abiotic stresses relevant to Syrian conditions such as drought and salinity and factors affecting flowering in plants.
6. Using transformation techniques to improve resistance to insects and tolerance to abiotic stresses in some major crops.
7. Studying the effects of various physical and chemical agents on the living system and on the cellular and sub cellular levels, and the modifications of these effects.
8. Detection and classification of cancer diseases widespread in Syria using immunophenotyping, cytogenetic and molecular techniques.
9. Detection and classification of genetic diseases widespread in Syria
10. Detection and classification of pathogen agents widespread in Syria

The Syrian National Biosafety Committee was established in 1999 by the AECS. The AECS is involved in all biosafety issues in Syria and in risk analysis and training on various aspects of biosafety.

- **Funding Resources: Government budget**
- **Human resources:**
- **Number of PhD researchers: 27**
- **Number of Research Assistants: 50**
- **Capacity building:**
  More than 20 training course (international, arab or national)with a total of trainees of about 200.

– **Existing Biotechnology Linkages to the the national, and international entities:** There are many agreements with all national bodies for cooperation programs. There is also agreement at the regional and international level for scientific cooperation.

– **Outputs:**
  More than 140 research papers (peer-reviewed)

5. Ministry of High Education:

Prior to 1994, the Syrian universities were primarily engaged in teaching; research was a secondary activity for which negligible operational funds were available. Budget allocation has become available for research starting from 1994. Currently, teaching and research are receiving equal importance at least in terms of staff time allocation. The Faculties of Agriculture (Aleppo Univ (FAAU), Damascus, Tishreen, and AlBaath Uinv.) undertake postgraduate research, sometimes in conjunction with the Ministry of Agriculture and Agrarian Reform (MAAR) and other International and Regional Research Centres.

There are some educational programs on biotechnology at the universities. Varius courses in the academic curricula are given. In 2004, 2 year Master program on Biotechnology has been launched at Damascus University, Faculty of Agriculture in close collaboration with NCBT and other bodies in the country with support of TEMPUS program of EU. Research studies (thesis) during the last semester are performed in a European country (France, Belgium or Germany). The program>s main aim is to prepare students for higher degrees and/or to build a professional carrier in plant sciences, plant breeding techniques and the use of tools in biotechnology. The curriculum contains courses on molecular biology, genetic engineering techniques, bioinformatics, plant breeding, Cellular and molecular biology, Evolution Biology, Statistics, immunology, biochemistry, proteins and enzymes, Cell and tissue cultures, microbiology

5.1. Tishreen University

5.1.1. Faculty of Agriculture

- **Infrastructure:**
  2 well- established labs. (Microbiology, Molecular Biology and Biotechnology) with all facilities needed for Molecular biology lab and microbiology available . It was established in 2001.
- **Funding:** Governmental
- **Human Resources:**
  8 Ph.D holders as follows: 2 Ph.D in Microbiology, 1 Ph.D Molecular Genetics, 4 Tissue culture, 1 Embryo transfer (Animals), 3 Ph.D students: 1 Plant Biotechnology, 1 animal biotechnology, 1 genetic engineering,
- **Capacity Building:**
  Capacity building is mainly focused on education for BSc and post-graduate studies.
- **Modules include:** Molecular biology, Biotechnology, Microbiology, Genetic engineering, Plant breeding, tissue culture,…

– **Existing Biotechnology Linkages to the national, and international entities:**
A 4-years (2002-2006) project funded by EU on using molecular markers to improve tolerance of barley to drought with cooperation of 4 European countries and 3 arab countries. A 3-year project within the framework of the Challenge program "Generation" Cooperation with ICARDA and National programs in Syria in different fields of biotechnology.

– **Publications:** Many papers were published in peer-reviewed Journals.

5.1.2. Faculty of Science Infrastructure:

Equipments available: Autoclaves, Incubators, analytical balances, microscopes,...

– **Teaching modules related to biotechnology:**
Molecular biology, Microbiology , Biotechnology, Tissue culture,
– **Funding:** Governmental
– **Human resources:** 1 Ph.D tissue culture, 2 Ph.D genetics, 2 Ph.D students in biotechnology (environmental and Marine biotechnology).

5.1.3. Faculty of Pharmacy

– **Infrastructure:** 4 labs. (Microbiology, Biochemistry, Botany and Drugs, Food Analysis).
– **Modules:** Molecular Biology, Biotechnology, Microbiology
– **Funding: Governmental**
– **Human Resources:**
3 Ph.D Microbiology, 1 Ph.D Genetics, 8 Ph.D students: 1 Biotechnology, 2 Molecular biology, 2 Biochemistry, 3 Microbiology, and others in immunology.

5.2. Aleppo University

5.2.1. Faculty of Agriculture

- **Infrastructure:** 3 labs. (Microbiology, Tissue culture, Biotechnology) established in 2004. Equipments: Tissue culture facilities and some of Molecular facilities. Additionally, it should be mentioned that Faculty of Agriculture has already established a centre of biotechnology to serve all approved research projects.
- **Funding:** The government is the main source of policy and funding.
- **Human Resources:** 10 Ph.D holders in Microbiology, Tissue culture, genetic engineering, plant pathology
- **Capacity Building:** Capacity building is mainly focused on education for BSc and post-graduate studies. Modules include: Molecular biology, Biotechnology, Microbiology, Genetic engineering, Plant breeding, tissue culture,…
- **Existing Biotechnology Linkages to the national, and international entities:** There is collaboration with established centers of excellence, through the assistance development agencies (UNDP and World Bank), bilateral donors (Islamic Development Bank, European Commission and Arab Fund for Economic and Social Development) and the International Agricultural Centers.
- **Publications:** many papers are published in national, regional and international Journals.

5.2.2. Faculty of Technical Engineering

- **Infrastructure:** A biotechnology Department at the Faculty of Technical Engineering was established in 2005/2006 for teaching and research purposes. 3 labs. (Microbiology, Tissue culture, Biotechnology) established in 2005. Equipments: Tissue culture facilities and of Molecular Biology facilities.
- **Human Resources:** Limited Ph.D holders in Molecular Biology, Microbiology, Tissue culture, genetic engineering, plant pathology,
- **Capacity Building:** Mainly focused on education, Modules include: Molecular biology, Biotechnology, Microbiology, Genetic engineering, Plant breeding, Tissue culture, .Biosafety, Bioinformatics, ..

Faculty of Science:

- **Infrastructure:** 7 labs. For undergradate students and 5 labs for post-graduate studies (microbiology, Botany, Histology, ...). Equipments: PCR, Fermentor, Spectrophotometer,
- **Funding:** Governmental
- **Human Resources:** Ph.D in Microbiology, 1 Ph.D Molecular Genetics, 4 Tissue culture, Ph.D students: 1 Plant Biotechnology, 1 animal biotechnology, 1 genetic engineering
- **Capacity Building:** Focused mainly on education, Modules include: Biotechnology, microbiology, genetic engineering, Microbial biotechnology, Plant breeding, Biodegradation,…

College of Medicine, Damascus University

- **Infrastructure:** 1 Molecular biology lab. with all facilities needed.
- **Funding:** Governmental

5.3. ALU-Bath University:

5.3.1. Faculty of Agriculture

Biotechnology center has been established at ALU-Bath University with many types of equipment provided including tissue culture and Molecular biology facilities. Faculty of Agriculture has also established plant tissue culture laboratory where tissue culture is practiced for teaching purposes.

Faculty of Chemical and Petroleum Engineering: Dept. of Food Engineering

- **Infrastructure:** 8 labs. (Dairy, microbiology, biochemistry and nutrition, storage, ...) It is involved in education for BSc degree and run MSc program on Biotechnology in Food engineering (modern technology in microbiological industry, Alcoholic brewing and applications, Dairy production,...)
- **Funding:** Governmental funds and International funds through bilateral and multilateral projects and Donation.
- **Human Resources:** 16 Ph.D and 24 technicians, and others.

5.3.2. Faculty of Veterinary Medicine

Faculty of Veterinary Medicine is interested in biotechnology application in animals such as embryo transfer and fingerprinting of animals. It has established Molecular Biology laboratory with some work is being applied at limited scale for teaching purposes.

Faculty of Pharmacy

- **Infrastructure:** 7 labs. in Analytical chemistry, toxicology, biochemistry, Drugs effects, Drugs control, microbiology, Botany,…….

