Status and Options for Regional GMOs Detection Platform: A Benchmark for the Region

by

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Foreword

In the Near East and North Africa region, agriculture is a key element of the economy and an important source of employment and most of the countries are committed to implementation of the Global Plan of Action for Conservation and Sustainable use of Plant Genetic Resources for Food and Agriculture for boosting production and development. Despite the initial acceleration, the region is experiencing delays in the adoption of new biotechnologies and in the implementation of national NBFs, mainly due to lack of adequate institutional capacities in the area.

FAO has approved a two year regional project (TCP/RAB/3202) entitled "Strengthening capacities towards the establishment of a regional platform for the detection of genetically modified organisms». The participating countries include Lebanon, Jordon, Sudan, Syria, UAE and Yemen. The aim of this project is to strengthen regional capacities and to enhance regional information exchange and dialogue in biosafety that would lead to the establishment of a regional platform for handling and managing GMO detection and related procedures through increased regional cooperation and standardization of GM detection and analysis procedures within the region.

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Gratitude is expressed to **Dr. Kakoli Ghosh,** Plant Production and Protection Division (AGP), Food and Agriculture Organization of the United Nations (FAO) in Rome for providing the opportunity to contribute in setting the priorities for six countries from WANA the region to enhance capacities in the field of modern biotechnology and in the establishment of this regional platform for GMO detection.

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Contents

Introduction

Agriculture and food production are the main fields of biosafety applications. Since the Cartagena Protocol on Biosafety (CPB) entered into force in 2003, FAO has been providing assistance to countries in building technical, institutional and information sharing capacities for biosafety, towards the safe use of modern biotechnologies and to enhance sustainable agriculture and food production. In the countries, the focus is on building national capacities at the policy and institutional level to implement the CPB and to establish effective linkages among all relevant stakeholders including the Ministries of Agriculture, Environment, Science and Technology, research and technology centers, the private sector and the civil society.

An equal amount of emphasis is placed on strengthening regional dimensions of biosafety capacities and information exchange. Given the commonalities amongst the regions, countries could often adopt a common regional approach on biosafety both in terms of critical mass of technical expertise availability and through increased regional cooperation lead to standardization of GM detection and analysis procedures within the region.

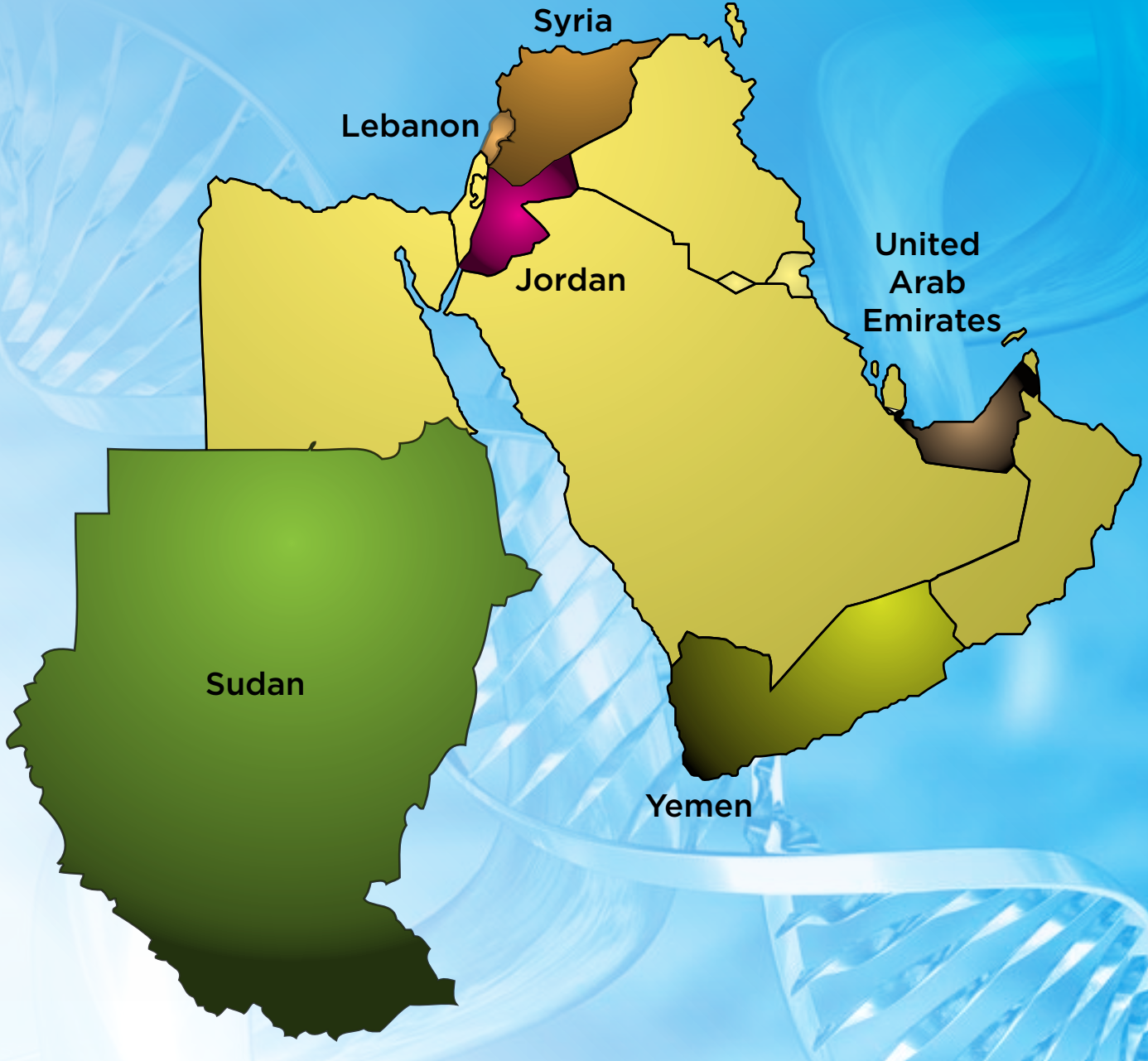
In the Near East and North Africa region, a FAO regional project entitled "Strengthening capacities towards the establishment of a regional platform for the detection of genetically modified organisms»(TCP/RAB/3202) has been ongoing since 2008 with six countries include Lebanon, Jordon, Syria, UAE, Yemen and Sudan. The aim of the project is to strengthen capacities and to enhance regional information exchange and dialogue in biosafety towards the establishment of a regional platform for handling and managing GMO detection and related procedures

The main outputs of the project are to

1. Enhanced regional collaboration in GMO detection among the participating countries , in particular among national laboratories in order to harmonize their practices and certification schemes based on common standards and good practices.
2. Training package a including an information exchange forum make available for the project training activities as well as for future in-house training courses.
3. Increased capacities of technical staff of the participating countries in GMO detection technologies
4. An agreement prepared for the establishment of the 'regional platform for GMO detection in the region' among the participating countries

Within this project one of the tasks is to prepare a Comparative analysis of the current practices in use in the six participating countries and identification of options for standardization. The aim of this document is to present the Status of GMO detection in these countries, identify the gaps, needs and options for strengthening the Regional approach towards establishing a GMO detection Platform for the region.

Chapter I
Agricultural Sector in the Arab Countries



Chapter I: Agricultural Sector in the Arab Countries

The total area of the Arab countries is around 14061.46.2 square kilometer, representing 10.8 % of the world area. The agricultural land area in 2004 was around 69.6 million hectares which represent 5.0% of the world agriculture area. The water resources are in general limited and represent only 1% of the world water resources.

The population of the Arab countries was 309 million in 2004 which represent 4.84 % of the world population and expected to reach 431 million in 2020. The increase rate is 2.31% (for the 1990-2004 period) which is double the world rate.

Arab countries exports value in 2004 was 396.5 billion US$ which represent 4.36% of the world total export, while the imports value for the same year was 243.1 billion, which represent 2.6% of the world imports. This indicates that the contribution of the Arab countries in the world trade is around 3.4%.

1.1. Agricultural sector's contribution to GDP

The contribution of agriculture sector to GDP is usually taken as an indicator of the importance of the agriculture sector in relevance to other sectors in the country. We should notice, however, that as the contributions of other sectors increase and those of the agriculture sector stay constant, then the percentage of agriculture sector contribution to GDP will decrease, which, in fact, does not mean that its importance is declining.

Contribution of agricultural sector to GDP varied significantly among Arab countries and ranged from 63.07% for Somalia to 0.35% for Kuwait, with an average over the Arab countries of 6.80%. However, there are countries with strong agriculture sectors, this is judged by their gross agricultural products (GAP) values and the contribution of the agriculture sector to the national GDP, and these are: Algeria, Egypt, Iraq, Morocco, Saudi Arabia, Sudan, Syria, Tunisia, and Yemen. These countries have also good agricultural resources and also high populations. The contribution of the agriculture sector to the GDP in these countries ranged from 3.32 % for Saudi Arabia to 35.37% for Sudan, with an average of 9.30%. It is interesting to notice that the contribution of agriculture to GDP in Saudi Arabia is relatively small (3.32%), but agriculture sector is very important sector in comparison to other Arab countries; the GAP in this country is ranked second after Egypt whereas the GDP is about three times greater than Egypt. This is due to the high income that being generated from oil exports as we indicated earlier.

- The Gross Domestic Product GDP of the Arab countries in current prices has scored a noticeable take off during the year 2006 to grow to US$ 1.274 billion against 1.084 billion during 2005, with a rate of increase of 17.4%.
- The Arab countries have realized real high rates of growth in the GDP which surpassed a rate of 6% during the year 2006 compared to 5.4 % in 2005. These rates are regarded as better than the growth rates of the developed countries group which has registered 3.1% and less than what was realized by the highly developing countries which have recorded a growth rate of 7.9%.
- The average per capita income at the current prices has increased in the Arab countries from approximately US$ 3613 per person in 2005 to approximately US$ 4156 in 2006, thus realizing a rate of increase of 15%.
- The structure of GDP shows a continuous rise in the relative importance of the extracting industry sector compared to the rest of the sectors, whereas the share of the same in the GDP has increased from 38.5% in 2005 to 40.2% in 2006.
- The services sector comes in second level in terms of the relative importance in the GDP for the Arab countries (22.5%) followed by the manufacturing industry sector (15.6%) and the agricultural sector (7.5%).

1.2. Key factors affecting agricultural investment in Arab countries

- **Policy:** Agricultural development and civil society buy-in/ participation in the policy process are significant.
- **Location:** By its central Mediterranean, Asian and African position, its vigor and growth and its preferential treaties with numerous partner countries, Arab countries offers access to numerous markets for companies that desire to develop their activities.
- **Size of the market:** Arab world has a relatively large population (more than 340 million habitants) with sufficiently strong purchasing power that serve as huge consumer market as incentives for investments.
- **Resources:** Arab countries have huge raw materials (natural resource) base, serve as incentive for low factor-cost investment.
- **Infrastructure:** Access to power, transportation (multi-modal), communication and social welfare (healthcare and education facilities) are in order.
- **Human resources competitiveness:** Highly skilled staff at competitive prices.
- **Investment incentives:** Most of the Arab countries have adopted a numerous incentives, in the form of tax exemption, investment bonuses, no-cost infrastructure, and assumption of employer's share of social costs.

- **Simplified procedures: In most Arab countries, the procedures to start a company are done at a one-stop window that gathers all the concerned administrations.**
- **Regulation: This is improving, especially as institutions are strengthened at an on-going basis.**

1.3. Major agricultural imported commodities:

The imported quantities of agricultural commodities by Arab countries are very large (Table 1); almost all food commodities are imported with wheat barley and maize at the top of the list from the plant commodities, and sheep, goats and cattle from the animals. If we consider the imports of cereals by country, which are the most important food and feed commodities. The Arab countries imports of cereal represents 16.32% of the world imports.

Table (1): Arab countries imports (in 2003) of the major plant and animal commodities

Commodity Plant Commodity	Quantities (tones)	% of the world imports
Wheat	18877147	17.46
Barley	5974545	27.79
Maize	10800724	12.08
Rice	3142120	12.41
Dates	109129	21.57
Banana	14328208	3.76
Fibers (cotton)	129839	1.43
Animal Commodities		
Cattle (Head)	233453	5.85
Sheep (Head)	662686	64.28
Goats	1012063	39.99
Camels	53670	99.99

Source: FAO-AOAD.2005. Selected indicators of food and agriculture for Arab States 2000-2004. AOAD. Khartoum, Sudan.

Public investment is critical for funding agricultural Research and Development (R&D) because it represents 94% of the agricultural R&D in developing countries. Whereas growth in public sector spending in agriculture increased in the 1960s and 1970s, it has slowed down significantly in the last 25 years in developing countries, including the Arab countries. Thus, it is both timely and appropriate to consider a significant public sector investment in biotechnology, particularly crop biotechnology, which is more advanced than biotechnology applications in livestock.

Biotechnology provides an excellent opportunity for the Arab countries to improve and sustain their agriculture productivity and to overcome the major problems that agriculture is facing. In addition, the Arab region is very rich in biodiversity and harbor important genes that biotechnology could use and benefit from.

On the other hand, the most important economical crops in the Arab countries have low productivity due to their susceptibility to major diseases and pests, and to their crop varieties that have low yield and lack the tolerance to the major abiotic stresses such as drought, heat, and salinity. Biotechnology provide answers for most of these problems; biotech (GM) crops substantially increase productivity, reduce the use of chemicals, and increase farmers' revenues.

1.4. FAO biotechnology programs

FAO's strategy concentrate on activities such as the collection and dissemination of information, monitoring and advice, facilitation of access to new technologies, provision of a forum for reviewing trends, development of appropriate guidelines and codes promoting the environmentally sound and equitable application of advance biotechnologies, assistance to developing countries in identifying biotechnology needs and priorities, strengthening of their capabilities and assessment of socio-economic impacts. The FAO is promoting international, inter-laboratory co-operative research through networking, where it assists in establishing several specialized regional networks, and support workshops and training activities in the area of biotechnology.

1.5. The three generations of biotech applications

Agricultural biotechnology has the potential for enormous impacts on crop and livestock productivity, the environment, and sustainability and on the lives of poor smallholders and consumers.

1.5.1. Tissue culture & molecular diagnostics - The first generation

The first generation of biotech applications features plant tissue culture for the production of disease and virus-free propagules, molecular diagnostics for crops and livestock diseases and embryo transfer for livestock. Tissue culture has been successful in many countries for propagation of bananas, multipurpose trees, date palms and is particularly suited for vegetative propagated crops. The further development of improved high value disease-free date palms from tissue culture in the Middle East should be carefully assessed in view of continuing and rapid improvements in the technology. In the continents of Africa, Asia and Latin America tissue culture of bananas has been very successful and easily and cost effectively implemented. Disease-free

sweet potatoes have been grown on 500,000 hectares in Shangdong Province in China with productivity benefits of up to 40%. In terms of biotech diagnostics the render pest virus in cattle has been successfully detected and eradicated using an effective biotech-based diagnostic for the virus.

1.5.2. Molecular markers and genomics – The second generation

In plants, molecular markers are used to effectively track certain traits (for example disease resistance) of value in crop improvement programs – this allows "speeding of the breeding" in crop improvement programs. Accordingly "marker assisted selection (MAS)" of improved conventional varieties of crops can expedite the development and deployment of improved varieties at the farm level. MAS has been successfully used in crops ranging from maize, rice and wheat to vegetable and fruit crops. In India, MAS has been used to develop varieties of pearl millet resistant to the fungal disease caused by downy mildew. In the Philippines it is effectively deployed to develop resistance to bacterial blight of rice. MAS can also be used to breed livestock that are tolerant to African sleeping sickness. Initially the costs of these markers were high but now they are modestly priced and can be used cost-effectively in conventional crop and livestock breeding programs in developing countries.