6. General Commission for Biotechnology (GCBT)

A supervisory and coordinating organization established in 2002. The General Commission of Biotechnology within the Ministry of High Education was established by virtue of law 33 dated 04 April 2002 and signed by the Syrian President. The law has promulgated the creation of a national autonomous institute under the name of "the General Commission for Biotechnology". It is officially affiliated to the Ministry of High Education. Its mandate includes:

- **Coordinating** with / within institutions concerned by biotechnological research.
- **Capacity** building and development of human resources in the same domain.
- **Determining** national needs and priorities.
- **Realizing** research projects in applied biotechnology (Agriculture, industry, human and animal health, food products and others).
- **Contributing** to the preservation of biodiversity and its rational exploitation.
- **Facilitation** of graduate research leading to M.Sc. and Ph.D. degrees.
- **Establishing** regulations for research and development, academic and industrial partnerships, intellectual property rights, biosafety and bioethics.
- **Local**, regional and international cooperation in the field of biotechnology. The clause 15 in the law N°33 stipulates that part of the budget could be covered by its own productive activities (expertise, bio-products, diagnostic kits,.. etc.).
- **Infrastructure:** 5 well –equipped labs with almost all necessary facilities for tissue culture, molecular biology with a grant from the Government of India and also some from governmental fund. These labs are: Plant Biotechnology lab., Biomedical and veterinary molecular biology lab., Plant molecular biology and Phytopathology lab., Food and industrial microbiology lab., and Animal and plant biodiversity lab.
- **Funds:** Government, Donations
- **Human Resources:** 6 Ph.D holders, 8 MSc degree holders, 11 BSc and Post-graduate studies in different specializations, 1 veterinarian, 6 MSc students, 1 Ph.D student

Scientific Studies and Research Center (SSRC)

- **Infrastructure:** 2 labs for medical and environmental studies.
- **Fund:** Governmental.
- **Cooperation** with National, Regional, and International Organizations and Foundations: there are various national and international organizations cooperation programme

Ministry of Health

- **Infrastructure:** Molecular biology labs. (2002), with 20 well-trained technicians
  - **Equipments:** Facilities of molecular biology lab. with all necessary consumables and chemicals
  - **Establishment** of IBC in 2004
  - **Establishment of Biosafety** Committee in 2005
  - **Designation** of Biosafety officer
  - National Committee for waste management
- **Fund:** Governmental

7. Arab Center for Studies of Arid and Dry Areas (ACSAD)

The center is working in genetic improvement through traditional techniques (selective-breeding). Molecular Biology laboratory including is under establishment and it is expected to start its activities in the second half of this year 2009. The future plan of molecular biology laboratory is the identification, characterization and evaluation of species in the Arab World without any activities in genetic transformation. Equipments under purchase include all that need for molecular work such as: PCR Thermocycler (gradient), Speed vacuum dryer, Microcentrifuge, Spectrophotometer, Imaging system, Horizontal and vertical gel system with Electrophoresis power supplies, Double distillation system, Deionization water system, Flake Ice Maker, Shaking Water bath, Magnetic stirrer, pH and pH/mV meters, Autoclave, General Incubator….

8. International Center for Agricultural Research in the Dry Areas (ICARDA)

- **Infrastructure/ Physical resources:** 3 well-equipped laboratories, ICARDA has a fully established molecular marker laboratory. Multifluorophore fragment analysis is being carried out on an ABI prism TM 377 DNA sequencer and analyzed with GeneScanTM analysis software version 2.0.2 and Genotyper TM analysis software version 2.0 (PE Applied Biosystems). However, also standard sequencing gels are used for microsatellite as well as AFLP analysis with the silver staining protocol.

  ICARDA has also a fully established tissue culture laboratory. This includes a culture room, walkable growth chambers (mainly for growing donor plants for doubled haploid production), a gene gun for biolistic transformation etc. ICARDA has also received permission by the Syrian National Biosafety Committee to carry out transgenic research in its premises and has a Biosafety infrastructure in place.

- **Funding Resources**: CGIAR, donations, international projects and cooperation.
- **Human Resources:** 8 Ph.D holders , 6 Research assistants, other human resources: 11 Ph.D 16 Ph.D holders , 13 Research assistants,
- **Capacity building on biotechnology:** Strengthening Capacity of NARS through individual and group training and research
- **Project activities:** A training courses are also organized every year such as: 2006: Short term training courses: JICA funded for 15 participants, "Genetic transformation of plants and detection of GMOs", Third Country training Program (TCTP) for Iraq 2007, Short term training courses: JICA funded Molecular markers 15 Individual trainees 2008 Short term training courses: JICA funded for 15 participants, "Genetic transformation of plants and detection of GMOs", 15 Individual trainees
- **Existing Linkages:** Cooperating Institutions include the following:
  - U. of Frankfurt, G Kahl, chickpea genomics
  - U. Hannover, H.J. Jacobsen, legume transformation
  - U. of Kiel, C. Jung, lentil markers
  - U. of Hamburg, H Loerz, cereal transformation
  - DSMZ, Braunschweig, Dr. H Kiesecker, legume transformation
  - IPK-Gatersleben, A. Graner, barley genomics
  - Kopenhagen U., Denmark, A. Jahoor, barley genomics
  - SCRI, Uk, J. Russell, barley genomics and genetic resources
  - Udine U., M. Morgante, allele mining
  - NIAB, Dr. W. Powell, allele mining,
  - CRC-Adelaide, J. Eglington, P. Langridge
  - CLIMA: legume transformation, P. Smith
  - Cornell U., M. Sorrells, cereal genomics
  - Oregon, P. Hayes, barley genomics,
  - U. of Missouri, H Nguyen, cereal and legume genomics
  - Washington S. U., Dr. F. Muehlbauer, population development
  - CIHAM, Maich, gene cloning
  - AGERI, transformation technologies, biosafety, H El Itriby, A. Bahieldin
  - ABRII, transformation
  - INAT, Tunisia, S. Hamze, legume and cereal genomics
  - INRA, Morocco, M Labhilili, cereal and legume genomics
  - U. of Tishreen, W. Choumane, biodiversity

- **Publications:**

  More than 40 research papers in peer-reviewed international Journal

9. Private Sector

Green House Company/ Latakia

- **Infrastructure:** Tissue culture laboratory with needed facilities, three growth rooms, 8 laminar flow cabinet, 2 autoclaves, etc…, as well as glass and plastic houses for acclimatization and growing invitro-derived plants (4000 m2). It was established in mid 1990s.
- **Activities:** In vitro propagation of ornamental plants on large-scale for local market and export, mainly: carnation, gerbers, Anthourium, bulbs, trees, Philedendron, orchid, Fresia, gardenia, and many others .
- **Human Resources:** 3 technical supervisors, around 50 technicians and workers Website:
  www.greenhouse-sy.com

Scientific Council for Pharmaceutical Industries (SCPI)

- **Infrastructure:** well-equiped labs , with all necessary equipments mainly Laminar flow cabinets,…..
- **Human resources:** 112 Ph.D. in Pharmacology, medicine control, chemistry, 3525 B.Sc, Post-graduate and M.Sc holders

10. Facilities engaged in GMO research and development:

10.1. Objectives of biotechnology programs in Syria

Presently, there is no official policy or strategy for biotechnology in Syria. However, there are some national programs in biotechnology and genetic engineering which aim at improving the agricultural and medical sectors. Most of these programs focus on:

1. Detection and classification of cancer diseases widespread in Syria using immuno-phenotyping, cytogenetic and molecular techniques.
2. Diagnosis of hereditary and malignancy disease and prenatal diagnosis for malformation.
3. Detecting the degree of biodiversity in plant genetic resources at the molecular level to support national biodiversity programs.
4. The use of molecular techniques in marker assisted selection in plant breeding programs.
5. Understanding the molecular basis of abiotic stresses such as drought and salinity.
6. Studying plant pathogen and improving plant resistance using in vitro culture and molecular markers techniques.
7. Improving plant tolerance to a biotic stresses, such as drought, salinity, heat, using biotechnological techniques.
8. Conducting biological and genetic studies on the most economical insect pests in Syria. Advanced molecular techniques.
9. Reduction of potential hazards arising from genetic engineering activities and its products to the lowest possible level and the protection of human life and the environment to the highest possible level and at the same time encouraging safe research and development in all biotechnology applications and transboundary movement of GMOs.
10. Establishing biosafety frameworks and legal instruments for research and development and the supervision of biotechnology research and the release into the environment as well as the use of products of modern biotechnology.
11. Setting a mechanism for assessing and managing risks of GMOs and developing mechanisms for mentoring assessing potential environmental effects.
12. Developing human resources and capacity building in various areas of biotechnology including genetic engineering, molecular techniques and marker assisted selection and other related technologies.
13. Increasing public awareness towards biotechnology and its products.

10.2. Priorities for biotechnology programs in Syria:

There are no official priorities for national biotechnology programs; however, researchers in the national institutes emphasize the following priorities:

10.2.1. Capacity building:

a. Developing human resources to high levels in biotechnology and biosafety.
b. Strengthening ties between researchers, farmers, and other stakeholders.
c. Establishing cooperative programs with institutes in developed countries to help in finance and mange biotechnology programs.
d. Setting legal mechanisms for IPR, biosafety, and protection of biodiversity.
e. Capacity building for authorities responsible for monitoring scientific and industrial biotechnological activities in the country.
f. Capacity building for authorities responsible for assessing, communicating, and managing risks related to food and biodiversity.
g. Establishing laboratories for detecting genetically modified plants and food.

10.2.2. Research programs:

Biotechnology institutes are trying to identify specific priorities for conducting research programs that can help solve some persistent problems in the country. In general these programs focus on:

a. The development of genetically modified crops tolerant to biotic and abiotic stresses.
b. Identification, utilization and preservation of genetic resources. Such programs have been going on at the atomic energy commission where studies have been conducted on several crops and trees such as pistachio, almond, olive, wheat, etc. Also, the general commission of agricultural scientific research conducted a project on the sustainable use and preservation of genetic resources funded by UNDP. The project ended in 2004.
c. Conducting biological and genetic studies on economic insects in the country and the on use of biological control.
d. Study the effects of various physical and chemical agents on the living system and on the cellular and sub cellular levels, and the modifications of these effects.
e. Diagnosis of hereditary and malignancy disease and prenatal diagnosis for malformation.
f. Studying plant-pathogen interactions and improving plant resistance using in-vitro culture and molecular markers techniques.

11. Ongoing and Planned GMO research and Development efforts

The existing institutes dealing with biotechnology can be divided as follows:

11.1. Institutes conducting genetic engineering work:

11.1.1. International Center for Agriculture Research in the Dry Areas (ICARDA):

ICARDA is conducting experiments on plant genetic engineering. ICARDA has an Institutional Biosafety Committee that cooperates with SNBC in biosafety matters. There is a genetic transformation laboratory and another for molecular biology work. Both of these laboratories are supervise by ICARDA IBC and the SNBC.

So far, experiments have been conducted on the transformation of chick pea and lentil using Agrobacterium to improve their tolerance to biotic and abiotic stresses. The transgenic plants are being tested in growth rooms suitable for biosafety requirements of these genetically modified plants.

Biotechnology Activities at ICARDA

1. Tissue culture techniques (Doubled haploid breeding)

- Inter-specific crosses with maize tested for doubled haploid production in wheat, and with H. bulbosum tested for doubled haploid production in barley
- Development of mapping populations for Hessian fly and yellow rust resistance by doubled haploid technique in spring bread wheat

2. Molecular marker application

- Genetic resource characterization (1000 accessions of faba bean (20 SSR), Direct sequencing of 10 candidate genes in 300 barley accessions, Characterisation of Fusarium, Characterisation of small ruminants.
- QTL mapping (4 populations in barley, 3 in durum wheat, one map each in lentil and chickpea) AB-QTL population Arta/H.sponatenum (BC2F2), Arta/Keel 2 populations for Russian Wheat Aphid QTL mapping for grain quality, drought-related parameters and diseases (LR) QTL mapping in several lentil and chickpea populations

Marker assisted selection (MAS):

- Ascochyta blight in chickpea (Pathotype I, II), PCR markers for MAS for stem and yellow rust in wheat, Marker assays for yellow pigment, gluten strength in durum wheat.

3. Genetic engineering/Biosafety:

- Leguminous crops, cereals, Transformation technology and genetic engineering tools utilized to incorporate genes into food legumes and cereals, Agrobacterium — mediated transformation.
- The lentil transformation system was licensed from the Center for Legume Improvement in the Mediterranean Areas (CLIMA), Australia, the chickpea system developed together with the Univ.

4. Future Activities/ Shifts in Emphasis:

- Medium and High throughput DNA analysis for genotyping and fingerprinting of plant genetic resources using Multi-fluorophore fragment analysis ABI prism TM 377 DNA Sequencer (ABI3100).
- Haplotype analysis (fingerprinting) using SSR and SNP genetic markers in barley and wheat germplasm selected for adaptation to drought tolerance
- Identify genomic regions containing genes that control stress-modulated gene activity through expression profiling
- Development of a DNA Chip for genome-wide high-throughput expression screening of stress-responsive genes in legumes
- Development of drought response gene expression profiles using a drought microarray in barley, wheat, chickpea and lentils
- Testing ECOTILLING and TILLING to describe natural and induced variation for biotic and abiotic stress resistance
- Increased production of doubled haploids in wheat using the interspecific crosses with maize and in barley with the crosses with H. bulbosum
- Early generation transformants will be advanced and expression of genes will be analyzed
- Constructs for abiotic stress tolerance will be prepared for biolistic transformation in cereal and cereals will be transformed.
- Evaluate transgenic material in cooperation with NARS in the field outside the center of origin of the agricultural crops (e.g. North Africa-Egypt, India, Pakistan)
- Enhance biosafety research with e.g. measuring geneflow of natural genes in ICARDA mandated crops
- Individual and group training courses at headquarters and in country in the area of marker technology, transformation and biosafety
- Support regional activities towards the development of biotech and biosafety research in NARS

11.1.2. The Atomic energy commission of Syria (AECS)

The AECS has a biotechnology department and an Institutional Biosafety Committee. The department includes several laboratories conducting different activities such as human genetics, immunology, microbiology, molecular biology, plant pathology, entomology, and transformation. Laboratories have been classified into three levels of biosafety according to the risks associated with the experiments and the organisms in use. These laboratories were designed to match the required level of biosafety, and they were supplied with suitable biological safety cabinets.

In addition to the various experiments in the department on fingerprinting applications (RAPD, AFLP, ISSR) and protoplast and tissue cultures, some limited experiments are being conducted on genetic modification of potato, tomato, and cotton using Agrobacterium and gene gun. Also, experiments are being done on Brucella under controlled laboratory conditions that match biosafety level III.

The IBC supervises biosafety matters in the laboratories of departments of biotechnology, agriculture, medical radiology, and chemistry. The IBC requires laboratory workers to wear coats with different colors according to safety level (white for BSL1, pink for BSL2, blue for BSL3, and green for workers in the animal raising laboratories).

Current Research activities at the division of plant biotechnology:

- DNA fingerprinting and phylogenetics of plant varieties and species.
- Biodiversity of wild plant species in Syria.
- Detection of adulteration of food products based on DNA analysis.
- In vitro induction and selection of mutants tolerant to salinity and blight diseases.
- Improvement of cotton tolerance to salinity and drought using mutations and genetic transformation techniques.
- Protoplast isolation and fusion in garlic and carrot.
- Isolation of candidate flowering time genes in Gossipium hirsatum and studying spatial and temporal gene expression levels using Real Time PCR.
- Screening for drought tolerance in local varieties of cotton using physiological and molecular approaches.

11.1.3. General Commission for Scientific Agricultural Research (GCSAR):

There is a biotechnology department and an IBC in the GCSAR. The department of biotechnology includes laboratories for genetic engineering, molecular biology and tissue culture. Micropropagation techniques have already been applied to many horticultural crops such as apple, cherry, grape, ….

There is safety cabinet in the genetic engineering laboratory suitable for isolation and propagation of non-pathogenic bacteria such as Agrobacterium and for plant inoculation. There are also, incubators and growth rooms for containing transgenic plants. The department of biotechnology has the technical capabilities to conduct genetic transformation experiments. Transformation of apple using Agrobacterium to obtain plants resistant to Powdery Mildew has already been started recently. The department has taken the necessary safety measures to prevent the escape of genetically modified plants outside the laboratory. The department intends to perform the necessary nests on these plants in the growth rooms only until suitable conditions for greenhouse and field tests are available.

Activities: The department is involved in applying tissue culture techniques since the establishment of PTC lab. in late 1993 for the production of healthy and disease-free plants, and developing techniques of micropropagation of some economically important plants.

Molecular characterization of some crops is also being done for identification of genetic resources and breeding purposes. ..

Additionally, genetic transformation for developing techniques for transformation of some crops for the aim of introducing new varieties that carry traits of resistance to biotic- and a biotic –stresses has already started in the last two years. In parallel, a Biosafety Division is active through the institutional biosafety committee which was established in 2003 to be responsible for the fulfillment of the biosafety guidelines set by SNBC, and also to collaborate with SNBC for the aim of following-up the latest developments of global biosafety issues.

Tissue culture Activities:

- In vitro Micropropagation of some important cherry and apple rootstocks and varities in Syria.
- In vitro microtuberization of some important varieties of potato.
- In vitro Micropropagation for some Horticultural plants (pear, local apple, pomegranate, grape, hawthorn, fig, some ornamentals (Rose, Carnation, Gypsophila paniculata, Kalanchoe, Philodendron, Myrtle,…….).
- Recent GMOs activities include:
- Agrobacterium- mediated transformation of apple (Malus x domestica Borkh.) cv. Golden Delicious and apple rootstock MM111 using g2ps1 gene from Gerbera hybrida (Asteraceae) for improved fungal and insect resistance.
- Agrobacterium- mediated transformation of potato and Tomato for salt tolerance.
- Agrobacterium- mediated transformation of grape for virus resistance.
- GMO detection in some products from the local market.

Some Activities of Molecular Biology Division:

Molecular characterization of some genetic resources such as Rosa damascena, Hawthern, apricot, apple, wheat, barley and others

The department is a partner in a project funded by EU within the framework of the FP6 EU (project INCO-CT-2004-509136) with other five countries: UK, Spain, Italy, Tunis, Morocco. It is TRITIMED project http://www.rothamsted.bbsrc.ac.uk/cpi/tritimed/indexcontent1.html aiming to identify crop traits and genetic ideotypes, in wheat, that impart higher and more stable yield under Mediterranean drought conditions. This shall be realised by using an integrated approach combing genomics, quantitative genetics and crop physiology with a strong integration of socio-economic aspects.