1.5.3. Genetically modified (GM) crops/biotech crops – The third generation

Genetically modified (GM) crops, also called transgenic or biotech crops result from transferring one or more genes from a different species (of crops, or bacteria, or viruses, or other organisms) to enhance the characteristics of the crop undergoing improvement.

1.6. Biotechnology constraints and challenges

There is no doubt that agricultural biotechnology has opened up new possibilities, particularly in crop and livestock development. However, there are major challenges that need to be addressed and tackled especially in the developing countries, in order for these countries to maximize their benefits from biotechnology in solving the urgent problems of food supply, protecting the environment, and reducing poverty. The main constraints and challenges that need consideration and actions are in the followings:

1.6.1. Clear biotechnology agenda and supporting policies

There is a need for Arab countries to develop clear and time-bound national agenda for biotechnology research and development (R&D) and commercialization. This could be achieved by linking science and technology with industry, and having both well tuned to market demands.

Similarly, there is a need for policy initiatives to accelerate investments by technology holders and adoption by the farming communities. These policies include the registration and approval of GM crops and funding and infrastructure support for public-private partnership programs in plant biotechnology, and other related areas. The supporting policies should also provide the framework for research and business institutions, and outline the trade and investment guidelines for the newly emerging biotech sector, which should be in agreement with the international guidelines, including the necessary biosafety measures and tests for new or introduced genetically modified crops.

1.6.2. Intellectual property rights (IPRs)

Patenting and IPR are promoting privatization of scientific research in agricultural biotechnology, and might increase the gap of biotechnology know-how and its applications between developing and industrial countries. Most Arab countries, especially those joined the World Trade Organization (WTO) develop their IPR policies and regulation which suppose to cover those of the biotechnology products.

Significant achievements have been made on IPR protection for genetic engineering in general and for plant biotechnology particularly in the developed countries. However, problems and challenges are emerging with the implementation of IPR policies and regulations. Areas that need attention particularly in the developing countries include: Public awareness on IPR, capacity building on IPR protection, implementation on IPR protection, and enforcement of laws and regulations related to IPR.

1.6.3. Biosafety regulations

The cost of biosafety regulations some times are a major cause in slowing down the progress that is expected from biotechnology. It is estimated that in the United States, the cost of obtaining regulatory approval of a new transgenic crop variety can be as much as $30 million. In such events there is a greater need to find synergies, including through the regional approach that will reduce costs by using mutually accepted procedures..

Since biosafety regulations are not fully operational in most developing countries, there is a an added challenge on how to increase applications of biotechnology while keeping costs of regulations at bay.

Arab countries, however, face a number of challenges, including low levels of awareness about the Cartagena Protocol and a lack of necessary human, institutional and technological capacities. There is an urgent need for countries and organizations, in a position to do so, to provide additional financial and technical assistance and facilitate access and transfer of technology to enable Arab countries promote awareness and build their capacities.

There is a need in the Arab countries to Issue and approve national legislations regarding the GMOs and ways to handle them in terms of: their importations to the country, trading, GMOs variety release regulations at the national level and their monitoring and evaluation procedures, biosafety measures for health and environment for the crops and their products, and biosafety regulations for the importation and testing of transgenic crops, with regulations for field tests.

1.6.4. Public acceptance

Public acceptance of biotechnology products, especially transgenic crops and genetically modified (GM) food, is a major constraint to the adoption of plant biotechnology in the region. Public awareness programs and campaigns should be organized to educate the public on the benefits of biotechnology products.

1.6.5. Capacity building

One of the most challenging matters for the biotechnology implementation is the human building capacity and qualified personnel capable of handling and carrying out biotechnology research and applications.

1.7. Conclusions

Plant biotechnology offers an unprecedented opportunity to address some of the world's most serious issues, including hunger, poverty and disease. This is because biotechnology can circumvent the species barriers that prevent useful traits being introduced into plants by conventional breeding. By transferring genes from bacteria, fungi, animals and sexually-incompatible plants into our food crops and medicinal plants, it is possible to improve their agronomic traits and provide them with additional metabolic abilities.

Genetic engineering and biotechnology provide good opportunities for the investment and improvement of food security and food production in the Arab countries, however, it has it is own challenges that need to be considered by the Center.

The following questions are relevant to be asked not only as related to Arab countries, but also for the developing countries in general:

- What opportunities exist for biotechnology to contribute toward improving agricultural productivity, expanding markets, and stimulating employment and income generation in Arab countries, and what are the constraints that limit capturing these opportunities and in using biotechnologies approaches?
- What challenges do these countries face in realizing these opportunities and in mitigating the risks associated with the use of biotechnology?

Considering the important challenges that encounter the agricultural sector and its sustainability in the Arab countries, it seems that the new biotech crops applications offers enormous potential benefits in the second decade of commercialization,2006 –2015, in terms of meeting increased food, feed and fibre demands in the Arab World and contributing to more prosperity for both producers and consumers. Of particular importance are the genes for drought tolerance that are under development in both the private and public sector. The genes for drought tolerance are genes that very few farmers in the world can afford to be without and this is particularly true for the rainfed dryland areas that typify much of the land in the Arab countries for which ICARDA (International Center for Research in the Dry Areas) has a regional mandate, and where biotech research is undertaken on drought tolerance. The first commercial variety with drought tolerance is expected to be drought tolerant maize in the US in 2011. The drought genes have already been introduced into several crops and early field tests are underway; for example, drought tolerant wheat is being field-tested in Australia.

In this regards it is evident that the decision to invest in agricultural biotechnology is timely and appropriate and is of great strategic importance at a time when the new technologies can contribute to:

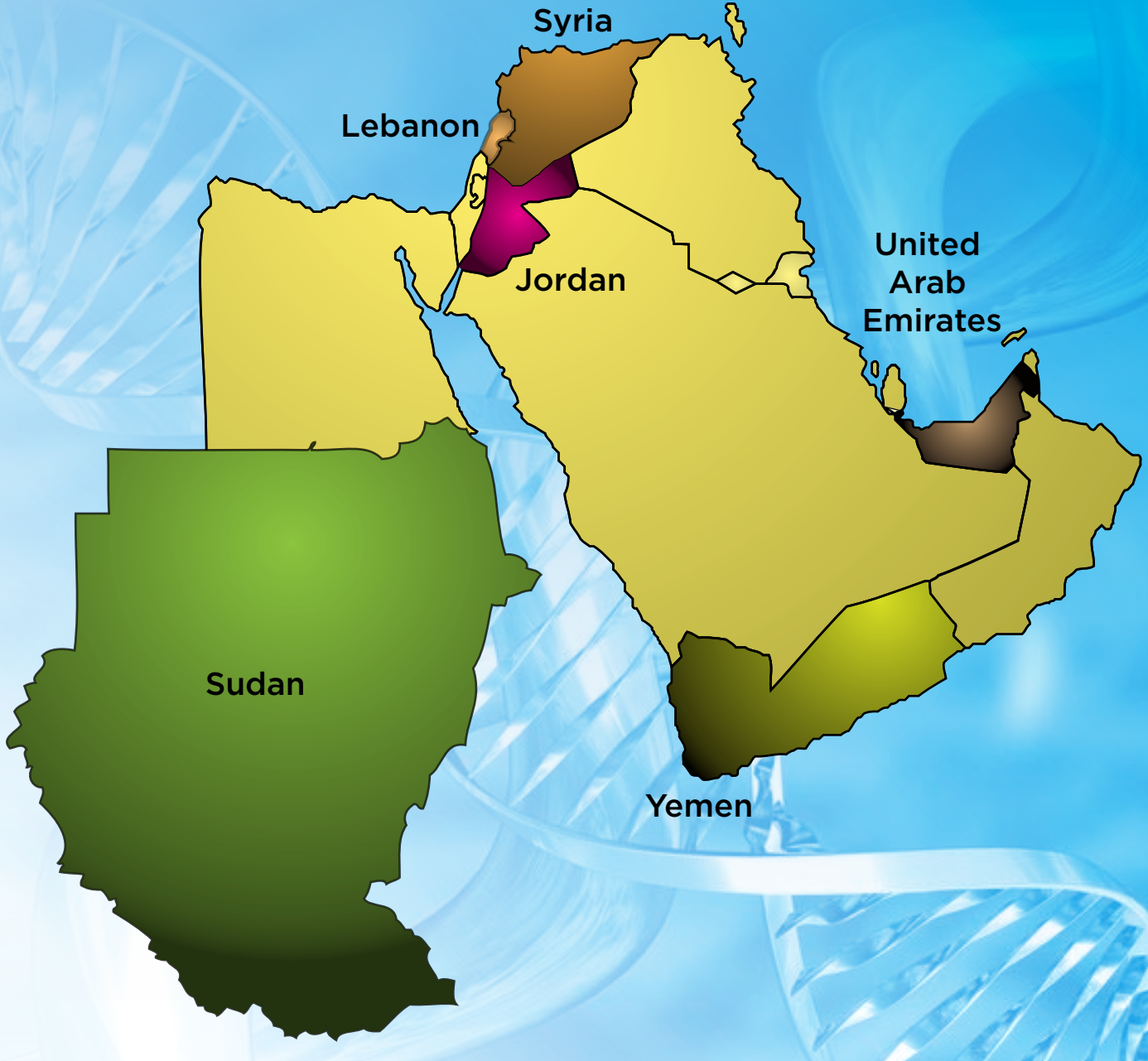
- an increased sustainable supply of the most affordable and nutritious supply of food, feed and fibre, which is critical for facilitating prosperity for both producers and consumers in the Arab States;
- sustainable crop production in the dry-land areas to alleviate poverty of the rural poor who are farmers and the rural landless who are dependent on agriculture for their lively hoods
- Speeding the crop breeding that will mitigate the new challenges associated with climate change when droughts will become more severe and prevalent, temperature changes will be more variable, and when agriculture which produces up to 30% of greenhouse gases, must be part of solution rather than part of the problem.

On the another hand, investment opportunities in biotechnology in the region are highly needed and required a strong partnership and alliance between the public and private sectors which have a visible and potential strategy to boost the adoption, investment and industrialization of biotechnology and their products for better sustainable agriculture and economy, healthy, safe, and sufficient food and feed, and safe environment.

In order for the region to be able to invest in biotechnology, certain requirements are needed:

- Outstanding centers which are run by good scientific personnel and very well equipped with all necessary facilities and instruments.
- Identification of the important products and their needs and demands with availability of investment environment.
- Developing a strategic research platform.
- Strong collaboration between public and private sectors.
- Good marketing strategy.
- An enabling policy and investment environment that will enhance and encourage the investment in this field.

Chapter II
Country Profiles; The regional analysis



Chapter II: Country Profiles; the regional analysis

2.1. Introduction

During the last decades, scientific and technological progress in modern biotechnologies have opened new perspectives to the national/regional strategies to fight poverty by providing powerful tools to contribute to food productivity and safety and promote environmental sustainability. In agriculture, the use of modern biotechnologies has had its main expression in the development, introduction and wide dissemination of genetically modified organisms (GMOs) including genetically modified (GM) crops, and related commodity products. GM crops are increasingly part of the global food/feed market, including in the developing countries where they are contributing to higher production and economic benefits.

In the Near East and North Africa region, agriculture is a key element of the economy and an important source of employment and most of the countries are committed to implementation of the Global Plan of Action for Conservation and Sustainable use of Plant Genetic Resources for Food and Agriculture for boosting production and development. Despite the initial acceleration, the region is experiencing delays in the adoption of new biotechnologies and in the implementation of national NBFs, mainly due to lack of adequate institutional capacities in the area. Once functional, the NBFs will provide the base to create an efficient biosafety management system to merge countries needs for a smooth advancement in biotechnology applications with the necessary regulatory and technical precautions.

In this context, a consultation was organized on 'Biotechnology and Biosafety for Agriculture and Environment' in Aleppo, Syria, on 8-10 September 2007 with the national authorities in the region and in coordination established with other international organizations such as the United Nations Environment Programme (UNEP) and the International Centre for Agriculture Research for Dry Land Areas (ICARDA). The solid dialogue confirmed that foundations have been laid for future sustainable growth in biotechnology, and biosafety was a priority area of work in the region. In particular, it showed that most of the countries of the region have their primary legislation in place and are currently developing specific implementing regulations in line with the international obligations. However, human and technical capacities haven't followed these development trends and show a great variability from one country to another. These weaknesses are especially clear with respect to GMOs research, monitoring and detection activities. This was, as it was pointed out, mainly due to a general lack of coordinated investment in biosafety for biotechnology advancement in most countries of the region.

The regional workshop in Aleppo brought the countries to opt for improving their regional cooperation in GMO detection as a step towards strengthening their capacities in the area in a cost effective manner.

As a follow-up, six countries from the region, namely: Lebanon, Jordan, Sudan, Syria, united Arab Emirates and Yemen, have submitted a request for technical assistance to FAO and a proposal for a regional technical cooperation project was developed, aiming at:

- establishing a regional mechanism for sharing experiences, expertise and know-how and harmonizing laboratory procedures, standards, and techniques of GMO detection;
- training relevant officers and technicians at national level in the subject,
- developing a platform for information sharing and networking amongst technical staff in GMOs detection laboratories.

The main outcome of the project will be increased collaboration in GMOs detection and enhanced harmonization of the related laboratory procedures, standards, techniques among the participating countries as well as strengthened technical skills in GMOs detection in agriculture products. These together will foster the process for setting up a 'Regional Platform for GMO Detection' for the regular exchange of information and experience that progressively could be extended to other countries in the area.

The project has four main outputs as follows:

1. Enhancing regional collaboration in GMO detection among the participating countries, in particular among national reference GMO detection laboratories in order to harmonize their practices and certification schemes based on common standards and good practices.
2. Developing a training package in GMO detection, including an information exchange forum to be made available for the project training activities as well as for future in-house training courses.
3. Increasing the capacities of technical staff of the participating countries in GMO detection.
4. Preparing an agreement between the participating countries for the establishment of the 'regional platform for GMO detection in the region'.

2.2. Enhancing regional collaboration in GMO detection:

The project has undertaken a stock-taking exercise in the six countries through national assessments of the current biotechnology applications in these countries with special reference to GMO production, GMO detection practices, available laboratory expertise, techniques and equipment in use and possible physical, technical and regulatory gaps and/or bottlenecks.

Moreover, this process provides the benchmark for these areas and thereby, will facilitate setting up the process for establishing a regional platform. The national assessments have been carried out by national consultants. The analysis of the results of these assessments will form the basis for this benchmark document entitled: 'Status and Options for Regional GMO detection Platform'-A Benchmark for the region. This document.