Activities of Aleppo Research center include:

- Tissue culture of some plants such as walnut (Juglans regia), and others
- Producing mushroom spores,....
- Molecular and biochemical characterization for wheat varities
- Molecular characterization for olive varities and other crops

All three above-mentioned institutes are capable of detecting genetically modified plants.

11.2. Institutes conducting medical or agricultural biotechnology and not conducting genetic engineering work:

11.2.1. Ministry of Health:

The Ministry of health has an institutional biosafety committee, however, it is not conducting any research that can be classified as genetic engineering (or Dana) according to the Syrian guidelines. However, there is a molecular biology laboratory in Damascus. This laboratory provides diagnostic services for viral diseases such as Hepatitis B, C and HIV and recently bird flue. There is a laboratory for diagnosing parasites such leishmaniasis. It is also possible to diagnose tuberculosis at the onset.

Ministry of health has 1600 health units that belong to the directorate of environmental and chronic diseases. These units have the capacity for diagnosis and vaccinations against infectious diseases should they happen.

Laboratories of the Ministry of health have not so far dealt with GMOs and they have no capability for detection of GMOs or their products.

Activities of biotechnology at the Ministry of Health include:

- Detection and genotyping of HCV Calibration of the virus vector HCV, HBV and HIV
- Detection of Avian Influenza virus (bird flue) and other diseases. Producing vaccines : HBV Producing drugs, Insulin, growth hormone Diagnosis

11.2.2. College of Medicine, Damascus University:

College of Medicine has a laboratory for genetics and genetic consultation and an institutional biosafety committee, however, there is no genetic engineering laboratory. The laboratory is equipped with Laminar Flow Hoods and incubator that are suitable for biological research at Biosafety level II.

11.2.3. Faculty of Agriculture, Tishreen Univ.

The activity of biotechnology has recently developed in the Faculty of agriculture at Tishreen University. These activities are divided into two sections:

- Section of tissue culture
- Section of molecular markers

The development of biotechnology activities include:

1. Development of infrastructures
   a. Laboratories: established on 2001, they have the necessary equipment obtained through special research projects , gifts and from the budget of the University)
   b. Support staff (trained through training courses or individual training)
2. Research activities:
   a. Research of Post graduate students
   b. National research.
   c. International research.
3. Consultancy and collaboration with the international centers through the post¬graduate students or co-conducting training courses either in Syria or abroad.

Researches realized in the laboratories of the Agriculture Faculty.

Researches in tissue culture:

Evaluation of some wheat varieties for salt stress in vitro and looking for in-vitro and in-vivo markers linked with resistance to salt stress (M Sc study).

Research in molecular markers:

a- Based on protein analysis:

- Study of genetic diversity of Watercress in Syria
- Study of genetic diversity in wild and cultivated olives.
- Study of genetic diversity of barley

b - Based on DNA markers:

- Identification of DNA fingerprinting for new varieties of carnation using the RAPD markers.
- Identification and estimation of genetic relationship between the annual species of Cicer by RAPD markers.
- Identification of DNA fingerprinting of olive varieties grown in Syria with the RAPD markers, and estimation of the genetic diversity (Preliminary study).
- Fingerprinting for some promising chickpea varities
- Molecular characterization of some Citrus rootstocks used in Syria.
- Using biochemical markers for characterization of durum and bread wheat in Syria

11.2.4. Faculty of Agriculture, Aleppo University

Current Biotechnology-Related Research for Sustainable Development at the, and Prospective

Because of critical constraints related to trained manpower on biotechnology research work, equipment and operational facilities, some of biotechnology activities being conducted outside the Faculty laboratories in collaboration with the ICARDA, some research institutes at France, and various laboratories of MAAR.

It is wise to mention that the Faculty has yet no research activities on modern biotechnology, (transgenic or genetically modified organisms), which involves crops that are engineered to increase yield or pest and disease resistance. However, some activities are going on at the Faculty laboratories, such as fermentation process, and tissue culture.

Horticulture Dept is working on tissue culture technology, in particular Potato, Date palm, Olives, Pistachio, Banana, Stone fruits, and vegetables.

Another activity is also conducted at the Faculty on biological control of cotton pests. The Biological Control Research Lab was initiated in 1991 at the Plant Protection Dept in cooperation with the Cotton Research Administration (CRA) of MAAR. It has a particular attention to collect/import the biological enemies of cotton pests, identify, test, rear and release in cotton fields. Each year, hundreds of hectares are treated with reared useful insects in particular Trichogramma principium and Hapropracon privicornis (for cotton bollworms), T. obae (for olive moth) and Harmonia uxiridis (on aphids of various crops). Activities on biological control are also underway in cooperation with ICARDA on sun bug pest of wheat as a regional project, the parasitoid Opius monilicornis on chickpea leaf minor and Bacillus spp.

on the lentil Fusarium wilt pathogen. Similar promising activities on Melia azedarrach extracts and the Neem Azal-T/S as biocides. The biological control of cotton pests, and development of polyclonal antibodies (antisera) as diagnostic tools for bacteria and viral diseases in cereal and legume crops, is great benefiting opportunities to farmers. This for sure improves cotton yield and reduce the cost of production as well as reduction importation and uses of harmful chemicals on farms. The antisera produced can help for a fast laboratory diagnosis of the pathogen and even directly in the field (bacteria). Similarly, the locally produced potato seed and banana plantlets are of great benefits to the country and farmers. Additionally, it should be mentioned that Faculty of Agriculture has already established a centre of biotechnology to serve all approved research projects.

Constraints:

The constraints that impede progress in the biotechnology research work include:

1. Inadequate number of trained scientists: the number of specialized in modern biotechnology-related staff remain very low, particularly the DNA techniques, including the transgenic, and detailed analysis of the genetic materials. However, there are several qualified scientists in tissue culture, fermentation process, and biological control.
2. Absence of adequate equipments and facilities that are needed for biotechnology research work, and difficulties in obtaining/purchasing.
3. Lack of information, literature, appropriate language, or state of the art knowledge on biotechnology.
4. Lack of cooperation with international institutions.
5. Lack of incentives for research staff., The Faculty of Agriculture can only succeed in this challenge through collaboration with established centers of excellence, through the assistance development agencies (UNDP and World Bank), bilateral donors (Islamic Development Bank, European Commission and Arab Fund for Economic and Social Development) and the International Agricultural Centers. Meantime, the government is the main source of policy and funding.

11.2.5. Scientific Studies and Research Center (SSRC)

Activities of Biology Department include:

environmental and medical biotechnology such as Biodegradation for some pollutants and waste-water and many other medical microbiological applications, genotyping of microorganisms, with special attention to the Epidemiology studies and designing Specific DNA Probes, dot blot and southern blot for enterotoxine S. aureus. Production of vaccins against scorpion and snakes toxins.

11.2.6. Scientific Council of Pharmaceutical Industry (SCPI)

Pharmaceutical R&D investment made by the biotechnology and pharmaceutical industry/ biopharmaceutical industry:

- Coverage of local market by 90% of its demands
- Local market value > 350 mill$
- Providing jobs to >13000 highly qualified personnel .
- Technology transfer and the concept of total quality management
- Securing business and jobs to the pharmaceutical sector (more than 25000 families)
- The best example of industrial investment in Syria
- Saving between 600-900 mill$, would have been spent on importing medicines
- Securing the success of national health policy.
- Export value Now exceeding 120 mill$
- Export to 44 countries
- Generics 91.8%
- Securing the success of national health policy.
- Licensed products 8.2%

Application of medical Biotechnology:

For producing specific drugs, Vaccine production, Insulin production, pharmaceutical materials purification, Purification of active substances., Avoiding polluted sources of active substances such as blood products, or enzymes by using fermentation techniques, The use of Bacteria,cells,fungi for bio synthesis, Laboratory Diagnosis, Environmental treatment.

The following table summarizes the current biosafety status at the national and international research institutes in Syria that are conducting or have the capacity to conduct genetic engineering work.

Name of Institute	Available biosafety levels	Genetic Engineering Work/GMO	Incubators & growth rooms	Suitable containment greenhouses	Contained Field experiment
ICARDA	II	Yes	Yes	No	Yes
AECS	III	Yes	Yes	No	No
GCSAR	II	Yes	Yes	No	No
Ministry of Health	II	No	No	No	No
Medical College	II	No	No	No	No
Other institutes	II	No	No	No	No

12. Cooperative Agricultural biotechnology programs in Syria

Cooperative programs present in Syria are either bilateral national or multilateral international. Most of these programs are still ongoing, while some others have already been completed. Some other cooperative proposals are also under consideration and discussion. Other programs, however, are approved or signed but still not started yet. The Funding of the international programs come from EU and many other European (such as AvH, DAAD, JICA or Arab organization (IDB,…).