The following set of tables is a synthesis and comparative analysis of the status and issues related to biotechnology research, existing infrastructure and human resources engaged in agricultural biotechnology in the six countries under study. This chapter will also focus on GMO detection in the region including:

i) A comparative analysis of the GMO detection practices in use in the six countries involved;

ii) Identification of options for the harmonization and partnerships among the coutries GMO-detection practices and standards

2.3. Table 1: Highlights of Biotechnology Applications

Country	Plant Biotech.	Animal Biotech.	Others
Jordan	• Tissue culture • Micro-propagation of different plants • Production of disease-free plants • Selection of biotic and abiotic tolerant stocks • Characterization of plant genetic resources (using molecular markers such as RAPD,AFLP,SSR and ISSR) • Virus and fungi detection and identification	• Production of immunological diagnostic kits and animal vaccines • Screening for organisms that have a potential biotechnological application • Animal and human cell culture on medical and veterinary applications	• Study conducted on the (Allele and genotype frequency for pti gene in cows at Jordan)
Lebanon	• Tissue culture • True-to-typness of plant materials • Production of virus free materials • Characterization of plant genetic resources (using molecular markers) • Virus detection and identification • Immunodiagnostic of viruses • GM tomatoes tolerant to TYLCV	• Diagnosis of animal diseases (using RT-PCR) • Identification of the ethiologic agents that are involved in economic diseases of animals (using RT-PCR)	• Detection of pathogens in food products • Detection of myco-toxins in food • Towards production of biopesticides (Bt)
Sudan	• Plant tissue culture for mass production • Development of doubled haploid wheat for heat stressed environment • Transgenic drought tolerance Maize	• Production of vaccines • Artificial insemination to improve the genetic make up and productivity of the Sudanese Nubian goats • Embryo transfer (ET) in bovine • Diagnosis of viral and parasitic diseases	• Molecular diagnostic techniques used for detection and identification of specific infectious agents
Syria	• Molecular biology techniques • Genetic transformation • Tissue cultures • Animal and human cell culture • In vitro fertilization and embryo culture	• Embryo transfer • Diagnosis of animal diseases • Production of animal vaccines • Fingerprinting of Alawasi local sheep	• Brewing industry • Beer industry • Yeast production
UAE	• Micropropagation and tissue culture of date palms • Biosaline Agriculture		
Yemen	• Several breeding programs of field crops • Tissue culture		• Fishing and Algae Biotechnology

2.4. Table 2: Institutions Involved in Biotechnology

Country	Academia		Research Institutions	
	Public	Private	National	International
Jordan	Jordan Univ. of Sci. & Tech. (JUST) Univ. of Jordan Al-Balqa Applied Univ. Hashemite University Mu'tah Univ. Yarmuk Univ. Al-Albyt Univ.	Although some of the private universities have biotechnology programs. No research activities are going on in Biotechnology. Research is very limited as they are teaching oriented.	National Center for Agriculture Research and Extension (NCARE) National Biotech. Center Jordan Institution for Standards and Metrology Ministry of Agric. (MOA)	JOVAC VAPCO Syngenta Monsanto
Lebanon	Lebanese University (Establishment of AZM Center of Biotechnology in process)	American Univ. of Beirut Saint Joseph Univ. (USJ) American Univ. for Sci. & Tech. (AUST) Univ. of Balamand (UOB) Notre Dame Univ. Lebanese American Univ. (LAU) University of Saint Esprit of Kaslik (USEK)	Lebanese Agricultural Research Institute (LARI) Industrial Research Institute (IRI) Lebanese National Council for Science Research (LCNRS)	
Sudan	University of Khartoum Gezira university University Sudan	Nilain University	Agric. Res. Corporation (ARC) Commission of Biotech & GE Lina Tissue culture Co Date Palm production Co. Kenana Sugar Co.	
Syria	Tishreen Univ. Aleppo Univ. Damascus Univ. ALU-Bath Univ.		Ministry of Agric. & Agrarian Reform (MAAR) Atomic Energy Commission of Syria (AECS) General Commission for Biotech. (GCBT) Scientific Studies and Res. Center (SSRC) Green House Co. (Latakia) Scientific Council for Pharmaceutical Industries (SCPI)	International Center for Agric. Res. in the Dry Areas (ICARDA) Arab Center for Studies of Arid and Dry Areas (ACSAD)
UAE	Date Palm Tissue Culture Lab. (DPTCL)		Al Wathba Marionnet Green coast nurseries Al Rajhi Laboratory Advanced Biotech. Center (ABC), Dubai Dubai Biotechnology and Research Park (DuBiotech)	International Center for Biosaline Agriculture (ICBA) APRP/ICARDA International Center for Agric. Res. in the Dry Areas
Yemen	Univ. of Sana'a Univ. of Aden Univ. of Taiz Univ. of Hadhramout Univ. of Hudaida Univ. of Dhamar Univ. of Ibb		Agricultural Research and Extension Authority Ministry of Agriculture & Irrigation	YASAD YAPB

2.5. Table 3: Institutions Involved in GMOs R & D

Country	Academia		Public Institutes	Private Companies
	Public	Private		
Jordan	Jordan Univ. of Sci. & Tech. (JUST) Univ. of Jordan Al-Balqa Applied University Mu'tah University Yarmuk University Al-Albyt University		National Center for Agriculture Research and Extension (NCARE) National Biotech. Center FDA Jordan Institution for Standards and Metrology Ministry of Agric.	Al-Nawa Nurseries Al-Barakah Nurseries Sukhtian Company JOVAC VAPCO Syngenta Monsanto
Lebanon	Lebanese University (Establishment of AZM Center of Biotechnology in process)	American University for Science and Technology (AUST): Reference Laboratory upon designation by the Ministry of Economy and Trade to be the accredited laboratory for GMOs detection. Univ. of Balamand (UOB) American Univ. of Beirut Saint Joseph Univ. USJ	Lebanese Agricultural Research Institute (LARI) Lebanese National Council for Science Research (LCNRS)	
Sudan	Khartoum University Gezira university University Sudan	Nilain University	Agric. Res. Corporation Commission of Biotech & GE	Lina Tissue culture Co. Date Palm production Co. Kenana Sugar Co.
Syria	Tishreen University Aleppo University Damascus University ALU-Bath University		Ministry of Agric. & Agrarian Reform (MAAR) Atomic Energy Commission of Syria (AECS) General Commission for Biotech. (GCBT) Scientific Studies and Res. Center (SSRC) Arab Center for Studies of Arid and Dry Areas (ACSAD) International Center for Agric. Res. in the Dry Areas (ICARDA)	Green House Co. Scientific Council for Pharmaceutical Industries (SCPI)
Emirates	Date Palm Tissue Culture Lab. (DPTCL)		International Center for Biosaline Agriculture (ICBA) APRP/ICARDA Dubai Biotechnology and Research Park (DuBiotech)	Al Wathba Marionnet Green coast nurseries Al Rajhi Laboratory Advanced Biotech. Center (ABC), Dubai
Yemen	Sana'a University Aden University Taiz University Hadhramout University Hudaida University Dhamar University Ibb University		Agricultural Research and Extension Authority Ministry of Agriculture & Irrigation	YASAD YAPB

2.6. Table 4: Status of Biosafety Regulations

Country	(CPB) Cartagena Protocol on Biosafety	(CBD) Convention on Biological Diversity	Biosafety Regulatory Status (National Biosafety System)	Others
Jordan	✓ (Nov 2003)	✓ (1992)	✓	(SPS, TBT, TRIPS, Article XX of GATT) WTO agreement
Lebanon	✓ (Oct. 2008)	✓ (1994)	✓	NBSAP (1998), WTO agreement (accession in process)
Sudan	✓ (2005)	✓ (1985)	✓	
Syria	✓ (Apr. 2004)	✓ (1994)	✓	
UAE	✗	✗	✗	
Yemen	✗	✗	✗	

2.7. Table 5: Examples of GM Detection Applications

Country	Case			
	Targeted Genes	Detection Methods	Crop	Date
Jordan	CaMV 35S promoter	PCR	Some market food	2002
Lebanon	CaMV 35S promoter, NOS terminator, Cry genes	PCR	Corn	2007-2008
Sudan	CaMV 35S promoter, NOS terminator	PCR and RT-PCR	Corn Soybean	2007
Syria	33 different cases : • Lactin gene • 35S promoter • NOS terminator • Zein • invertase genes • bar gene • EPSPS gene • cry1A(b) • *npt*I gene • GUS gene	PCR and RT-PCR	Corn Soybean Barley Tomato Cucumber Sunflower	2007 (GCSAR)
UAE	Facilities for GMO detection are available, (No cases were reported)			
Yemen	No genetically modified crops or microorganism were imported, No facilities is available for production or detection of GMOs at present			

2.8. Findings and Recommendations

During discussions it was evident that the Arab states involved in this study recognize the importance of biotechnology, especially in regard to food trade. Special emphasis is placed on the cooperation with international organisations, such as FAO and WHO, and among the Arab States. The UAE, as well as other GCC countries, highlight their special situation as net food importers, and their need to be adequately equipped and prepared to test imported foods for their nature, quality and safety, indicating that current testing for GM foods in imported products is only sporadic and on a case by case basis. The use of analytical kits, particularly for the application of ELISA technique to GMO food detection is indeed well known, but further training on the proper application of these kits is needed. Furthermore, at least one laboratory should seek and obtain accreditation in GMO food analysis from an internationally recognized institution as this is important for international food trade.

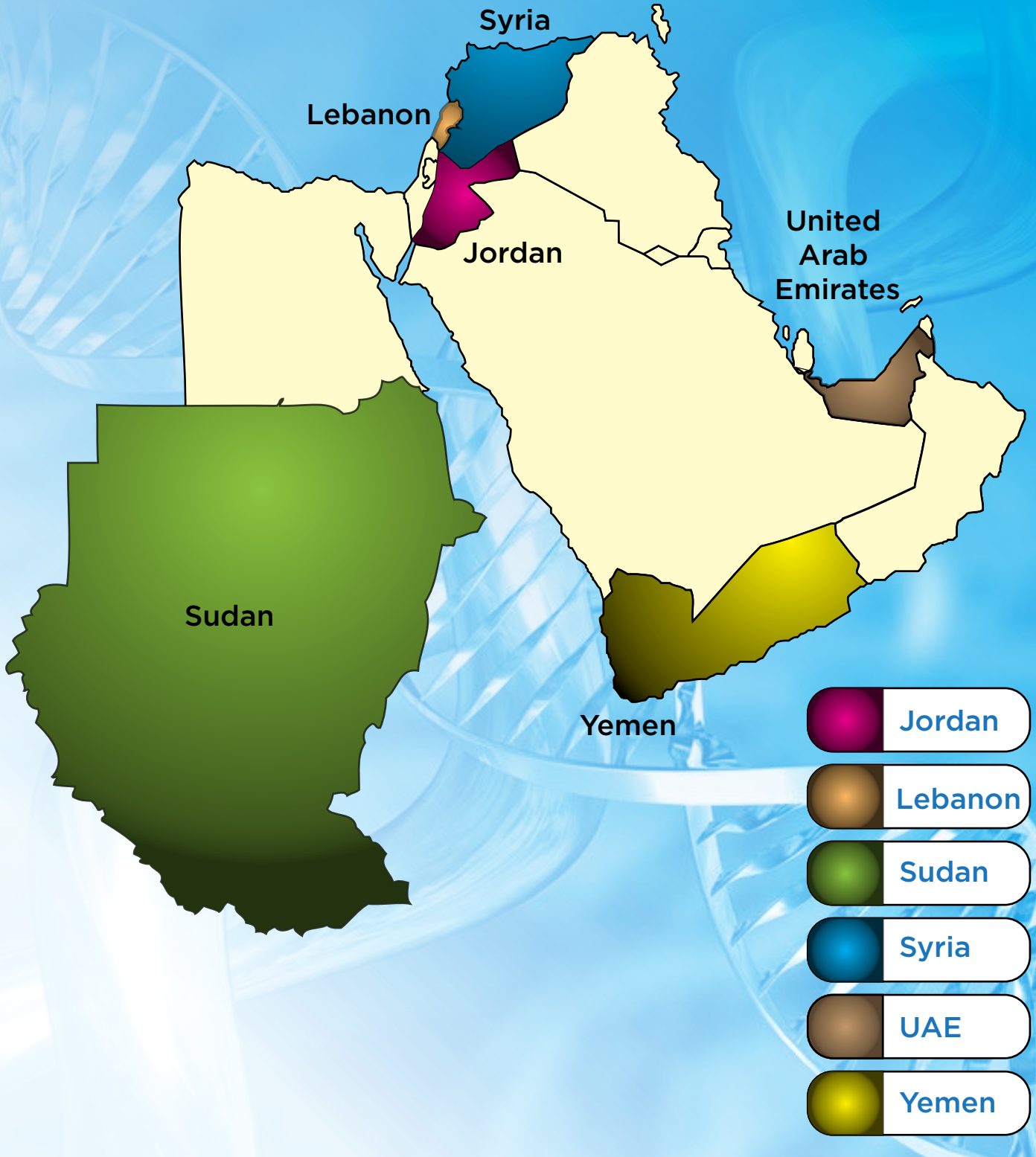
It was also apparent that a monitoring and surveillance system should be put in place to check on the presence of GM foods in imported food shipments. Capacity building is urgently needed to strengthen the ability of Arab countries to control and test GM foods and foster research in the area of biotechnology. There is also a need to strengthen capacities both at regulatory and institutional level and to improve partnerships and dialogue at the regional level through strengthened technical, institutional, international cooperation on biotechnology and biosafety.

Moreover, the United a number of Arab countries are not signatory to the CPB so far and lack specific skills within its regulatory system. Indeed, currently, countries as single entities and the region as a whole cannot fully address the problems deriving from uncontrolled movements of GMOs in the area which could produce unpredictable effects on the regional biodiversity and human health.

The following gaps could be true and common among the Arab countries under study:

- Lack of full technical expertise in GMO detection and the evolving methodologies and practices;
- Lack of standardized procedures for the management of GMOs at various ports of entry;
- Lack of trained staff in GMOs detection and monitoring;
- Lack of equipment and containment facilities; and
- Lack of technical information or access to information in Arabic as a preferred language

Chapter III
Individual
Country Reports



Jordan

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National Centre for Agricultural Research and Extension (NCARE)

3.1. Jordan

1. Status of biotechnology in Jordan

Jordan is located in the Middle East with Israel and the West Bank to the west, Syria to the north, Iraq to the northeast, and Saudi Arabia to the east and south. It is slightly smaller than Indiana and encompasses a total land area of 92,300 square kilometers (91,971 square kilometers of land and 329 square kilometers of water). Jordan consists mainly of a plateau that varies in elevation from 700 to 1,000 meters and is divided into ridges by valleys and gorges and a few mountainous areas. The valley floor varies in level, dropping from just above sea level in the north to 400 meters below sea level at the Dead Sea—the lowest point on earth. Variation in climate and topography in Jordan has led to a wide diversity in ecological habitat and flora. Flora of Jordan comprises approximately 2500 species ecologically and genetically adapted to local conditions. Most of these species are even adapted to the dryer parts such as the desert of Jordan. The country has a four distinct biogeographical. Mediterranean, Irano-turanian, Saharo-Arabian (Badia) and Sudanian (Tropical penetration).

The Jordan total population of 6,342,948 million (July 2009 est.). Jordan is a food deficit country with an annual growth rate 3.3%, the population of Jordan is expected to reach 7.1 million by the year 2010 and will exert heavy pressure on the fragile natural resources base of the kingdom. Total imports of food commodities still exceed exports by far so that Jordan is a deficit country with respect to food supply. In 1990, the deficit in agricultural trade balance was around JD342 million. Between 1990 and 1995, there was a slight decline, but the deficit remained around JD 300 million. In 1999, the agricultural trade deficit reached almost JD 350 million (www.unep.org/biosafety/files/JONBFrep.pdf).

Biotechnology is considered to be a frontier area offering a new technological base for the provision of solutions to some of mankind's problems. This technological base involves interactions amongst people, microorganisms, biomass, and industry, underscoring the utilization of renewable resources with a low environmental impact and high regenerative capacity. Biotechnology has produced new products and processes in a number of economic sectors including agriculture, food processing, chemical and pharmaceutical industries, pesticides, detergents, feed stocks, recycling, and waste treatment. Jordan has made some progress in biotechnology projects for research and development. Projects have been undertaken by university laboratories, research institutions, and private companies in the following fields: plant tissue culture and basic biotechnology research (in medicine etc…), (Moh'd M. Ajlouni and H. Malkawi.

Jordan: Status and Future Prospects of Biotechnology (www.cgiar.org/biotech/rep0100/Ajlouni.pdf|). Jordanian universities have covered research and development (R&D) fields in biotechnology, in the following activities: 1. Embryo transfer in animals, 2. Early diagnosis using monoclonal antibodies, 3. Applied microbiology, 4. Biogas, 5. Single cell protein, 6. Enzymes and antibiotics, 7. Plant growth inhibitors, 8. Natural products, 9. Cloning, 10. Protein solvent concentration, 11. Bioreaction, 12. Gene isolation, 13. Biological nitrogen fixation.

Similar to most other developing countries, biotechnology in Jordan attracts high attention but still in early development stages and behind the developed countries. There are some efforts in Jordan to catch up in this rapidly developing area, especially in the fields of medicine and agriculture. Several universities have recently established graduate and undergraduate programs in biotechnology or genetic engineering. Research program in universities or biotechnology centers are using basic biotechnology, immunology, and molecular biology techniques (www.unep.org/biosafety/files/JONBFrep.pdf). There is also high research interest for and a limited production of immunological diagnostic kits and animal vaccines.

Traditional biotechnology is being used in Jordan for the production of food, drink and yeast. Some work was conducted in the area of screening for organisms that have a potential biotechnological application. Plant tissue culture has attracted high attention from public and private sectors. Several university, governmental and private research programs were conducted to optimize micro-propagation of plant tissues (www.unep.org/biosafety/files/JONBFrep.pdf). Tissue culture has been used for in vitro conservation and cryopreservation, production of disease-free plants, plant propagation, selection of biotic and a biotic tolerant stocks and production of secondary metabolites. Private and governmental laboratories commercially produce regenerated plants such as ornamental and cut flowers, date palm, potatoes and banana.

Animal and human cell culture is mainly centered on medical and veterinary applications such as in-vitro fertilization and embryo culture (www.unep.org/biosafety/files/JONBFrep.pdf). On the other hand, Jordan has King Hussein Institute for Biotechnology and Cancer which is a not-for-profit non-governmental organization in Amman, Jordan; it aims to provide state-of-the-art care for the purpose of eliminating suffering and death from cancer through education, awareness, prevention, diagnosis and treatment. Furthermore, the Institute aims to advance life sciences and biotechnology and their contribution to medicine in the world through innovative research and scientific discoveries (www.jordanembassyus.org/new/emp/eoKHIBC.pdf.).

The Jordan government is increasingly enacting policies to foster economic development. Jordan is party of several international treaties and conventions related to free trade (WTO, Arab Free Trade Agreement, Free Trade Agreement with the USA (2000), several bi-lateral trade agreements to establish free trade zones with some Arab countries; association agreement with the EU (2001)), intellectual property rights and the protection if biological resources (Convention on Plant Variety Protection (UPOV); Convention of Biological Diversity (CBD). Jordan ratified the International Treaty for Plant Genetic Resources for Food and Agriculture (ITPGRFA) (Redia Shibli, UNIDO study on agriculture biotechnology sector and investment opportunities in Jordan. www.unido.org).

1.1 Plant biotechnonlgy

Plant biotechnology, which is one of the many approaches involved to solve the complex problems of hunger, poverty and food insecurity, may be an appropriate technology within reach of rural and disadvantaged farmers (DaSilva et al., 2002). DaSilva et al. (2002) reported that the genetic engineering techniques generally are applied to crops important to the industrialized world, and less to crops on which the world>s hungry depend. In Jordan, modern plant biotechnology researches began before twenty years ago and researchers have been using the advanced biotechnology methods and techniques in molecular analysis of genetic resources as well other fields.

Jordanian researchers and scientists in biotechnology laboratories (See the Rosters of National Scientists Involved in Biotechnology Research in Jordan, (www.unep.org/biosafety/files/JONBFrep.pdf.), page 48-52) are working on the improving plant propagation and multiplication of major horticultural crops and fruit trees using tissue culture techniques to obtain virus-free plants utilizing tissue culture techniques and the technique is currently applied to potato, banana and date palm in both public and private sectors. Fingerprints of major cereals (such as wheat, barley, chickpea, and lentil), medicinal plants (Qisoum and hypericum), Sumac, olive, date palm and other crops for identification purposes was practiced by using RAPD , AFLP, SSR, SAMPL and ISSR techniques in genetic diversity studies. Experiments on genetic transformation has also been started at Al-Balqa' university / Jordan.

In Jordan, traditional biotechnology is being used in plant breeding improvements and food production. Plant tissue culture attracts much attention from the public and private sectors, where lab of tissue culture has been establishing since twenty years ago at Ministry of agriculture and it is under NCARE umbrella now. There is no GMOs produced, neither commercialized in Jordan. Jordan has not yet established specific laws that regulate biotechnology and Biosafety. However, active steps in this direction are underway.

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. Jordan government like other countries looking for harvesting the benefits arise from modern biotechnology taking into consideration the risks might be affected on the plant genetic resources, human health, livestock>s and environment. Incorporate biotechnology procedures within the circle of sciences, agriculture researches and food production is of priority in Jordan for increasing the productivity of crops, sustainability and food safety. Building capacity and research funding are keys for modern biotechnology success. Absence the cooperation between the different sectors and lack of such biotechnology regulation could complicate importing or local production of such biotechnology products.

Jordan gives major efforts for building capacity in biotechnology to keep in touch with the recent biotechnology developments, considering it a priority to improve agricultural production to be self-sufficient. Jordan has formulated national Biosafety guidelines since 2004. Jordan is developing country and needs a continues supporting in the field of biotechnology particularly GMOs, through international cooperation by projects funding and increase the number of qualified researchers in this field. Jordan government has limitations with their financial resources so the supporting will not meet the needs of researches. The Jordanian national research institutions are encouraged to deal with biotechnology aside to the conventional breeding programs for rapid growth development in agriculture sector. So far, there is no regulation to control introduction and handling of biotechnology products.

Table 1: Current, future, and essential biotechnology research in the industrial private sector (www.cgiar.org/biotech/rep0100/Ajlouni.pdf|.).

Current activities	Future activities	Essential activities
Tissue culture	Enzyme production	Amino acid sequence determination
Natural fertilizer	Veterinary drugs Applied microbiology	Applied microbiology
Monoclonl antibodies	Scientific laboratory equipment Biochemical engineering	Biochemical engineering
Scientific equipment		Bioreactor modeling
Yeast production		Environmental engineering
		Gene mapping, transfer, and synthesis
		Hormone synthesis
		Molecular genetics
		Molecular immunology
		Monoclonal antibodies
		Process engineering
		Protein engineering
		Single cell protein
		Enzymes
		Tissue culture
		Vaccine production

Current research activities at level of plant biotechnology

- DNA fingerprinting and phylogenetics of plant varieties and species.
- Biodiversity of wild plant species and detection mutations in Jordan.
- Detection of adulteration of food products based on DNA analysis.
- In vitro induction of plant tissues.

1.2 Animal and veterinary biotechnology

The activities of animal and veterinary biotechnology in Jordan are less than that of plant biotechnology. The working was exclusived in some of Jordan universities such as, in Jordan University of Science and Technology (JUST), the work focused only on in vitro fertilization in Awassi sheep and it did not show good work so far. Other work was done in the veterinary area and mainly involved with disease diagnosis using biotechnology approaches. Mut'ah University, started recently with minimal work on animal genetics using molecular markers. Some work has started on Baladi (local) chickens and on Baladi cattle in Jordan (Redia Shibli, UNIDO study on agriculture biotechnology sector and investment opportunities in Jordan. www.unido.org). In the NCARE, there is a limited working in this filed. Lately, in 2009 one study was conducted on «The Allele and Genotype Frequencies of Bovine Pituitary Specific Transcription Factor and Leptin Genes in Jordanian Cattle Population by Using PCR-RFLP» by Khaleel I. Z. Jawasreh, Faisal Awawdeh, Ibrahim Rawashdeh, Faiq Hejazeen and Miassar Al-Talib and published in Australian Journal of Basic and Applied Sciences, 3(3): 1601-1606, 2009.

In private sector, the working of veterinary biotechnology wasn't common, just they are interesting with vaccines production. However, vaccines and disease diagnosis kits for animal and fish diseases were produced. Jordan has 18 registered factories for veterinary drugs, 19 pharmacies and 15 registered stores in the year 2006. Jordan imported vaccines with about 5 million USD in the same year. Jordan also exports veterinary vaccines and medicines to almost all Arab countries, African countries and some Asian countries as well and others. This is a great opportunity but the technology to produce vaccines and other veterinary materials through biotechnology is still weak. Jordan needs a strike in this field. A huge market is available for this industry in the region and worldwide. In vitro-fertilization and embryo transfer in sheep and cattle (Redia Shibli, UNIDO study on agriculture biotechnology sector and investment opportunities in Jordan. www.unido.org).

The other activity was dealed with:

- Feed additives in the livestock production.
- Producing transgenic animal for high milk production.
- Producing transgenic animals that work as life bioreactors for the production of therapeutic proteins.
- Producing transgenic animals with disease resistance characteristics

1.3 Microbial/ industrial biotechnology

There is no evidences are obvious according to the microbial and industrial biotechnology in Jordan. All of needs in this filed were imported from companies of developing countries neighbor countries if they produced them. For microbial utility, the bacteria Lactobacillus acidophilus was used for production egg and meat with low cholesterol, also production of monoclonal antibodies against E. sakazakii, this monoclonal antibody once produced can be utilized in a test kit that can be used in food factories for a quick test before the release of the product. This will be particularly important in infant foods factories (Redia Shibli, UNIDO study on agriculture biotechnology sector and investment opportunities in Jordan. www.unido.org).

2. Physical facilities dealing with biotechnology

2.1 Research institutions (Academic and research center)

A. Public sector.

1. Al-Balqa' Applied University
2. Al-Albyt University
3. Al-Hashmiah university
4. Al-Hussein university
5. Jordan University
6. Jordan University of Science and Technology (JUST)
7. Mut'ah University
8. National Center for Agricultural Research and Extension (NCARE)
9. Yarmouk University

B. Private sector

1. Philadelphia university

Public Sector - Services

1. Incubator at College of Agriculture, University of Jordan
2. Food and Drug Administration (FDA)
3. Jordan Institution for Standards and Metrology
4. Ministry of Agriculture (MOA)
5. Ministry of Investment and Trade (MIT)
6. The National Biotechnology Center

Private sector (research, industrial production)

1. Al-Barakah Nurseries
2. Al-Nawa Nurseries
3. JOVAC
4. Sukhtian Company
5. VAPCO

Table 2: Physical facilities dealing with biotechnology in the public and private sector universities in Jordan.

Public sector	No. of functional labs.*	Year established	Funding sources	Laboratory infrastructure	Access to information
Al-Balqa' Applied University	2	1995	Government	Available	Journals and website
Al-Albyt University	1	2000	Government	Available	Journals and website
Al-Hashmiah university	1	2006	Government	Available	Journals and website
Al-Hussein university	1	2007	Government	Available	Journals and website
Jordan University	3	1989	Government	Available	Journals and website
Jordan University of Science and Technology (JUST)	4	1992	Government	Available	Journals and website
Mut>ah University	2	1999	Government	Available	Journals and website
National Center for Agricultural Research and Extension (NCARE)	5	1990	Government	Available	Data base- FAO electronic site
Yarmouk University	1	1999	Government	Available	Journals and website
Private sector					
Philadelphia university	1	2000	Private	Available	Journals and website

The number could be less or more based on faculty type within the University.

Table 3: Available human capabilities/ staff/ categories in biotechnology in Jordan.

Institute	* Plant Tissue Culture			Plant Molecular Biology			Animal Molecular Biology			Food Biotechnology		
	PhD	M.Sc.	Technician	PhD	M.Sc.	Technician	PhD	M.Sc.	Technician	PhD	M.Sc.	Technician
Al-Balqa' Applied University	2	1	2	2	1	2	-	-	-	-	-	-
Al-Barakah Nurseries	0	1	5	0	0	0	0	0	0	0	0	0
Al-Nawa Nursery	0	0	6	0	0	0	0	0	0	0	0	0
Jordan University	2	-	-	4	-	-	-	-	-	-	-	-
JUST/ Agriculture	1	1	1	2	0	0	2	0	0	2	0	0
JUST/ Biotechnology Department	1	-	-	6	1	-	-	-	-	-	-	-
Mu'tah University	-	-	-	2	0	0	1	0	0	1	0	0
NCARE **	0	2	4	3	5	2	-	-	-	-	-	-
Princes Haya Biotechnology Center	-	1	-				-	-	-	-	-	-

Table 4: Laboratories equipments and amounts in the NCARE, Jordan universities and private nurseries.

Equipment type *	Universities							Research center	Private nurseries		
	Al-Balqa' Applied	Al-Hashmiah	Al-Hussein	Jordan University ABU& AC	JUST& PHBC	Yarmouk	Mut ah	NCARE	Al-Nawa	al-Barakh	Ben Hayyan
Autoclave	-	-	-	2	4	-	-	3	2	6	-
Bacterial incubator	-	-	-	5	-	-	-	-	-	-	-
Balance	-	-	3	5	4	-	-	15	-	1	-
Centrifuge	-	3	3	3	-	2	2	10	-		1
Capillary EF	-	-	-	-	1		-	-	-	-	-
DNA isolation machine	-	-	-	-	-	-	-	1	-	-	-
DNA sequences	-	-	-	-	5	-	-	-	-	-	-
Deep freeze (-80C)	-	1	1	1	-	-	-	1	-		1
Distiller	-	-	-	2	1	-	-	2	-	-	-
ELISA reader	-	-	-	1	3	-	-	-	-	-	-
Freeze (-20C & 4C)	-	-	1	1	-	-	-	5	-	-	-
Gas Chromatography (GC)	-	-	-	1	1	1	1	-	-	-	-
Gene pulzer	-	-	-	1	1	-	-	-	-	-	-
Growth room	-	-	-	4	-	1	-	4	-	-	-
Chamber room	-	-	-	4	-		1	4	-	-	-
Horizontal gel electrophoresis	-	-	5	10	11	4	1	10	-	-	-
Hot plate	-	-	-	1	4	-	-	-	-	-	-
HPLC	-	-	-	2	1	1	1	1	-	-	-
Ice Maker	-	1	1	1	-	-	-	1	-	-	-
IR spectrophotometer	-	-	-	1		-	-	-	-	-	-
Laminar Air Flow	-	-	-	2	2	4	2	8	6	2	-
Microscope	-	-	-	11	1	-	-	6	-	-	-
Microwave	-	-	-	1	1	-	-	4	-	-	-
Oligonucleotide synthesizer	-	-	-	-	1	-	-	-	-	-	-
PH meter	-	-	-	1	1	-	-	5	-	-	-
Photo documentation system	-	1	2	1	-	1	1	5	-	-	1
PC)	-	2	1	10	6	2	1	7	-	-	2
Shaker	-	-	-	1	3	-	-	6	-	1	-
Southern blotting	-	-	-	-	3	-	-	-	-	-	-
Spectrophotometer	-	1	-	1	6	-	1	3	-	-	-
Protein EF	-	-	-	1	5	-	-	-	-	-	-
Real-Time PCR	-	1	1	1	1	-		1	-	-	1
Vertical gel electrophoresis	-	-	2	1	-	-	-	6	-	-	-
Virus testing	-	-	-	-	1	-	-	-	-	-	-
Water bath	-	3	10	1	1		-	4	-	-	-

More data available on (Redia Shibli, UNIDO study).
(-): Data or equipments are not available

2.3 Access to consumable, reagents and supplies

Companies importing biotechnology-derived products

All consumable materials and reagents imported from external of international companies and the Jordanian institutions were dealing with biotechnology research's purchased their needs from local agencies. A considerable number of companies are currently importing reagents, consumable materials and supplies used in biotechnology research, teaching and production processes in the different public and private institutions. Those include primers, kits, Petri dishes, chemicals...etc. It is estimated that about $ 3.0 million worth of supplies are used alone in Agriculture alone.