The Personnel involved in these programs are BSc, MSc and Ph.D holders. Some programs support infrastructure through purchasing of laboratory equipments and include training and visit exchange for capacity building purposes. These programs are of agricultural nature.

12.1. MAAR

Cooperative programs present at the MAAR are either bilateral national or multilateral international. Most of these programs are still ongoing, while some others have already been completed. Some other cooperative proposals are also under consideration and discussion. Other programs, however, are approved or signed but still not started yet.

The collaborative programmes and national / international agreements pertaining to agricultural biotechnology at the MAAR are summarized as below:

- **Trimmed project:** Exploiting the wheat genome to optimize water use in Mediterranean Ecosystems. EU funding: - UK: Rothamsted Research, Univ of Bologna: Italy, Barcelona Univ. Spain,- INRAT: Tunisia, INRA: Morocco, ICARDA, GCSAR & ICARDA: Syria.

- **Project with Italy**: Improvement of olive oil quality and table olive varities (including: Molecular characterization of olive varieties in Syria in cooperation with Italy GCSAR- Italy.
- (recent project). **FAO Regional Project** (TCP/RAB/3202) titled: Establishing a Regional Platform for Handling Genetically Modified crops, and related commodity Products in The Near East and North Africa Region
- Collaboration with Damascus, Tishreen, and Aleppo Universities for MSC and Ph. D degrees

12.2. SAEC

SAEC has collaborated and continue to do so with Syrian universities and government institutions. Several technical and scientific co-operation agreements were signed with Arab and regional parties.

International Cooperation:

- AECS is Affiliated Center for the International Center for Genetic Engineering and Biotechnology ICGEB.
- Agreement with ICARDA for scientific cooperation.
- Agreement with Institute of Genetics and Cytology of National Academy of Sciences of Belarus (Minsk, Belarus) for scientific cooperation
- Agreements with National institutes.
- The department of Molecular Biology and Biotechnology conducts several cooperative projects with national and international institutes such as the universities, Ministry of Agriculture, ICARDA, IAEA, and ICGEB.

12.3. MHE

Some of the collaborative programmes and national/international agreements pertaining to agricultural biotechnology at the MHE can be shown below:

National and International Cooperation of Tishreen Univ, Faculty of Agriculture:

- A 4-years (2002-2006) project funded by EU on using molecular markers to improve tolerance of barley to drought with cooperation of 4 European countries and 3 arab countries.
- A 3-year project within the framework of the Challenge program “Generation”.
- Cooperation with ICARDA and National programs in Syria in different fields of biotechnology.

National and International Cooperation of Aleppo Univ, Faculty of Agriculture

- Identification of virus pathogens in different plant species using diagnostic tools-with ICARDA.
- Mapping QTLs associated to drought and disease stresses in durum wheat. With ICARDA, and Bologna Univ. (Italy).
- Development of polyclonal antibodies (antisera) as diagnostic tools for
- bacterial and viral pathogens in cereal and legume crops

Cooperation of GCBT:

- At the national level cooperation with all bodies involved in biotechnology mainly with AECS and GCSAR.
- At the international level: cooperation with EU (France, Germany, Belgium) to conduct MSC program in Biotechnology within the framework of TEMPUS program for Academic cooperation. This program was very successful and led to graduate 19 MSc degree students where 11 of them achieved their thesis in universities in Germany, France and Belgium and 6 others did their thesis in the AECS labs, and the other 2 in GCBT.

12.4. ICARDA

There are many collaborative programmes and national / international agreements pertaining to agricultural biotechnology at ICARDA as Joint workshops, conferences and training, Exchange of germplasm and also joint research collaboration with many organizations.

13. Regional cooperation in risk analysis of GMOs:

Syria shares natural borders with Turkey, Iraq, Lebanon, Palestine, Jordan, and Saudi Arabia. This necessitates cooperation in biosafety and risk analysis issues. In this regard we suggest the following:

1. Establishing a committee from the above mentioned countries that meets on regular basis to review ongoing activities in every country with regard to GMO release especially those with potential impact on human health and the environment and ways to avoid or minimize these impacts.
2. Harmonization between biosafety guidelines in these countries in line with international agreements and especially with Cartagena Protocol on Biosafety.
3. Unify efforts to study long term environmental effects by establish a common center or distributing studies on regional institutes so that every body can participate in the efforts and share benefits.

As a conclusion it can be said that genetically modified plants have a number of benefits on the environment and biodiversity, and at the same time some potential risks which should be well understood and studied before such genetically modified plants are allowed in Syria.

Such plants or their products have not, officially entered the country, however, they're expected to enter in the next few years either through national institutes or importation or simply smuggling through the boarders from neighboring countries.

Biosafety in biotechnology research and applications and as well as risk analysis of the impact of GMOs on human health and the environment is the responsibility of both policy makers and scientists. This necessitates that all concerned institutes follow SNBC and international (Especially Cartagena Protocol) guidelines very carefully. The recent regional project can serve this objective very well.

Current status of National capacities in agricultural biotechnology, Biosafety and GMOs detection

13.1. GMO detection

There is increased interest and public awareness to protect and preserve biodiversity from uncontrolled or illegal introduction of GMO material into a centre of origin of such crops.

- **MAAR- GCSAR:** The department of biotechnology has established a laboratory of Molecular Biology in which GMO detection is being donor using PCR techniques and other methods of GMO detection. The Ministry of Agriculture and Agrarian Reform strongly supports providing farmers with information to help them better understand the nature of their crop choices.
- **SAES:** The department of Biotechnology, AEC has established a laboratory for GMO detection using conventional and Real-time PCR techniques.
- **ICARDA:** is doing GMO detection and run regional training courses on GMO detection

  A few personnel at GCSAR and SAEC are trained on some techniques of GMO detection.

13.1.1. Biotechnology and genetic engineering

SAEC and GCSAR has build up good capacities in different disciplines of biotechnology. They have a small pool of highly educated scientists competent in different fields of modern biotechnology techniques including molecular biology, genetic transformation, plant tissue culture, as well as in Biosafety, risk assessment and management of biotechnology products. There is also a few highly educated personals at the universities and other institutes in Syria (see table 2 below).

It should be mentioned that, as the main regulatory body assessing the safety of agricultural products derived from biotechnology, including plants, animal feeds, biofertilizers, and animal vaccines, it is the responsibility of the Ministry of Agriculture and Agrarian Reform to keep pace with the technology as it develops and evolves. SAEC has limited expertises in biosafety and biotechnology. Ministry of high education also has a few expertises in different fields of biotechnology.

Table 2. Approximate number of specialists in different fields of Biotechnology at the different institutions in Syria (MSc, Ph.D degree)

ICARDA	Others	Ministry of High Education	Atomic Energy Commission	Ministry of Agriculture	
5	3	4	15	7	Molecular Biology
6	-	10	8	15	Plant Tissue Culture
3	-	2	5	5	Genetic Transformation
5	-	5	10	5	Phytopathology
-	2	5	12	3	Microorganisms and Immunology
-		5	12	0	Human Genetics
-		4	8	2	Animal Physiology
-		3	0	2	Food Science

13.1.2. Food safety:

Syria is working on a new law for food which is supposed to be approved by the designated authorities in the near future. Although the draft law does not specifically deal with foods derived from GMOs, it does not require labeling of all packaged foods and testing of novel foods.

Ministry of Economic and Trade, directorate of Food supply is responsible for monitoring and controlling the food safety. Some relevant laws are effective but not dealing with GMOs and wether it considered safe or not.

13.1.3. Cartagena protocol:

Syria joined Cartagena protocol on Biosafety on April 1 st 2004 and entered into force on June 30th 2004. The Ministry of Environment is in charge of implementing the protocol. It is currently working on building biosafety frameworks in cooperation with UNEP-GEF and the national agencies including the MAAR and the SNBC.

13.1.4. National Biosafety Committee (SNBC):

SNBC membership is diverse, comprising academic scientists, Ministry representatives, scientists from research institutes. It includes representatives from the following bodies: Atomic Energy Commission of Syria (SAEC), Ministry of Agriculture and Agrarian Reform (MAAR), Ministry of Health, Ministry of High Education (universities of Damascus, Aleppo, Tishreen), General Commission for Biotechnology (GCBT), Ministry of Trade and Economy, Ministry of Local Administration and Environment / General Commission for Environmental affairs, Administration of Medical and Military Services, …

13.1.5. Institutional Biosafety Committees (IBCs):

Institutional Biosafety Committees

Have been established at SAEC, GCSAR, Ministry of Heath, ICARDA to review in-house biotechnology research prior to submission to the NBC. In accordance with the national biosafety guideline, they include in-house scientists and expertise in the following areas: Biotechnology, rDNA technology, physical containment, plant protection specialist

14. Constraints and Gaps facing agricultural biotechnology/GMO research & development in Syria

14.1. Lack of Capacity building in Biosafety issues and risk Analysis:

There is no any non-governmental organization active in Syria addressing biotechnology or biosafety issues. Also, there is no companies applying modern biotechnology tools or releasing transgenic crops. Further, there is no donor-agencies active in the field of biotechnology and biosafety in Syria.