2.4 Existing biotechnology linkages with national, regional and international

There is a lack or gap in the collaboration between the international biotechnology centers, Jordan government and biotechnological institutions, all of them are looking forward to open the channels between them for supporting the research and private investments in this filed. At the national level, collaborating is existing particularly lab to lab collaboration

2.5 Publications

There is a huge published scientific papers related to the biotechnology and its branches in hardcover of local and international journals. In this report, selected papers will be mentioned to have view about the outputs in this filed. FAO was initiated database on biotechnology in developing countries (2007/2008) in which Jordan was included among them as well the databases have all publications.

3. Facilities engaged in GMO research and development

3.1 Procedures, protocols and techniques in use

3.2 Ongoing and planned GMO research and development efforts.

Jordan is one of the developing countries in the Middle East and has some ongoing projects in biotechnology. Most of the genetically improved organisms existed in the country are as a result of conventional traditional methods, for example genetically improved crop plants are available from the conventional breeding programs. To our knowledge very few studies are being conducted using the molecular biology technology (specifically recombinant DNA technology) to produce transgenic animals or plants. In addition Jordan is still working to have a license to conduct recombinant DNA technology research for the production of transgenic organisms. Many developing countries are importing genetically modified crops and are planted in their fields for trial and commercial use. It is possible that Jordan may start to plan to import some genetically modified crops. One of the main objective of the current case study is to educate people in the country to be aware of the new technology and how to deal with such products and to seek for an appropriate guidelines, risk assessment and regulations of all issues concerning GMOs.

3.3 Existing or planned collaboration in GMO activities (regional and international)

Some of Jordanian companies have been collaboration with Syngenta; which is «a Swiss company» that dealing with crop seeds and GM crops. They are selling seed in Jordan but they do not have any actual biotechnology work yet going on in the country (Redia Shibli, UNIDO study on agriculture biotechnology sector and investment opportunities in Jordan. www.unido.org). Also, Monsanto as a US biotechnology company involved with GM crops; Jordan is covered by Monsanto's regional office in Turkey responsible for the West Asia and North Africa Region (WANAA); but it has no biotechnology activities in Jordan (Redia Shibli, UNIDO study on agriculture biotechnology sector and investment opportunities in Jordan. www.unido.org)

3.4 Possible gaps (infrastructure, human, skills) affecting GMO R& D

In Jordan, human resources and infrastructure for biotechnology and biosafety and more specifically for risk assessment of GMFs is limited in spite of the long list of experts and many research work represented by the master theses shown in Annex I and II. However, there is an increasing interest by some institutions to train the staff in relevant discipline and equip their laboratories to increase its research potential in biotechnology (www.unep.org/biosafety/files/JONBFrep.pdf).

The constrains or possible gaps can be summarized as follows:

1. Shortage of highly trained manpower: the human resources are scattered in different universities, departments and centers. The scientists in the universities are buzzy, in most of the times, with research related to their promotion. There is no critical mass of scientists in the different lines of sciences and technology such as molecular biology, breeding, ecology, risk assessment and management.
2. Limited institutional capacity for training in biotechnology: lack of high technological equipment.
3. Lack of appropriate research environment and brain drainage.
4. Lack of basic organized information, required data and many essentials techniques.
5. Lack of sufficient participation of the private sector in research support and activities.
6. Lack of national biosafety guidelines
7. Insufficient funding: Biotechnology requires expensive and updated equipment.
8. Inadequate of awareness on the importance and potential use and application of biotechnology and the related safety.
9. Inadequate national systematic policy, strategies and structures.
10. Inadequate institutional collaboration and consultation in biotechnology resulted in dilution of the human resources.
11. Lack of sustainability and long term planning (www.**unep.org**/biosafety/files/JONBFrep.pdf).

4. Biosafety regulatory status

4.1. Status of biosafety framework in the Jordan

Despite the potential benefits raised from a new technology, the sounds of public and scientific concerns have been raised about the environmental and food safety of products derived from the use of modern biotechnology. In view of these concerns, the coming years may prove decisive for the commercial and economically viable uptake of the technology. Without the consent of society at large, the promise of biotechnology may not be realised. Safety concerns are being converted into extensive bodies of regulation and legislation.

Since no risk assessment guidelines have been approved yet officially, certain act regulations and guidelines should be considered and hopefully adopted in the near future. In the past, several committees have been formed in the Ministry of Agriculture to put guidelines and outlines for Biotechnology and Biosafety. Also, several committees were formed in the universities and the Ministry of Health for biotechnology and again nothing significant has been concluded. Lately, a national committee was made by the Prime Minister and headed by the Minister of Agriculture to put again guidelines for genetically modified food and nothing.

4.2 Compliance with international conventionals and protocols

Over the recent years, several internationally agreements were concluded to deal with biotechnology or were amended with respective provision. Examples are the WTO agreements (SPS, TBT, TRIPS, Article XX of GATT), the Biosafety Protocol of the Convention on Biological Diversity (CBD), Codex Alimentarius, etc. The Biosafety Protocol of the CBD is the foremost international instrument dealing with regulation in biotechnology and is legally binding for the signatory countries (http://www.cbd.int/biosafety/). Jordan actively participated in the negotiations leading to the Convention on Biological Diversity, and considers one of the earliest countries signed it at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, Brazil, in June 1992, and ratified it in 1993. Also, Jordan has been participated in the intergovernmental negotiations of the Biosafety Protocol in the past few years, and signed it in October, 2000, and ratified it in November, 2003.

Jordan government has taken many initiatives to project its environment since the independence of the Kingdom in 1946. The government has also realized that an essential impute to the protection of environment is the issuance and enforcement of environment related laws. Legislation and regulation pertaining to the environment have been adopted and enacted by the government of Jordan since 1950's. Present legislation and regulation include more than 250 articles related to environmental is-

sues. A new environmental law (law 1/2003) was adopted, and regarding to it a new ministry of environment were established.

Regarding the law No. 1 / 2003, the main tasks of the ministry are to set the general policies for the protection of environment and prepare the plans, programs, projects, measures and criteria and specifications for the elements of the environment, in addition to the supervision the public and private organizations and institutions. There are many of laws, by-law, regulations and decisions related to the biotechnology, biosafety and environment protections as follows:

1. By-law on hygiene and food safety (No. 8 / 1994):
2. Ministry of Agriculture (law No 4 / 2002 temporary)
3. Public health law (No. 21/1971)
4. The law for the protection of new plant species (No. 24/2000)
5. The law on descriptions and specifications (No.15/1994)
6. The by-law on health quarantine in Aqaba port (No. 32/1972)

4.3 Existing or planned biosafety regulatory bodies:

4.3. 1 National biosafety committee

4.3.1.1 National biosafety committee members (www.unep.org/biosafety/files/JONBFrep.pdf).

- Agriculture Engineer Association
- General Association for Foodstuff Merchants
- General Organization for Food and Drugs
- Jordan Institution for Standards and Metrology
- Jordan Veterinarians Association
- General Union for Farmers
- Ministry of Agriculture
- Ministry of Environment (Chair)
- Ministry of Finance-Customs
- Ministry of Health
- Ministry of Industry and Trade
- Ministry of Planning
- The Higher Council for Science and Technology
- The National Association for the Protection of the Consumers
- The National Center for Agriculture Research and Technology Transfer
- The Ministry of Environment will provide the Secretariat for the Committee.
- Two national experts nominated by the Chair
- Two Universities nominated by the Chair

4.4 Status of regulatory approvals

Regulatory framework of national biosafety management

The government of Jordan has taken many initiatives to project its environment since the independence of the Kingdom in 1946. The government has also realized that an essential impute to the protection of environment is the issuance and enforcement of environment related laws. Legislation and regulation pertaining to the environment have been adopted and enacted by the government of Jordan since 1950.s. Present legislation and regulation include more than 250 articles related to environmental issues. A new environmental law (law 1/2003) was adopted, and regarding to it a new ministry of environment were established. Based on the above information, we found we don't have any regulation in Jordan deal with LMOs or the biotechnology products direct, so we start to work on a regulation which can control transporting dealing and use of the LMOs product based on the Cartagena Protocol. A subcontract was done with national experts to draft the By-law to control dealing with biotechnology based on the ministry of environment law. Three workshops were organized to discuss the draft also another workshop was organized in presence of an international expert.

The draft covers the following features: controlling transporting, dealing and using LMOs, labeling the LMOs products, a national committee to follow this by-law which they can establish any technical / advisory committees to do risk assessment for any LMOs products. The national regulatory system of biosafety will be established according to the identified scope of By-law to govern various phases and areas of 13 modern biotechnology development to prevent their negative impacts on human health and environment. The experience in other countries and the experience and expertise available in international organizations will be drawn upon and the reality in Jordan taken into account to gradually improves the biosafety regulatory system. The components of the national regulatory system for biosafety will include: 1. A national By-law on biosafety; 2. A number of specialized regulations concerning biosafety; and 3. A set of management procedural regulations, including institutional legislation concerning EIA, assessment procedures, and technical guidelines for assessment. The first step in developing appropriate policies and procedures for the regulation of biotechnology is to establish a National Biosafety Committee (NBC) under the Ministry of Environment.

The NBC should then move quickly to establish policies and procedures to govern the use of modern biotechnology and its products in Jordan (www.unep.org/biosafety/files/JONBFrep.pdf).

By-Law for Biosafety of Genetically Modified Organisms Issued in Accordance with Article No (23) of the Law of Environment No (1) for the Year ( ). Article 16: Regional cooperation ' Jordan may enter into agreements for regional cooperation in any field related to GMOs, particularly with respect sharing information and building capacity to manage GMOs (www.unep.org/biosafety/files/JONBFrep.pdf).

5. Capacities for GMO detection

5.1 Examples/ case study on GMO detection

5.2 Areas of implementation/national adoption

5.3 Detection fees

Genetically modified (GM) plays a great role for identifying targets for development of new drugs and vaccines against diseases, as well as for producing high yield crops. GM has been using in animals and engineered to produce milk or therapeutic agents to benefit humans. GM animals are being produced that stay healthy, offer higher yield and eat less. Insects that spread disease are being genetically modified in a way that renders them incapable of transmitting disease. The potential hazards of these new practices must be carefully evaluated to minimize adverse harm that might occur not only to the GM species but also to humans, adverse effects on environments and ecosystems, and changes in the ability of animals to be reservoirs for human disease.

These practices therefore need mechanisms for careful monitoring and control. The application of GM crop technology must therefore be considered on a case by case basis, evaluating rationale, need and evidence (WHO. 2004. www.emro.who.int/rpc/pdf/EMRC51TechDisc03.pdf). Detection of GMOs is very important issue to be seriously considered for the great interest and benefit to the farmers in controlling the GMOs introduction into the country. Also, GMO detection is a prerequisite for enforcement of such regulation when already in place.

Marketing of biotech crops in Jordan is prohibited (Giles and Khraishy, 2007). Based on the time and effort were spent for information surveying about GMO in Jordan through internet sites and publications, there is no working was done on GMOs either producing the transgenic plants or testing the modified organisms, except some cases, in 2002, it seems that PCR was used for detection gene of CaMV 35S promoter from foods of local markets. So far, there are no GMOs approved in the Jordan and neither legislation controlling the introduction of GMOs into the country. There has been no permission already given regarding neither importation nor field release or commercialization of GMOs into environment. Also, regulating the GMO introduction with potential capability of detection in Jordan is required.

The LAW of biosafety regulations is stilling between hands of Jordanian parliament waiting to be ratified. However, GMO detection faced the following gaps:

1. Lack of full technical expertise in GMO detection, methodologies and practices.
2. Lack of modern molecular biology equipment and containment facilities.
3. Lack of standardized procedures for the management of GMOs at various ports of entry
4. Trained staff in GMOs detection and monitoring is needed.
5. Lack of financing supporting.
6. Lack the coordinating and the cooperation between institutions dealing with GMO detection.
7. Lack the risk assessment and management.

Lack of financing is the most important restriction in universities and official institutions and in the private sector

1. Although financial support is a serious problem, researchers (15 percent) cited other problems such as the shortage of professional technicians trained on advanced and specialized scientific equipment. Also of concern is the approvals procedures for biotechnological research, especially the long time between presenting the proposal and its implementation. The result is decreased interest of the researcher, who will often pursue other areas of research (www.cgiar.org/biotech/rep0100/Ajlouni.pdf|).
2. Another problem facing researchers in this area is the lack of consumable materials and routine ordering procedures (www.cgiar.org/biotech/rep0100/Ajlouni.pdf|).
3. It is important to mention that the right scientific atmosphere is often absent for this type of research activity; the importance of this type of research is not made clear; it is expensive; it does not directly produce goods for people; and there is a lack of scientific literature and other materials. This lack of public awareness of the importance of biotechnology research and the absence of scientific groups who will provide the necessary cooperation and technical assistance to the researcher were cited by 30 percent in the survey (www.cgiar.org/biotech/rep0100/Ajlouni.pdf|).

   Analysis at the national level of country contribution to the regional platform

1. Contribution of Jordan

Jordan will contribute with the regional platform through the following terms:

A. Feasibility studies

Jordan needs to make feasibility studies in collaboration with international organizations, NGOs as well other regional institutions to facilitate the investment areas in biotechnology and enhance the interest of investors in this area. Any expected problems for the investment in this area must be solved to enable the investment environment.

B. Biotechnology research

Research must be oriented to applied biotechnology to help in producing protocols and products that can be transformed to business in the Agriculture Biotechnology area.

C. Business incubator

Incubator (at UJ) must play a major role in looking after any opportunity in biotechnology to maximize the benefits of any ongoing research. More incubators are needed especially at JUST and NCARTT to facilitate more benefits of agriculture biotechnology research done there.

D. A national strategy for biotechnology

A national strategy for biotechnology is needed in Jordan to set up the areas of interest and the future prospects of agriculture biotechnology in Jordan.

E. GMOs network

Prompting a regional network in agriculture biotechnology and GMOs activities is a crucial at this stage to have progress in the events of biotechnology. This network will help in advancing the understanding of scientific issues relating to nutrition, food safety, toxicology, risk assessment, and the environment. Also, there is also need for a network at the regional level for technical capacity building in biosafety and risk assessment aspects.

2. National and regional perspectives in agriculture, food, biosafety and nutrition

- Climatic changes, GMOs, natural resources and plant genetic resources are the life keys and issues of the next generations should be conserved
- Environment protection and human heath should be taken into consideration with release GMOs products in the future
- Meetings should be in a regular time between countries to display the lasts out puts of the established project.
- Promoting and protecting biodiversity and natural resources
- Promoting collaboration between participants and neighboring countries in addition to those
- Strategies for enhancing safety and security in the food and agriculture is required.
- Stressing on the biosafety regulations, guidelines, laws and decisions and should be raised are not included within this project for controlling the borders and struggle GMOs smuggles.
- The national biosafety regulations should be harmonized with other countries in the region and their trading partners.

6. Conclusion

Strengthen capacity for establishment a platform for GMOs detection is a crucial decision to Jordan and participants countries. Import, handling and release genetically modified crops as well food products should be followed the national and international biosafety regulations. Development of suitable reference GMOs detection labs are needed at this stage. International funds through bilateral and multilateral projects and donation is needed.

Lebanon

Dr. Lamis Chalak

Lebanese University and Lebanon Agricultural Research Institute (LARI)

3.2. Lebanon

Introduction

Lebanon is a small country of 10 452 km2, located in the Near East Fertile Crescent region, which is considered as an important center of diversity in the world and where plant domestication started ten thousand years ago. Topographical, climatic and landscape diversity create diverse agro-ecosystems ranging from semi-arid to humid that allow for a large number of plant genetic resources ranging from temperate to subtropical crops to live and flourish. The main crops grown in Lebanon are olives, fruit trees and cereals each representing over 20% of the total cultivated area in the country, followed by tubers and fruity vegetables. About 36% of Lebanon is cultivated land, of which 7% is covered by forests and 57% is non-cultivated land or temporary pasture. In 2007, the cultivated area was about 277 000 Ha out of which 135 000 Ha is irrigated. Also, more than 30% of the population is entirely dependent on agriculture.

Modern biotechnology, synonymous with genetically modified organisms or GMOs, is today a main contributor to sustainable agriculture in the developed world, and in several developing countries in South America and the Far East. However, one can not say the same for the developing countries in the Near East and North Africa region. In such countries, conventional germplasm improvement programs are conducted largely by government institutions. Some of them have recently started to incorporate modern biotechnology tools in their programs. Nonetheless, failing to adopt biotechnologies places such developing countries at the risk of becoming markets for biotechnology-related products and renders their markets dependent on industrialized nations.

Although modern biotechnology has many advantages, it is not totally safe. There are many concerns regarding the impact of the products of modern biotechnology on the environment, human health, and animal health. Some of the adverse impacts of biotechnological products on ecosystems include the potential of weediness and the possibility of transferring genes to wild relatives. Moreover, the stability of the transfered genes is doubted. In this context, risks associated with GMOs fall into the categories of food safety, environmental and ethical.

Conscientious about the conservation of its natural resources and agro-environment, Lebanon has ratified the Cartagena Protocol on Biosafety (October 2008) that provides a guidance to the rational management of the risks associated with the use of modern biotechnologies and allows establishing an advanced informed agreement

(AIA) procedure for ensuring that countries are provided with the information necessary to make informed decisions before agreeing to import GMOs into their territory.

The implantation of Cartagena Protocol in the country requires the development and application of reliable methods for GMOs detection and analysis, together with capacity building on the base of appropriate sampling strategies and methods that are indeed essential for the application of the related biosafety regulatory aspects. Advanced techniques in molecular biology are for ensuring GMOs detection and analysis, both for trade and imports and for safeguarding the rich agro-biodiversity in the region.

In this report we will address the current status of agricultural biotechnology in Lebanon and the existing capacities for GMOs detection in line with Cartagena Protocol requirements.

1. Status of Biotechnologies in Lebanon

Presently, there is no official policy or strategy for biotechnology in Lebanon and, despite their limited capacities, biotechnology has been included in the structure and agenda of agricultural research institutions since the nineties.

1.1. Plant Biotechnology

- Production of certified plant material (true-to-type and virus free) of economically important crops by using tissue culture techniques. Mersitem culture ± thermotherapy has been successfully used for potato, prunus, strawberry, caper and ornamental species to produce virus free material. This sanitation procedure was usually followed by micro- propagation in order to achieve mass production of certified seeds/plants. In this context, a national cooperative project aiming at producing potato seeds is currently conducted at the Ministry of Agriculture in collaboration with an NGO in order to test the feasibility of the local production of potato seeds in Lebanon. The preliminary results are very encouraging. Another large scale application is the production and distribution of planting materials of fruits species root stocks that is predominantly carried out by the Ministry of Agriculture, the Lebanese private sector and CIHEAM Italy.
- Characterization of plant genetic resources of olive, fruit species and several leguminous by using molecular markers. Microsatellite markers associated to morphological descriptors are very helpful in assessing the diversity of the Lebanese patrimony and to determine the genetic distances and the cases of homonymy and synonymy among accessions.

- Virus detection and identification of new diseases by using conventional and RT-PCR. In this context, a long list of plant viruses, viroids and phytoplasm were identified in many crops cultivated in Lebanon such as Candidatus Phytoplasma phoenicium recently identified in the Lebanese almond trees, Candidatus Phytoplasma trifolii found to be associated with diseases of solanaceous crops (pepper and tomato), American Plum Line Pattern Virus detected on Lebanese cherries, two Fig leaf mottle-associated viruses found in the Lebanese fig trees.
- Immunodiagnostic of viruses using polyclonal antibodies developed against recombinant coat protein for producing antiserum for diagnosis of Prune dwarf virus.

- **Link with breeding programs:** Only few breeding activities have been carried out in Lebanon. They have been based on traditional crossings and were limited to wheat, barley, chickpea and lentil. Regarding fruit species, breeding activities are restricted to some clonal selection activities that have been recently conducted for stone fruits and grapevines. Only one single program relevant to Marker Assisted Selection (namely QTL's) was used by a special project funded by the EU (Improvement of water use efficiency in durum wheat), however, the work was carried out by ICARDA because of the absence of the facilities and know how in the Lebanese institutions.

1.2. Animal and Veterinary Biotechnology

- Diagnosis of animal diseases such as avian influenza virus by using conventional and Real Time PCR techniques. In this context, thousand of tests have been done through the Ministry of Agriculture in the framework of an investigation of epidemic studies. A similar study will be started in the coming months for diagnosing Blue Tong virus.
- Identifying to the molecular level the ethiologic agents that are involved in economic diseases of animals by using Real Time PCR, sequencing, electrophoresis, direct fluorescence, including the mycoplasma, viruses, bacteria and their plasmids. This program is undertaken through regional projects funded by the private sectors in developing countries.

1.3. Microbiological Biotechnology

- Identification of candidate genes of Bacillus thuringiensis in the aim of production of biopesticides. This activity is undertaken in collaboration with Tunisian Institution.
- Identifying pathogens species of fungus such as Aspergillus, Penicillim and Fusarium responsible of mycotoxins species (Afla- and Ochratoxins, Don) by using microbiological analytical techniques including Real Time PCR. These activities are undertaken through a research collaborative program between two national institutions within the framework of food quality and safety control applied on cereal grains.
- Detection and identification of pathogens in food products such as Salmonella, Listeria, Escerichia, by using microbiological analytical techniques including Real Time PCR.
- Isolation and characterization of microorganisms with high lipase activity.

1.4. Others

Other activities based on the use of molecular biology tools and related to basic sciences, food safety and health are conducted on different public and private academic institutions and hospitals. The examples are many:

- Basic sciences programs related to cell and molecular biology, DNA testing, cell differentiation, cancers, inflammation, and protein nucleic acids interaction are conducted by using molecular biology tools.
- Detection of myco-toxins in food by using chromatography techniques.
- Detection of melamine in milk and dairy products by using chromatography techniques.

2. Physical Facilities Dealing with Biotechnology

2.1. Involved Institutions

Research centers and academia are the major contributors to the agricultural biotechnology sector in Lebanon as shown in Table 1. They are:

2.1.1. Lebanese Agricultural Research Institute (LARI)

Based on decree 16766-1957, LARI is a governmental organization under the Minister of Agriculture supervision (NARS). The Institute conducts applied and basic scientific research for the development and advancement of the agricultural sector in Lebanon. In addition the Institute keeps close ties with the farmers and tries to develop research activities aiming at solving their problems. Seven centers located at different sites throughout Lebanon conduct research in crop production, crop protection, plant breeding, plant biotechnology, agro-biodiversity and genetic resources, medicinal plants, pomology, pasture and forage production, soil fertility, biology and biochemistry, animal health, poultry nutrition, ruminant production, irrigation and agro-meteorology, food technology and quality.

LARI houses four departments that are actively involved with biotechnologies:

- The Department of Plant Biotechnology that was established in 1997 is well equipped with tissue culture facilities and since 2006 with molecular biology tools such as conventional and Real Time PCR. Its main duties comprise the production of high quality plants of different species by using tissue culture techniques and the assessment of germplasm and diversity characterization for many fruit species by using molecular markers.
- The department of Phytopathology is commonly using the molecular tools for detecting and identifying plant pathogens.
- The Department of Food Safety for analytical and microbiological test methods that is seeking for accreditation ISO 17025.
- The Department of Animal Diseases (biosafety level III) that is well equipped with molecular tools such as Real Time PCR. It is currently working to fulfill the ISO 17025 accreditation requirements process.

At the national level, official conventions for collaboration in research and development already exist between LARI and the Lebanese academia. Undergraduate and graduate students are regularly joining the LARI laboratories for training and thesis preparation.

2.1.2. American University of Beirut (AUB)

Chartered in New York State in 1863, the AUB was established in 1914 in Lebanon. It is an institution of higher learning founded to provide excellence in education, to participate in the advancement of knowledge through research, and to serve the peoples of the Middle East and beyond. The AUB regroups many faculties such as Faculty of Agricultural and Food Sciences, Faculty of Medicine, Faculty of Health Sciences, Faculty of Arts and Sciences…

Since its origin in 1952, the Faculty of Agricultural and Food Sciences has been a leader in the agri-food industry in Lebanon and the Middle East. Actually, two departments are mostly involved in agricultural biotechnologies and well equipped with molecular biology tools: the Department of Agricultural Sciences (Laboratory of Plant Pathology established in 1960) that provides education and preparation of graduates for productive careers in agricultural technology, natural resources management, and agribusiness; the Department of Animal and Veterinary.

Table1: Lebanese Institutions and functional laboratories dealing with biotech

Institutions / webpages	Year established	Departments/Laboratories dealing with Agricultural Biotechnology	Mission	Main Programs / Activities	Equipments	Funds
Lebanese Agricultural Research Institute (LARI) (main NARS institution) www.lari.gov.lb	1957	Department of Plant Biotechnology	Research & Development	- Production of certified plant material (true-to-type and virus free) of economically important crops. - Diversity assessment and characterization of plant genetic resources of olive and fruit species by using molecular markers.	Plant Tissue Culture facilities DNA facilities Real Time PCR	National funds. International funds through bilateral and multilateral projects. Donation.
		Department of Phytopathology	Research, Development & Vulgarisation	- Pathogens detection and identification of new diseases.	DNA facilities	
		Department of Food Safety Accreditation for microbiological test methods ISO 17025 in process.	Research, Development & Vulgarisation	- Monitoring Food Quality Identifying pathogens species of fungus.	DNA facilities	
		Department of Animal Diseases (biosafety level III). Accreditation ISO 17025 in process.	Research & Development & Vulgarisation	- Detection and prevention of animal diseases - Investigation of epidemic studies.	DNA facilities	
American University of Beirut (AUB) www.aub.edu.lb	1914	Department of Agricultural Sciences, Laboratory of Plant Pathology	Education, Research & Development	Agricultural technology Natural resources management Agribusiness	DNA facilities	Internal funds. International funds through bilateral and multilateral projects.
		Department of Animal and Veterinary Sciences	Education, Research & Development	Animal science Animal Biotechnology Basic medical sciences	DNA facilities	
		Department of Biology Medical Center	Education, Research & Development	Cell and molecular biology Cell differentiation, Cancers, etc...	DNA facilities	
Saint Joseph University (USJ) www.usj.edu.lb	1875	Department of Science	Education, Research & Development	- Diversity Assessment of endemic plants by using molecular markers. - Animal biotechnology.	DNA facilities	Internal funds. International funds through bilateral and multilateral projects. Donation.
		Department of Food Safety	Education, Research & Development	- Identification of candidate genes of *Bacillus thuringiensis* in the aim of production of biopesticides.	DNA facilities	
		Medical Centers	Education, Research & Development	Basic medical sciences, Hereditary sickness, Microbiology, Toxicology.	DNA facilities	
University of Balamand (UOB) www.uob.edu.lb	1988	Department of Biology (2001)	Education, Research & Development	Biochemistry, Molecular Biology, Immunology, Microbiology, Experimental Plant Biology, Biotechnology, DNA testing Medical sciences.	DNA facilities	- Internal funds. - International funds through bilateral and multilateral projects. - Donation
American University for Science and Technology (AUST) Faculty of Health Sciences www.aust.edu.lb	2000	Laboratory of Molecular Biology This laboratory has been designated by the Lebanese Ministry of Economy and Trade as a testing center for GMOs in imported goods. Accreditation ISO 17025 is in process.	Education, Research & Development	Molecular biology, Forensic DNA testing, Toxicology, Medical sciences.	Conventional PCR Real Time PCR Micro arrays DHPLC Genetic analyser	- Internal funds. - International funds through bilateral and multilateral projects. - Donation.
Industrial Research Institute (IRI) www.iri.org.lb	1997	Accredited Laboratories of Chemistry and Microbiology (ISO 17025)	Monitoring Food Quality	- Detection and identification of pathogens in food products. - Detection of myco-toxins in food. - Detection of melamine in milk and dairy products.	Conventional PCR Real Time PCR HPLC GC MS	- National funds. - International funds through bilateral and multilateral projects. - Donation.

Sciences aiming at producing qualified graduates in all areas of animal science as well as in the basic medical sciences. On the other hand, molecular biology is commonly used in other departments such the Department of Biology within research programs on basic sciences related to cell and molecular biology, cell differentiation, cancer, inflammation, and protein nucleic acids interaction.

2.1.3. Saint Joseph University (USJ)

Founded and administered by the Compagnie de Jésus since 1875, the USJ is a Lebanese private university. It aspires to be an active member among the university institutions of the world, a pole of excellence and distinction in the Arab world in basic and applied scientific research and in its renewal and creativity in learning and teaching. Additionally, the USJ University houses the hospital of Hotel Dieu of France and many centers and laboratories that are well equipped with molecular tools and facilities and devoted to research within programs on basic sciences, medical sciences, heredity, microbiology, toxicology, hereditary sickness, plant and animal biotechnologies.

2.1.4. University of Balamand (UOB)

Based on decree 4885-1988, the University of Balamand is a private educational institution of higher learning, it has now nine faculties and hosts over 3500 students and 500 employees. Established in 2001, the Department of Biology is directly involved in biotechnologies. Its primary mandate is to provide excellence in teaching at the undergraduate and graduate levels. The undergraduate three-year curriculum introduces students to modern studies in general, molecular, cell, and environmental biology. It also emphasizes active, hands-on experience with modern technology, for the development of the intellectual and technical skills.

The Department offers a two-year graduate program leading to the Master of Science (M.Sc.) degree in Biology and provides training in many areas with particular strengths in Biochemistry, Molecular Biology, Immunology, Microbiology, Experimental Plant Biology and Biotechnology. A primary component of the degree is a thesis embodying the results of original research. The Department's laboratory facilities are well equipped for graduate training and research in a wide variety of biological sciences such as Real Time PCR. The resources are further extended by association with other faculties, including the Faculty of Medicine and Medical Sciences and the Faculty of Health Sciences.

2.1.5. American University of Science and Technology (AUST)

Based on decree 3585-2000, the AUST is a private non sectarian coeducational institution of higher learning. The Faculty of Health Sciences Resolution 677-2007 houses state-of-the-art Molecular Biology and Analytical Toxicology laboratories that conduct several specialized testing services such as forensic DNA testing (paternity testing, human identification, missing individuals, etc…), GMO testing, screening for Inborn Errors of Metabolism in addition to teaching and training services. These laboratories are well equipped with Real Time PCR, microarrays, DHPLC, that were given as a donation from QUALEB (Quality EU funded program in Lebanon).