By strengthening capacity in regulatory and biosafety process, we increase the efficiency and effectiveness of the regulatory system. The more capacity we have, the more knowledge we gain through expertise and research. The more knowledge we have, the better able we are to keep pace with the technology.

As a member of the international community, we are also tapping into the vast resources from abroad, and cooperating with other countries to obtain knowledge and research to strengthen our regulatory framework. This includes participation in international expert consultations conducted by FAO and other organizations.

We are faced with the need to increase the sustainability of agricultural production. Recent progress in biotechnology is rapidly increasing the possibility of modifying crops genetically to make them highly tolerant to various kinds of adverse conditions. These new crops should contribute to the increase and stabilization of agricultural production. However, lack of funding and human resources results in the application of limited aspects of biotechnology where genetic engineering is too costly. Thus, advanced research institutes in the public sector of industrialized countries may take the initiative to promote programs for the development of biotechnology techniques in collaboration with international organizations.

14.2. Areas of Capacity building needed:

Capacity building in the national biotechnology institutes should include:

I. Human capacity needs:

- Syria needs experts in scientific fields related to risk analysis of GMOs and with sufficient knowledge on methods of risk analysis. There is a number experts in the Atomic Energy Commission, universities, and General Commission of Scientific Agricultural Research, in different fields of biology and agriculture. However, a few of them have experience in risk assessment and management. This lack of expertise can be overcome by extensive training some of those scientists in the field of risk analysis inside and outside the country. Also, we can use expertise from developed and developed countries (such as India and South Africa).
- There is an urgent need in Syria for experts in short and long term monitoring of the impact of genetically modified organisms on the environment and human health.
- There is also a need for socio economic experts to conduct studies on the impact of GMOs and their products on small farmers and indigenous communities.
- Risk communication is an important component in the risk analysis process. It is necessary to have experts in this field so that people can be informed with risks in scientific and easy to manner so that the public can understand the information of the risk without becoming emotionally involved.

II. Infrastructure needs:

- There is a lack of containment and confinement facilities for conducting environmental risk assessment in the institutes conducting genetic engineering work for environmental risk analysis studies. So there is a need to have suitable greenhouse and field containment facilities.
- Lack of appropriate facilities such as laboratories, including those appropriate for conducting relevant analyses and detection studies, especially for analyzing food for the presence of allergens or toxins.
- There is a need for detection laboratories at ports of entry.
- There is an urgent need for adequate access to internet to retrieve information to support risk assessments.

III. Other considerations

Capacity building in public institutes in biotechnology and biosafety. That can be facilitated by:

1. Evaluate available and needed capacity in human resources and the need for training.
2. Provide necessary laboratory equipment.
3. Promote cooperation with regional and international institutes in all fields of biotechnology and biosafety.

15. Biosafety Regulatory Status in Syria:

15.1. National policies and strategies for biosafety in Syria

A policy on biosafety could either be a stand-alone policy, or it could be part of a more general policy or policies on biodiversity conservation, biotechnology, science and technology, food production, food safety, environment protection or even sustainable development in the country.

Biosafety policy is based upon the constitutional obligations of promoting agriculture and industry in a framework of sound environmental management and other sustainable management practices. In this connection, biosafety guidelines have been established as early as 2001 where the biosafety policies have been included in it.

It is also based upon the general agricultural policies which give a considerable attention to the conservation of genetic resources and biodiversity and puts a high priority on modern biotechnology as a key tool both in the research and development (R&D) plans and also in the modernization of agricultural practices with adopting policies in supporting scientific research and benefiting from modern techniques including modern biotechnology techniques for the final aim to improve crops and increase production taking the safety of food produced, environment protection, genetic resources conservation and sustainable development into consideration

Presently, there is no official policy or strategy for biotechnology in Syria. However, there are some national programs in biotechnology and genetic engineering which aim at improving the agricultural and medical sectors with emphasize on elaborate research policies and R&D collaborative programs in agricultural biotechnology with emphasize on the safe use of biotechnology and all related biosafety issues as a means to promote sustainable development while ensuring the protection of the environ-

ment and conservation of biodiversity given the top priority of the national policy and harnessing biotechnology and genetic engineering available worldwide to solve the temporary agricultural constraints such as biotic (insects, fungal and virus diseases), and abiotic stresses (drought, salinity, temperature, frost), detecting the degree of biodiversity in plant genetic resources at the molecular level to support national biodiversity programs and using of molecular techniques in marker assisted selection in plant breeding programs. Also, development of human resources of high capacity in Biotechnology and all related Biosafety issues is given the priority.

Modern biotechnology is regarded in Syria as a promising technology which has a potential to improve the crops against biotic and abiotic stresses and consequently can contribute to increase food security. There is, however a genuine concern on the potential risks and benefits of modern Biotechnology among the Syrian public. This focus has resulted in the development of the National Biosafety Framework (NBF), which ensure the use of modern biotechnology with the appropriate safety mechanisms in place.

The aim of the development of SNBF is to help executing the international treaty, i.e. Cartagena Protocol on Biosafety, in line with commitment of Syria to protect the environment and execute the international treaties.

Syria ratified the Convention on Biological Diversity on the 05/12/1995 and the Convention's Cartagena Protocol on Biosafety on the 29th January 2004 to help meet its international obligations in the area of sustainable use and biodiversity conservation in the global domain. It has established a supreme council for biodiversity and genetic resources in the Syrian Arab Republic, which has the main responsibility to plan and program for the conservation, management and sustainable use of biodiversity and genetic resources of plants and animals. A national strategy for protection of Biodiversity with work plan was prepared as first step towards improvement, localization and protection of biodiversity components with rehabilitation of degraded elements including agricultural biodiversity.

There is, however, a genuine concern on the potential risks and benefits of biotechnology among both the academic and civil society groups. The national focus is on the precautionary approach and the environmentally sound management of biotechnology. The primary priorities and targets of Syria is to do develop a framework that will ensure sound environmental management and sustainable use of modern biotechnology within the country and also help meet its international obligations under the Cartagena Protocol on Biosafety.

In line with this objective to manage biotechnology in an environmentally sound manner, National Biosafety Guidelines have been developed as early as 2001 before starting this project to develop the National Biosafety Framework.

The scope of these guidelines embraces all works related to gene manipulation employing recombinant DNA technology for all purposes including the development of transgenic plants, production of GMOs and products thereof, and their releases into the environment for field trials and for commercial purposes.

In Syria, overall development, including handling and production of rDNA organisms has not started yet. However, the National Biosafety Committee (NBC) in Syria was established in 30/5/1999. The NBC has been working on establishing biosafety guidelines which approved in 2001. These guidelines cover laboratory work, glasshouse, field work and the importation and/or release of GMOs into the environment. The establishment of institutional biosafety committees IBCs at various public institutes and also private companies is strongly required by the NBC.

The importation of prohibited materials under Plant Quarantine Law No. 237 dated on 17/7/1960 and the Legislation No. 21/T dated on 12/8/1991 implemented by the Ministry of Agriculture also controls to a certain degree the use of GMOs. Permission from the Ministry of Agriculture and from NBC is required to perform field-testing of GMOs brought into the country. So far, there has been no permission already given regarding neither importation nor field release or commercialization of GMOs into environment. The public seems to pay more attention to the introduction of GMOs into the country by agricultural companies than to considerations of technological information. Syria is rich in biodiversity and several genes resistant to biotic and abiotic stresses embedded in wild plants/landraces and other bio- resources need to be discovered and utilized. This illustrates the potential benefits of biotechnology and genetic engineering.

There is no any non-governmental organization active in Syria addressing biotechnology or biosafety issues. Also, there is no companies applying modern biotechnology tools or releasing transgenic crops. Further, there is no donor-agencies active in the field of biotechnology and biosafety in Syria.

The National Biosafety Committee (SNBC) in Syria was established in 1999. It is represented by most of the relevant ministries and institutions concerned with biotechnology. It is being refreshed, currently, to include representatives of private sector, media, and non-government organizations to allow for better interaction and communication among scientists and the stakeholders, which can increase public awareness

towards benefits and risks of genetically modified organisms.

The SNBC is assisted by Intuitional Biosafety Committees (IBC) that exists in the Atomic Energy Commission, ICARDA, General Commission for Scientific Agricultural Research, Ministry of Health and College of Medicine.

The SNBC published Biosafety Guidelines in 2001 in order to regulate research on GMOs at laboratory, greenhouse and field levels in addition to a mechanism to handle requests for releasing GMOs to the environment.

The Ministry of Agriculture and Agrarian Reforms is working on a by-law / decree to cover all biosafety issues related to biotechnology application including regulating importation and exportation of GMOs, which is expected to be approved in the near future.

Syria attaches great importance to building capacity in biotechnology to keep pace with the recent developments in this field, taking it as a priority action plan for the aim of improving the production of agricultural products to be self-sufficient with surplus for export.

Syria has formulated the Biosafety guidelines since 2001. Nevertheless, as a developing country, Syria lacks the technical and financial capacity for comprehensive implementation of the priority action plan for capacity building in Biotechnology. The domestic fund is limited. The international cooperation in biotechnology is also limited. Syria always attaches importance to this area for which a series of policies, regulations and strategies have been established.

A number of management approaches and technical measures have been taken in the aspect of developing the biotechnology programmes at the national institutes. Nevertheless, due to the difficulty of the purchasing the needed equipments and chemicals and its high demand for fund and technologies, the input from the government can not meet the demand of the actual and rapid progress. The input needs to be increased and more resources need to be obtained from home and abroad, so as to meet the demand of the actual practice. On the other hand, the protection of agriculture biological diversity is considered as a priority action in Syria.

Strong and dynamic capacity at the technical, institutional and management levels is the most important requisite for successful and sustainable application of biotechnology in food and agriculture.

Syria is now beginning to incorporate biotechnology increasingly in their agricultural research programs. Therefore, in the recent years, there has been a steady development of agricultural biotechnology capacity in Syria where human and financial resources allocated to biotechnology R&D are increased. The government is gradually building a strong scientific base in agricultural research and biotechnology. The national research institutes are encouraged to be actively involved in bilateral and international collaborative research programs in diverse fields of agricultural biotechnology.

Although the conventional agricultural research capacity is moderately strong, the trend now is to develop a strong biotechnology capacity in several areas.

Further, in the national policies science and technology, and biotechnology in particular, as an important engine of economic growth both for agriculture and for the health sector have been specifically identified.

The public agricultural research programs have had substantial success in promoting rapid agricultural growth.

On the other hand, in Syria, the marketing and management of biotechnology products are virtually absent, as is the critical mass required raising public awareness and so far, there is no regulation to control introduction and handling of biotechnology products. However, such act/ regulation is underway

The MAAR is mandated for biotechnology research development and all aspects related to introducing, handling, import and export of GMOs, LMOs, while the Ministry of Environmental affairs with the Ministry of Agriculture are responsible for monitoring of the impacts on the environment.

Syria started its biotechnology programs in mid 1990s, with the foundation of plant tissue culture and molecular biology laboratories at the governmental institutes.

15.2. Regulatory System

In Syria, so far, there is still no specific enactments set in place to address biosafety related to the modern biotechnology activities. However, there are some existing relevant regulations which will be summarized later on in this document. These include relevant laws, biosafety guidelines related to biotechnology which was set up by the SNBC of Syria in 2001 to guide practices in modern biotechnology and recently the Ministry of Agriculture and Agrarian Reform is working on jointly in cooperation with the NBC for preparing a draft by-law on Biosafety for regulating all biosafety related issues including the introduction/ importation, exportation and handling of LMOs/ GMOs Syrian National Biosafety Committee which was revised recently on 27/9/2006 will work closely to modify the biosafety guidelines in accordance with the Cartagena Protocol on Biosafety.

In order to reflect the multifaceted nature of agricultural biotechnology, the MAAR and other involved institutions will be constantly working to incorporate expert scientific views into our continuously evolving regulatory system.

No priorities in biotechnology research have already been set. However, development of human resources of high capacity in Biotechnology and all related Biosafety issues is given the priority.

Although the conventional agricultural research capacity is moderately strong, where the public agricultural research programs have had substantial success in promoting rapid agricultural growth, however, the trend now is to develop a strong biotechnology capacity in several areas.

Further, in the national policies of science and technology including biotechnology in particular, as an important engine of economic growth both for agriculture and for the health sector have been specifically identified.

On the other hand, in Syria, the marketing and management of biotechnology products are virtually absent, as is the critical mass required raising public awareness and so far, there is no regulation to control introduction and handling of biotechnology products. However, such act/ regulation, is underway.

The MAAR is mandated for biotechnology research development and all aspects related to introducing, handling, import and export of GMOs, LMOs, while the Ministry of Environmental affairs with the Ministry of Agriculture are responsible for monitoring of the impacts on the environment.

Syria did not produce specific laws that regulate Biotechnology and Biosafety, But Syria has some relevant laws as shown in the annex 8. However, active steps for the establishment of Biosafety by-law dealing with all biotechnology activities and biosafety related matters including controlling the importation, handling and exportation of GMOs are underway.

15.3. Biosafety Guidelines in Syria

The Syrian National Biosafety Committee issued the Biosafety guidelines in 2001 in both English and Arabic languages. The guidelines were approved by the prime minister on 27/2/2001. The biosafety guidelines have been developed on the basis of common elements and principles derived from national and international regulations and guidelines. They are designed to ensure that the products of biotechnology will not have adverse effects on the environment and agriculture, and to protect the surrounding communities as well as employees and researchers involved in the use of such. products from the research stage till commercialization.

The guidelines include guidelines for work in the laboratory, the greenhouse and the field as well as mechanisms for releasing GMOs to the environment

15.4. The Syrian National Biosafety Committee (SNBC):

The Syrian National Biosafety Committee has been established by the Atomic Energy Commission of Syria in 1999 with approval of the Prime Minister. The SNBC was reformed on 27 /9/2006 to include representatives from Ministry of Information, Private sector, and Consumer Protection Society.

This will allow for better interaction and communication among scientists and the stakeholders, which can increase public awareness towards benefits and risks of genetically modified organisms.

The SNBC is assisted by Intuitional Biosafety Committees (IBC) that exists in the Atomic Energy Commission, ICARDA, General Commission for Scientific Agricultural Research, Ministry of Health and College of Medicine.

The SNBC published Biosafety Guidelines in 2001 in order to regulate research on GMOs at laboratory, greenhouse and field levels in addition to a mechanism to handle requests for releasing GMOs to the environment.

The Ministry of Agriculture and agrarian reforms is working on a decree for regulating importation and exportation of GMOs, which is expected to be approved in the near future.

Members of the SNBC represent:

- Atomic Energy Commission of Syria.
- Scientific Studies and Research Center.
- Ministry of Higher Education
- Ministry of Agriculture.
- Ministry of Health.
- Ministry of Environment.
- Ministry of Supply and Internal Trade.
- Directorate of Military Medical Services.
- Ministry of Information
- Private sector.
- Consumer Protection Society.

Syrian National Biosafety Committee which was revised recently on 27/9/2006 will work closely to modify the biosafety guidelines in accordance with the Cartagena Protocol on Biosafety and establishment of a draft of Biosafety Law/ Bill in Syria.

Objectives of the National Biosafety Committee and its Role in Biosafety and Risk Analysis

The most important objective of the SNBC, when established in 1999, was to establish biosafety regulations for genetic engineering research as it will be explained later. The SNBC collects and disseminates updated biosafety information to the designated agencies and that is accomplished by publishing a quarterly news letter that is distributed free of charge. The SNBC also assesses the risk of releasing genetically modified organisms or their products (foods, medicines, vaccines, etc) into the environment and advise on whether they should or shouldn>t be released.

The SNBC provides consultation regarding biosafety issues and makes regular checks on laboratories working on research designated biosafety levels II and III making sure they adhere to guidelines set by the SNBC for the safety of laboratory workers and the community.

To achieve these objectives The SNBC designates one or more principal investigators (PI) whose duties include:

Inspect to determine whether institute facilities, involved in genetic engineering work, adhere to the local regulations and guidelines of the SNBC and report to the SNBC to decide whether a permit will be issued or denied.

Instruct and advise staff in practices and techniques to assure levels of safety concern.

Institutional Biosafety Committee (IBC)

All institutions (national and international) conducting R-DNA research are required to form an Institutional Biosafety Committee (IBC). The IBC includes experts in the R-DNA technology, and experts in biological safety and physical containment. Members of an IBC should not be involved in review or approval of their own project proposal(s) or commercial applications

Responsibilities of Institutional Biosafety Committee (IBC) would include:

- Consult with and seek approvals from the SNBC.
- Implement the recommendations of the SNBC.
- Establish and implement policies that provide safe conduct of biotechnology research and ensure compliance with applicable guidelines.
- Review and endorse applications from researchers.
- Maintain a central reference file and library of related documents, as a source of advice and reference.
- Develop a safety and operations manual and assist researchers in the required staff training.
- Certify the safety of facilities, procedures, and practices and that the level of training and expertise of the personnel involved have been reviewed and approved.
- Establish a program of inspections to ensure that the physical containment facilities and field trials continue to meet requirements and that other procedures and practices specified in the guidelines are followed.
- Maintain a list of researchers, project supervisors, and other supervisors approved by the IBC as competent to perform supervisory duties for particular projects.
- Maintain individual records and files of individual research projects.
- Investigate and report promptly to the SNBC all accidents and unexplained absences and illness.
- Provide an annual report to the SNBC.
- Undertake the assessment and review of all planned release proposals to identify potential hazards to human health and to the environment and to advise the project leader on their proper management.
- Review the qualifications and experience of personnel involved in potentially biohazardous projects.
- Take necessary steps to inform the public of the proposed planned release and provide the public with the opportunity to comment if possible.
- Submit to the SNBC all required project documents for review and approval.
- Ensure that all communications from the SNBC are conveyed to and, if applicable, compiled with by the project leader.
- Ensure that all relevant regulatory agencies have been consulted and necessary permits, licenses or approvals have been obtained before any planned release is made.
- Visit the release site periodically to monitor and evaluate the biosafety of ongoing projects and recommend additional safety measures, if necessary.
- Notify immediately the SNBC of any accidents or incidents arising from or related to the planned release activity.
- Submit a terminal report to SNBC at the end of the planned release project.
- Appointment of Biosafety Officer (BSO)

Biosafety Officer (BSO):

Every institute should appoint a Biosafety Officer (a member of the IBC). The BSO should be familiar with the biosafety requirements for the r-DNA work and the facilities and be able to make checks and advise on biosafety issues on day-to-day basis. Duties of the BSO include:

- Ensure that policies and regulations approved by the SNBC are not compromised by other considerations.
- Ensure through periodic inspections that laboratory standards are strictly followed.
- Advise on safety of laboratory work to prevent accidental escape of GMO's.
- Maintain a database on all aspects of biosafety related to mandate crops.
- Check and give advice on biosafety issues on a day-to-day basis.
- Monitor worldwide biosafety requirements for r-DNA and report to the IBC all related issues.