The Lebanese Ministry of Economy and Trade in the collaboration with QUALEB have designated AUST as a testing center for Genetically Modified Organisms in imported food and feed. The AUST is currently working to fulfill the ISO 17025 accreditation requirements process. The necessary paper-based and managerial (Standard Operation Procedures) requirements for accreditation have been completed. The technical and analytical procedures for GMOs and amino acid analysis are currently conducted by one Ph.D. scientist and one biologist. The application for accreditation is expected to be submitted to The Hellenic Accreditation System (ESYD) accreditation body in Athens, Greece by the end of 2009.

Except the administrative link with the Ministry of Economy and Trade, the AUST doesn't have yet any official linkage with other national or regional programs dealing with agricultural biotechnology.

2.1.6. Industrial Research Institute (IRI)

Established in 1953, and linked to the Ministry of Industry by Law n° 642/1997, IRI is a not-for-profit institution, with administrative and financial autonomy. The IRI is accredited for studies, industrial research and scientific testing and analysis by the Deutsches Akkreditierungs system Prüfwesen (DAP), including physical-chemical and microbiological analysis of water for human consumption, food and feeding stuff, microbiological analysis of cosmetics, wet wipes and baby diapers, chemical, physical-chemical, rheological and preparative-gravimetric analysis of grain and flour. The laboratory is well equipped with molecular biology tools and is opened for any kind of molecular testing upon request.

2.1.7. Other Institutions dealing with Biotechnologies

Other private academic institutions such as the Notre Dame University (NDU), Lebanese American University (LAU), the University of Saint Esprit of Kaslik (USEK) and the Lebanese University are housing laboratories equipped with molecular biology tools, for educational purposes within graduate programs. These academic institutions offer a two-year graduate program leading to the Master of Science (M.Sc.) degree in Biology, Biotechnology or other disciplines and provide training in many areas with particular strengths in Biochemistry, Molecular Biology, Microbiology, and Biotechnology. Actually, these laboratories don>t have well defined research axes in terms of the use of biotechnology.

More recently, **the Lebanese University (public sector)** is undertaken actions for establishing "AZM Center of Biotechnology" which will be affiliated to the Faculty of Sciences (Tripoli, Lebanon North). This center will be operational by the end of 2011 for conducting both research and education activities in environmental, pharmaceutical and microbiological biotechnologies, bioinformatics and biomedical engineering. At least, 10 PhD and 10 MSc holders are expected to be involved in biotechnology activities.

2.1.8. Lebanese National Council for Science Research (LCNRS)

Based on decree 12765-1963, the LCNRS is a governmental institution having a role in the preparation and updating of the national science policy and programs, promoting capacity building and national and international cooperation in the scientific field, and allocating funds and grants to research development. Noted here are the considerable efforts of the LNCSR to serve as a link between academia and researchers in this sector and the government, industry and public. However the limited funds available to LNCSR have considerably hindered such activity.

2.2. Additional Information

The personnel most involved in hands on biotechnology work are MSc and BSc holders (90%) with adequate technical background, while few PhD's (10%) are actually involved in ongoing laboratory work.

The number of human resources involved in biotechnology is not really precise. Actually, each laboratory devotes one Ph.D., one to two M.Sc. or B.Sc engineer for the molecular biology work. However, this staff is regularly strengthened by the undergraduate B.Sc. and M.Sc. students/trainees that are joining the biotechnology laboratories to prepare their thesis.

Funding for biotech-related projects in Lebanon is mostly sponsored by countries of the European Union and amounting to slightly more than 45% of the total funding. United States-based funding is a distant second with about 30%, and the remaining is from national agencies. Note worthy here is that at the national level there are three main funding sources for biotech-related research and these are LNCSR, LARI and AUB.

Several biotech-related projects are fruit of partnerships with American and European-based institutions. The national universities and institutions have established collaborative work with internationally recognized academic or development-oriented institutes. Of the international funding agencies, the major European ones are, and not in any order of significance, International Centre for Mediterranean Agronomic Studies (CIHEAM), Deutsche Forschungsgemeinschaft (DFG), European Union (EU, Tempus), Institut National de la Recherche Agronomique (INRA) France, Project CEDRE France, and University of Patras Greece. The American-based funding agencies are: United States Agency for International Development (USAID), Mercy Corps, United States Department of Agriculture (USDA), and to a limited extent the National Institute of Health (NIH). Other sources of biotechnology research funding are coming from international organizations such as FAO and ICARDA.

Access to information remains difficult at the national level, but this problem is often overcome through the regional and international trainings. For example LARI staff has regularly the opportunity of access to information and technology transfer through regional and international training courses under the umbrella of the Ministry of Agriculture.

Lebanese research papers on biotechnology are available in both regional and international levels (on line for each institution) on a wide range of subject. However, peer reviewed papers on GMOs production and GMOs detection are not yet available. Only one abstract regarding the GMOs production in Lebanon is published (cf. References).

3. GMOs Research and Development

3.1. GMOs Production

Only one single study relevant to GMOs research has been declared in Lebanon. It was conducted during the period 2003-2007 at the Laboratory of Plant Pathology of AUB (abujawyf@aub.edu.lb) within a collaborative program with Arab and American institutions. It was entitled: «Development of genetic transformation of tomato in order to improve their tolerance to viruses».

Effectively, genetic engineering via Agrobacterium tumefaciens combined with tissue culture techniques allowed the regeneration of genetically modified tomatoes that were tolerant to Tomato yellow leaf curl virus (TYLCV). Despite these promising results that could resolve the economic incidence of this geminivirus in the region through the development of tolerant/resistant lines of tomato, the transformed tomato plantlets tolerant to TYLCV were incinerated under the laboratory conditions, after being tested vis-à-vis the virus. In fact, since no appropriate glasshouses are available for studying the behavior of GM plants, the latest should be destroyed at early stages.

Currently, another research study is currently conducted in the same laboratory on the genetic transformation of cucumber for tolerance to viruses, also through a collaborative program with Arab and American institutions. Data are not yet available.

Although there is evidence that work with GMOs is being conducted in at least one academic research institutions, there is so far, no GMOs produced in Lebanon.

3.2. Main Gaps affecting GMOs R& D and Recommendations

It is evident that Lebanon is undertaking efforts to adopt biotechnology and its products into the agricultural sector. These efforts, however, are not mainly directed towards GMO production, risks and concerns. The major gaps that are limiting the development of genetic engineering in Lebanon are:

- The absence of a national strategy addressing the use of biotechnology in the agricultural sector.
- The lack of cooperation between academia, research, industry and government.
- The absence of biosafety legislations.
- The absence of appropriate infrastructure (glasshouses and others) to pursue the studies on GM plants after the first laboratory tests vis-à-vis transgenes.
- The deficiency of human skills specialized in genetic engineering.
- The lack of funds.

Whether Lebanon will choose, or strategize, to become an active participant in the biotechnology industry and a producer of knowledge remains to be seen. At this time, the following recommendations can be made:

1. Identifying promising niches for future research and development investments.
2. Providing support for capacity building to enhance research in agricultural biotechnology addressing in particular GMOs production and their risks assessment.
3. Establishing the appropriate/needed infrastructure to support biotechnology research.
4. Undertaking reforms and establishing opportunities to attract biotechnology industry.

4. Biosafety Regulatory Status

Recognizing the threats of GMOs to biological diversity and natural resources, Lebanon has ratified the CBD in 1994 and developed its National Biodiversity Strategy and Action Plan (NBSAP) in 1998.

Later Lebanon participated in several meetings and negotiations of the Cartagena Protocol on Biosafety, although it is not as of October 2009 a signatory of the Protocol. Nevertheless, Lebanon will adopt the protocol provisions and will develop its National Biosafety Framework.

4.1. Existing National Legislation

Biosafety concerns have not surfaced as a priority national issue in Lebanon. Some existing national laws, decrees or regulations are indirectly related to biosafety issues and GMOs products. These laws, decrees and regulations are aimed at regulating agricultural processes, animal safety, environment and biodiversity, health protection and food safety. Although they do not contain specific provisions related to GMOs and biosafety, the implementation of these laws could have beneficial repercussions on biosafety in Lebanon.

4.1.1. Laws Related to Agriculture and Animal Health

- Agriculture Quarantine Law dated 10/6/1948. This law establishes a department for agricultural quarantine at the Ministry of Agriculture which is entrusted with the task of preventing the entrance of the plants which could carry diseases or problems related to the safety of plants.
- Sanitary and Phytosanitary Measures Law 778-2006. This law intended to meet the requirements set by the WTO in an attempt to facilitate Lebanon>s accessions. Article 14 in this law bans the importation of genetically modified plants that may introduce new diseases and toxins into the country. It cites: “Taking into account the provisions (6), (8), and (9) of this law, plants, plant products and pests shall not be introduced into the State at any of the following circumstances, and shall be re-exported within a period of time determined by the Ministry, or shall be destroyed under the auspices of Ministry’s departments on the violator’s expense… If genetically modified or whenever this modification might result in risks or damages to humans, animals or plants.”
- Animal Quarantine Law implemented by decree No. 12301 dated 20/3/1963. This law subjects all animals and animals’ products, which are imported into Lebanon to an animal health control to prevent the leaking of diseases into Lebanese territory.

- Ministerial Decision No. 166/1 dated 13/4/1996 as amended by Ministerial decision No. 228/1 dated 14/5/1996: Importation of Live Animals. This decision said that animals should be free from infectious animal diseases.
- Ministerial Decision No. 18/1 dated 31/1/997 Vaccination of Imported Live Animals.

4.1.2. Laws Related to Environment and Biodiversity

- Law 256-1994: Framework Convention on Climate Change prepared by the Ministry of the Environment, with the objective of promoting in situ conservation of crop wild relatives;
- Law 260-1995: Convention on Biological Diversity prepared by the Ministry of the Environment with the objective of developing monitoring and early warning systems for loss of diversity;
- Law 469-1995: Convention on Combating Desertification prepared by the Ministry of the Environment with the objective of promoting sustainable agriculture;
- Law 444-2002: Protection of the Environment prepared by Ministry of the Environment and aiming at the conservation and the sustainable use of biodiversity through the protection of its natural resources. This law is therefore relevant to the regulations of GMOs-handling activities that present risks to environment and biodiversity. Article 21 stresses the necessity of conducting environmental impact assessment studies prior to the execution of a new project that might have a negative impact on the environment of the natural balance. Article 38 subjects any activity that might have a negative impact on natural resources to primary licensing by the Ministry of Environment. Article 44 provides for the control of the import, production, extraction, handling and disposal of chemicals that might threaten health, safety and the general environment primary licensing and continuous monitoring notably in emergency cases. Section 3 Chapter 2 calls for public participation in environmental management. Chapter 8 calls for the protection of biodiversity, nature and genetic heritage from any influencing activity.

4.1.3. Laws Related to Health Protection

Decree no. 11710 -1998. This decree establishes a committee at the Ministry of Public Health to organize the importation of natural medicine products in all their forms. The duties of this committee comprise studying the applications submitted requesting an authorization to import plants and herbs which have medical effects, proposing conditions for the importation and marketing of food supplements and the products which might have effect on health; accepting/rejecting the advanced application for the importation of medicinal plants; classifying the products as products allowed for import, products not allowed for import and products requiring further studies and test before decision.

4.1.4. Laws Related to Food Safety

- Decree No. 12/253-1969, which provides the conditions to be met by canned or preserved food, and describes the mandates of each ministry regarding food safety.
- Decree no. 71-1983, as amended by the law No. 63188-1988, which has provisions for food satety.
- Decree No. 1836-1999 which provides for the compulsory specifications for certain types of food.
- Decree No. 7177-2002, which sets Lebanese standards for certain types of food.

More recently, a food safety law draft has been prepared by many institutions involving Ministry of Public Health, Ministry of Agriculture and Ministry of Economy and Trade and is also awaiting endorsement by the parliament since 2006. This draft propose the establishment of the Lebanese Food Safety Agency comprising the Science and Technical Department that will take in charge GMO/GMF risk assessment for health. However, the coordination among all these ministries is limited, and they are suffering from understaffing.

4.1.5. Laws Related to Trade and Customs

The Ministry of Economy and Trade enforces various laws and plays a critical role in import and export regulation. Overall, this Ministry controls the import of goods for health, safety and environmental reasons.

The customs under the Ministry of Finance has the authority to decide on the entry of products into Lebanese territory and whether or not an imported good is for commercial or non-commercial purposes through import licenses and borders control measures including permits, advanced permits, approval and post approval. Moreover, an advanced visa is required which is a signature of customs document by a relevant ministry, indicating its approval that imported goods meet certain technical requirements and standards and may clear customs. In case the relevant ministry and customs suspect non compliance of imported goods with applicable requirements, testing is conducted and the visa is issued on the basis of test results.

4.1.6. World Trade Organization Agreement

Lebanon has been negotiating accession to the WTO since 1999. The country has acquired observer status in anticipation of gaining memberships. This will provide Lebanon with more opportunity of market access for its goods and services.

Under the WTO accession, Lebanon is working internally on updating the laws related to the Sanitary and Phytosanitary Measures (SPS) and Technical Barriers to Trade (TBT) agreements, which are both relevant to GMOs, and the process is in progress.

In the context of these agreements, several sanitary and phytosanitary measures were taken in Lebanon, such as food safety measures, and the ban of certain animal and plant species on the basis of scientific evidence that they carry certain risks. Moreover, Lebanon is already a member of the three organizations that provide standards, guidelines, and recommendations under the SPS agreement. These organizations include the FAO/WHO Codex Alimentarus Commission for Food Safety, the World Organization for Animal Health (OIE) and the International Plant Protection Convention (IPPC) for plant health. These may later provide a much needed momentum for Lebanon in developing its own guidelines and standards regarding GMOs.

One major step was recently taken towards the implementation of TBT agreement. In 2003, the Ministry of Economy and Trade signed with the EU the financing agreement for the Quality Program (QUALEB) to create the necessary infrastructure for the operation of a quality system that begin officially in October 2004. The program is working under the authority of the Presidency of the Council of Ministers

and aiming to establish a working quality infrastructure in Lebanon to create a quality culture and to improve consumer protection. QUALEB has formulated a national quality policy for the Government and drafted new legislation to bring the quality infrastructure of Lebanon in line with internationally accepted practices. It is building up capacities in the Lebanese Standards Institution (LIBNOR), working on the development of a national accreditation body (COLIBAC Law 722-2004). Components of the project that could have impacts on biosafety include the support for the development of institutions which have an essential role in analyzing the quality of products. This program foresees the establishment of accredited national biotechnology laboratory at the AUST in Beirut and provides it with appropriate equipments for GMOs detection to achieve international recognition of its competencies through accreditation.

4.2. International Conventions and Protocols on Biotechnology and Biosafety

4.2.1 The Convention on Biological Diversity

Lebanon has ratified the CBD on 11/8/1994, Law 360-1994. The country developed its National Biodiversity Strategy and Action Plan (NBSAP) in 1998 following a public participation strategy involving key players, representatives from national institutions and other stakeholders.

The obligations of Lebanon vis-à-vis biosafety were addressed in the NBSAP in light of CBD obligations. Knowing that the CBD articles 8 and 19 provide for the establishment of a mechanism to address the issue of modern biotechnology and biosafety. The action plan comprised the strict and quarantine ban/control of the import of potentially invasive animal and plant species. This action plan comprised also the establishment of an expert committee on biotechnology and genetic engineering to advise on regulatory requirements for dealing with biotechnology and genetically engineered organisms and the development of biosafety policy, legislations and regulations dealing with the handling, release and disposal of exotic or genetically engineered organisms.

4.2.2 The Cartagena Protocol on Biosafety

Finally Lebanon has ratified the Cartagena Protocol of Biosafety (CPB): Law No 31 dated 16/10/ 2008.