Responsibilities of the Researcher:

The researcher as an agent of an institution is responsible for conducting r-DNA research in a safe manner and in compliance with the appropriate research guidelines and all applicable regulations.

The responsibilities of the researcher include:

- Ensure that experiments, for which the researcher is responsible, are covered by institutional and national guidelines.
- Evaluate potential risks at appropriate stages of research and development of an organism, prior to its formal review or assessment.
- Notify and obtain approval from the NBC through the IBC, prior to the conduct of an activity involving the release of GMOs.
- Instruct and train staff in the practices and techniques to maximize safety and in procedures for dealing with accidents.
- Provide prompt reports to the IBC on any significant problems with implementation of relevant guidelines and regulations.
- Provide reports to the IBC on any research-related accidents that have resulted or could result in human illness, in unanticipated plant or animal disease, or in the escape of organisms under study from the intended confinement.
- Comply with applicable shipping requirements regarding human, plant, and animal health protection and policies, permit requirements, and containment conditions for possession of certain organisms.

Procedures for GMO Research application involving rDNA: :

Once a project involving r-DNA research has been reviewed and approved by the IBC, the project should be monitored periodically by IBC. The following scheme presents the steps of an application for a research involving R-DNA techniques takes at the IBC before it goes to the NBC.

Public awareness and education and public participation in decision making & Capacity Building:

It is widely acknowledged that scientifically oriented public education is the only way to bridge the gap about consumer knowledge, values, and views, and to achieve consensus about the use of genetically modified foods.

Public perceptive of risks may differ greatly from expert perspective based on scientific knowledge. That is why communication regarding essential issues among scientists, decision makers, and general public is very important. Communication is viewed as a mechanism to convey a message between the source and a receiver. General frameworks of biotechnology risk analysis can help in setting clear objectives and methods for management and transfer of knowledge in a way that can build trust for acceptance of risks. Media can play a major role in the communication of risks and formulating a general perspective not only in providing information but also in making the issues closer to the general public.

15.5. Existing Legislations, Laws, and Agreements Related to Biosafety:

Cartagena Protocol on Biosafety

The convention on biological diversity (CBD) in 1992 came to focus on comprehensive approach to sustainable development through three main goals; The conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising from the use of genetic resources. All of these goals play an important role in improving food for people especially when we know that 800 million people who don't have access to sufficient food to meet their needs, and 12 million deaths each year of children under five years in developing countries.

Cartagena Protocol on Biosafety is an international environmental agreement developed under the United Nations Convention on Biological Diversity. Its purpose is to protect the environment and global diversity by ensuring that there is adequate protection for transferring, handling and using living modified organisms (LMOs). The Protocol provides a regulatory framework to move LMOs safely between countries.

The Cartagena protocol on biosafety was adopted on 29 January 2000 and came into force on 11/9/2003. It is a supplementary agreement to the United Nation Convention on Biological Diversity. The overall objective of the Biosafety protocol is to contribute to ensuring an adequate level of protection in the field of safe transfer, handling and use of genetically modified organisms (GMOs) resulting from modern biotechnology that may have adverse effects on the biological diversity, taking also into account risks to human health, and specifically focusing on so-called "transboundary movement", i.e. movements across national boundaries.

Current Status of Syria related to the Protocol: Syria has ratified the convention on Biodiversity (CBD) by decree No. 364 dated on 5/12/1995, and takes full responsibility towords Cartagena Protocol on Biosafety where it joined it by decree No. 9 dated on 29/1/2004, and entered into force on June 30 th 2004.

Executing Agency: Directorate of Biodiversity and Nature Protected Gardens (Areas), General Commission for Environmental Affairs, Ministry of Local Administration and Environment - is in charge of implementing the protocol.

15.6. Relevant Legislations that regulate Biotechnology and Biosafety:

So far, Syria did not produce specific laws that regulate Biotechnology and Biosafety, But Syria has some relevant laws as shown in Annex 8. The most relevant ones are summarized in the table shown below. On the other hand, active steps for the establishment of regulation/ resolution to control the importation, handling and exportation of GMOs are underway.

Syria did not produce specific laws that regulate Biotechnology and Biosafety, but Syria uses existing relevant laws to do so as shown in the table below. However, active steps for the establishment of regulation/resolution to control the importation, handling and exportation of GMOs are underway.

Proposed Mechanism for the National framework of Biosafety and a System to handle requests for authorizations with respect to modern biotechnology activities and handling with GMOs/LMOs in the Syrian Arab Republic.

The proposed biosafety regime, the Syrian Biosafety Regulatory system, is a coordinated framework with a coordinating agency, the National Biosafety Committee , whilst monitoring and enforcement issues shall be handled by the existing regulatory agencies Applications and requests for authorizations with respect to modern biotechnology activities and handling with GMOs/LMOs in the Syrian Arab Republic are handled as follows:

- Requests are applied to the MAAR when the materials intended to be introduced into the country are LMOs and intended for agricultural purposes or food for humans or feed for animals. The details of application and Forms with the necessary documents are shown in annexes 10 and 11 in this document.
- Requests are applied to the Ministry of Economy and Trade when the materials intended to be introduced into the country are GMO products intended to place on the market as food for humans or or feed for animals.
- Requests are applied to the Ministry of Health when the materials intended to be introduced into the country are GMO products pharmaceuticals intended for use as medicinals or therapy

In all three previous cases, applications are forwarded to the SNBC for processing, reviewing, risk analysis and assessment and suggestion of decision within 45 working days if all information are provided in the application forms. In case when there is missing information in the application, the proponent is given 30 working days for supplementing the missing data or the application is rejected.

NBC can seek advice and consultation by any suitable expert for studding and analyzing the application. NBC also notify public and private sector seeking for their opinion for decision making during application process.

Application is then to be send back after process and decision making (approval/ rejection) by NBC to the relevant Ministry which in turn issue its final decision accordingly (approval / rejection) and notify the proponent.

In case of rejection, proponent can appeal for re-reviwing the NBC decision if there is new supplemental information which were not available when processing the original application.

Monitoring and Execution

Ministry of Agriculture should notify the Ministry of Local Administration and Environment with any approval of release any LMOs (plant or animal) into the environment providing it with all information including the place and date of release and details of materials intended to be released into the environment.

Ministry of Local Administration and Environment will take the responsibility of supervision and monitoring with studying the impacts on the environment and biodiversity, and should inform the relevant bodies including NBC with its results and observations. A system for monitoring and execution concering GMOs/LMOs is to be set up by the NBC in cooperation with the MLAE.

Monitoring:

Monitoring plans are usually part of the application process and are included in the recent biosafety guidelines. It includes general supervision on the biotechnology activities and release of LMOs into the environment. Based upon the results of the risk assessment, a system for monitoring and supervision is set up case-by-case.

Proponent who place GMOs on the market, should ensure execution of monitoring of the product impacts on the environment and human health according to systemic program and regulatory plan given to the relevant Ministry.

Monitoring is done by the responsible person in charge of the biotechnology activities, while the inspection and execution is done by the NBC.

Execution:

Done by the competent inspection bodies to ensure adhering to the regulatory system. Inspors are given a police authorization.

Capacities for GMO Detection: Human Resources & Institutional Capacity Building and Basic Requirements of GMO detection and Biosafety in Syria

Institutional Capacities for GMO detection

- **MAAR- GCSAR**: The department of biotechnology has established a laboratory of Molecular Biology in which GMO detection is being conducted since one year ago with good success using PCR techniques and other methods of GMO detection. A case study on GMO detection from samples collected from local market will be presented here after.
- **SAEC:** The department of molecular biology and Biotechnology, has established a laboratory for GMO detection using conventional and Real-time PCR techniques. A few personnel at GCSAR and SAEC are trained on some techniques of GMO detection.