The country has developed its National Biosafety Framework (NBF) under the provisions specified in the Cartagena Protocol since July 2005. To that end, the United Nations Development Program's management, the implementing agency Ministry of Environment (MoE), subcontracted the work to the Initiative on Biodiversity Studies in Arid Regions (IBSAR), an interdisciplinary program at the American University of Beirut (February 2004 – July 2005).

1. The NBF developed for Lebanon included procedures for the safe application of biotechnology in accordance with administrative, legislative, risk assessment and public participation systems. The main activities of NBF were:
2. Creation of a national database, through surveys and analyses, relevant to biotechnology and biosafety issues, including legislation.
3. Establishment of a National Coordinating Committee.
4. Creation of a directory listing national experts in fields related to biotechnology and biosafety, risk assessment and risk management of GMOs.
5. Initiation of public participation, for awareness purposes, and participation in decision making, by holding national workshops targeted to relevant stakeholders including public and private sectors and national legislators.
6. Production of public awareness materials and publishing of inventories and guides.

The NBF proposed the Ministry of Environment to be the National Competent Authority. A National Biosafety Commission (NBC) gathering experts and representatives from various sectors and research institutes will handle the review of information required to be handed to importing countries with the Advanced Informed Agreement. The Commission will assume full responsibility in reviewing the documents and giving the authorization for import, passage in transit and use of GMOs. Other mandate of the NBC is the classification of the GMOs crops and products in three levels of risk.

On the other hand, the Lebanese Biosafety Clearing House (LBCH) was established as an effective tool for providing information and protocols under the provisions of the Cartagena Protocol.

At the legislative level, The NBF includes guidelines for the interim measures to be adopted for the implementation of the Cartagena Protocol articles while a biosafety decree will be drafted and developed at a later stage.

Actually, within the framework of the same project, a draft decree to implement the provisions of the Cartagena Protocol in Lebanon was developed by the Ministry of Environment in 2005 with support of UNEP/GEF and UNDP and technical support of IBSAR/AUB. This draft decree provides the necessary procedures to regulate the transboundary movement, import, export, passage in transit, contained use, release into environment, direct use as food, feed, and processing, handling, transportation, use in research and testing, and placing on the market, of goods containing GMOs with the aim of protecting the environment and the humans from the potential negative effects of the GMOs.

The draft decree has proposed the establishment of a National Biosafety Committee which includes representatives from all concerned institutions. The committee will be established once the decree will be endorsed. However the decree is not endorsed yet. 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.

5. Capacities for GMOs detection

5.1. Areas of implementation

Although there is evidence that work with GMOs is being conducted at various academic and research institutions, and that is highly probable that Lebanese imports have GMOs components, to date no official legislation outlines the mandatory of GMOs detection in Lebanon. However, after the development of the National Biosafety Framework for Lebanon, many Lebanese institutions took the initiative to start working on GMOs detection in line with Cartagena Protocol requirements and with respect to food safety.

Table 2 presents the different laboratories working on GMOs detection or having potential to conduct GMOs detection work.

5.2. Case studies on GMOs detection

We have to note here that, excepting the AUB and UOB case studies, all the other studies relevant to GMOs detection have just been started in different institutions and concrete results are not yet available.

To date, all the case studies that have been undertaken in Lebanon focus on corn seeds and products. Qualitative and quantitative tests have been commonly used based on both conventional PCR and RT-PCR (BIO-RAD), searching mostly for the presence of Cauliflower Mosaic Virus CaMV 35S promoter and NOS terminator. Certain studies are planning to identify the Cry genes that might be present in the GM crops and products.

AUB Case Study

The first case study on GMOs detection has been reported in 2007 at the Department of Agricultural Sciences of AUB through a M.Sc. thesis entitled «Prevalence of genetically modified corn in Lebanon and implications on biosafety». This study assessed capabilities in Lebanon to test GM plants and investigated the presence of GM corn in varieties imported to Lebanon.

Twenty seed samples from field and sweet corn varieties were collected from the Lebanese market and were tested by conventional PCR for the presence of the CaMV 35S promoter, a promoter used in most GM plants. The CaMV 35S was detected in eight out of twenty samples analyzed, suggesting the presence of unrecorded existence of GM corn in Lebanon. These preliminary results should be confirmed by further tests using event specific detection methods to make sure that they do not represent false positives.

UOB Case Study

The Department of Biology at UOB started to work on GMOs detection in 2008 within a two years M.Sc. graduate project «General screening of Corn cans and seeds for GMOs in Lebanon». Qualitative testing via conventional PCR was done in a first place searching for the presence of CaMV 35S promoter. The preliminary results indicate evidence of at least two brands of cans on 20 brands tested with positive results. Quantitative data via RT-PCR are not yet available and the identification of Cry genes is not yet achieved.

LARI Case Study

The Department of Plant Biotechnology at LARI has started to work on GMOs detection in March 2009 with the perspective of implementation of the Cartagena Protocol on Biosafety in national institutions (NARS). The study aimed to assess capabilities at LARI to test GM plants and to investigate the presence of GM corn in varieties imported to Lebanon focusing on seeds for food, feed and agriculture that have been collected from importers and the local market.

Qualitative GMOs testing by conventional PCR was used searching for the presence of CaMV 35S promoter for 33 corn entries. The DNA melting temperature was also determined by Real Time PCR. A sequencing of the amplicon was also achieved in order to validate the preliminary data in the absence of certified positive and negative controls.

The results indicated the presence of only one positive sample on 33 entries tested. This positive case was found in one entry for feed coming from Argentina, while its import was not accompanied by a file or label indicating this fact.

AUST Case Study

The Laboratory of Molecular Biology of AUST has been designated in 2007 by the Lebanese Ministry of Economy and Trade to be the accredited laboratory for GMOs testing; and, it is actually finalizing the ISO 17025 accreditation application. The laboratory has launched in October 2008, a study aiming at the establishment of the basic platform for the implementation of the Cartagena Protocol on Biosafety.

The study includes the development of the protocol's procedures for the detection and quantification of GMOs in all GM products, which fall under the Cartagena Protocol provisions. Furthermore, the study integrates a general assessment of all imported GM products as feed and food for processing and seeds for agriculture.

The first stage of the study established the GMOs testing strategy. The laboratory started to work on GMOs testing using the quantitative Real Time-PCR. The procedure consists of screening and quantifying the CaMV 35S promoter and NOS terminator as well as a species reference gene. Recently, the laboratory has standardized the testing methods using positive and negative controls and Certified Reference Material (CRM). The quantification of CRMs showed accurate results and therefore validated the laboratory's testing procedure.

The second stage of the study involves the assessment of GMOs food. The laboratory has screened a small sample from the Lebanese market, for the presence of CaMV35S promoter and NOS terminator using Real Time-PCR. The results indicated the absence of the GMO sequences in this sample.

Currently, the laboratory has initiated a survey of the Lebanese market involving GMOs. Moreover the laboratory is setting up the conditions to extend its studies regarding the testing strategies as well as the tested materials.

5.3. Detection fees

The average cost for GMOs detection was estimated by AUST in August 2009 according to the multiplex PCR as following:

- 100-150 $ / sample for screening by Real Time PCR;

- 500-600 $ / sample for certified quantification by Real-Time PCR.

The price per sample will decrease with the increase of samples number.

5.4. Gaps, Needs and Recommendations

As indicated above, all the ongoing activities on GMOs detection are still limited to the technical adjustment and the standardization of the protocols.

- The most important needs for GMOs detection in Lebanon are:
- The absence of biosafety regulations
- The lack of funds: limited internal funds are allowed to cover the consumables expenses.
- Many recommendations could be proposed:
- Application of the interim regulatory measures developed within the development of NBF that will guide action vis-à-vis all GMOs activities, waiting for the endorsement of the draft decree by the Government.
- Capacity building in terms of sampling/collecting procedures and GMOs testing in all kind of agricultural products.

Table 2: The Lebanese laboratories working on GMOs detection or having potential to conduct GMOs detection work, case studies and recommendations.

Institution / Department / Laboratory / mail address of contact person	Area of implementation	Period	Case Study	Methodology	Preliminary Results	Constraints, Needs & Recommendations
American University of Beirut (AUB) abujawyf@aub.edu.lb	R & D Within the NBF project	2005-2007	Seeds and sweet corn varieties collected from market	Traditional PCR Testing for CaMV 35S	8 positive samples on 20 samples tested.	Funds availability for consumables.
University of Balamand (UOB) jihad.attieh@balamand.edu.lb	Applied Research within undergraduate M.Sc. thesis	2008-2009	General screening of Corn cans GMOs in Lebanon	Traditional and Real Time PCR Testing for CaMV 35S Testing for Cry genes	2 positive brands on 20 brands tested.	Funds availability for consumables.
American University for Science and Technology (AUST) Faculty of Health Sciences Laboratory of Molecular Biology mansour.issam@gmail.com gabousleymane@aust.edu.lb	R & D Upon designation by the Ministry of Economy and Trade to be the accredited laboratory for GMOs detection.	Ongoing work	- General assessment of all imported products as feed and food for processing and seeds for agriculture in order to prepare the technical platform for the implementation of Catagena Protocol. - GM detection in corn seeds for feed, food and agriculture. - GM detection in Soybean.	Quantitative Real Time PCR Testing for CaMV 35S And NOS terminator	Data not yet available.	Funds availability for consumables. Needs for trainings on seed sampling and GMOs detection in processed food (oil, jam, etc..).
Lebanese Agricultural Research Institute (LARI) Department of Plant Biotechnology lchalak@lari.gov.lb lamischalak@hotmail.com	R & D Technology transfer	Ongoing work	Corn seeds for food, feed and agriculture belonging to 33 entries and collected from importers and local market.	Traditional PCR Testing for CaMV 35S Melting Temperature with Real Time PCR Sequencing	One positive sample on 33 entries tested.	Funds availability. Needs for the establishment of an appropriate infrastructure for Risk Assessment of GMOs on biodiversity and agriculture. Needs for trainings on seed sampling and risk assessment.
Lebanese Agricultural Research Institute (LARI) Department of Food Safety Accreditation for microbiological test methods (ISO 17025) in process fanarlab@lari.gov.lb	Monitoring Food Quality	Not yet	Not yet	Availability of molecular equipments such as Real Time PCR	-	Needs for trainings and capacity building on GMOs testing techniques in GMF. This laboratory has a potential for GMOs testing upon request within the Food Safety Draft Law.
Industrial Research Institute (IRI) Chemical and Microbiological Laboratories info@iri.org.lb, chem@iri.org.lb	Monitoring Food Quality (ISO 17025)	Not yet	Not yet	Availability of molecular equipments such as Real Time PCR	-	Needs are not defined yet. This laboratory has a potential for GMOs testing upon request within the Food Safety Draft Law.

6. Conclusions and Recommendations for Lebanon

Lebanon is given a great attention to strengthening human resources and developing the institutional and infrastructural capacities in biotechnology to be able to cope with new developments and applications of modern biotechnology as they arise, with emphasize to achieve biosafety issues.

This attention is, however, mainly directed on the technical adjustment of GMOs detection. Up to date, not a single program including a risk assessment and/or management component has been conducted. Knowing that risk assessment is vital element for determining, implementing and controlling biosafety conditions and is defined as a scientific method to assess the risks posed by any new technology that may have potential adverse effects on human, animal or environmental health. It serves as the basis for the decision making process for granting consents for GMOs release and marketing.

Considering high vulnerability of mountain biodiversity of the country, nature conditions, diversity of biological species, genetic resources, the most complex issue is a risk assessment with possibility of GMOs release into the environment. It is therefore imperative to have a risk management strategy including the implementation of a variety of measures in place to minimize risks to the environment that might emerge from applications of modern biotechnology.

Accordingly, the implementation of a national biosafety policy requires systematic capacity building at the national level:

1. Identifying and operationalizing the responsibilities of different public and private institutions in terms of GMOs research, risk and management. Knowing that some relevant research institutes such as LARI (NARS) should be responsible of developing guideline and studies on risk assessment and management.
2. Synergizing efforts and promoting cooperation between the involved ministries (more particularly Ministry of Environment, Ministry of Agriculture, Ministry of Economy and Trade) and research institutions in terms of GMOs risk assessment and management.
3. Developing capacities for risk assessment and management of GMOs technologies and methods, categorization criteria, analysis and listing through a central body that is qualified for this function as well as supporting infrastructure.
4. Attracting international experts for participation in risk assessment and preparation of a risk management plan.

At the regional level, three recommendations are strongly required:

- Establishing a regional platform for sharing expertise and know-how to harmonise laboratory procedures, and standardized techniques of GMOs detection.
- Initiating and maintaining networks with the regional countries of the project that would ensure continued public awareness, collaboration and strengthening capacities in the different issues relating to biotechnology and biosafety.
- Inquiring the possibility of assigning a laboratory of Excellency among the six involved countries, that could provide further consultancy, capacity building and assistance as well in GMOs testing, confirmatory analysis and result interpretation.

Sudan

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3.3. Sudan

1. Status of Biotechnology

1.1. Plant Biotechnology

Sudan is one of the developing countries with limited resources to meet the huge investment to maintain and run biotechnology research. Nevertheless, a number of research institutes have initiated efforts to establish biotechnology laboratories to support agriculture research. The number of labs increased from 5 in 2003 to over 15 in 2007, while the number of trained staff in biotechnology increased from less than 15 to over 50 in the respective time periods (Table 1).

Production of major crops in Sudan is below the world average. This is mainly attributed to limited funding capability of farmers, reduced inputs, shortage in labors, and losses due to biotic and a biotic stresses. Biotechnology can play a major role in addressing these constraints and improving agricultural production in Sudan particularly in irrigated and mechanized rainfed areas.

The Agricultural Research Corporation (ARC) is the leading institute in Agricultural Biotechnology in Sudan. A tissue culture lab was established in 1992 for research on mass propagation of planting materials, in vitro mutation and production of doubled haploids. A biotechnology lab was established recently in 2002 which is well equipped for various molecular marker applications in diagnostic, genetic diversity and marker assisted breeding. The two labs were initially supported by the International Atomic Energy Agency (IAEA) through national technical cooperation projects for capacity building in mutation breeding and related biotechnologies. Most of the young plant breeders in the ARC have a short or long training in related applications of molecular marker techniques. Most of these researches have concentrated on plant tissue culture for mass production of planting materials and molecular makers for marker assisted breeding, diagnostics and assessment of genetic diversity. Most of the research activities are funded through regional and international projects. Examples of such projects and the achievements include:

In vitro mutation breeding of banana variety Albeely in 2004 as an outcome of Technical Cooperation (TC) project with the IAEA and the ARC Tissue culture Lab at Wad Medani.

Development and release of two doubled haploid wheat varieties (2004) for heat stressed environment as an outcome of a regional Project for application of Biotechnology in the WANA region funded through ICARDA by the Arab Funds for Social Development (1998-2001)

Marker Assisted selection for stay green trait to enhance terminal drought tolerance in sorghum.-regional project supported by ASARECA Biotech program (2005-2007).

- Production of transgenic drought tolerance Maize for East and Central Africa-
- Marker Assisted recurrent selection for increased outcrossing rate in caudatum-race sorghum from Sudan -collaborative project between ARC and Hohenheim university, Germany (2007-2009)
- Marker assisted transfer of resistance to Striga to local farmer preferred sorghum varieties (2003-2006)-regional project supported by GTZ, Germany
- Genetic diversity in striga hermonthica collected from different locations and host plants (2005-2008)-supported by Japan Society for Promotion of Science AA program.
- Genetic Diversity in new collection of sorghum (2006-2007)- supported by GC program.

The ARC is currently constructing a TC lab at the Forestry Research Center at Soba, Khartoum and a more advanced Biotechnology and Biosafety Center (BBC) at Shambat, Khartoum. The BBC at Shambat will contain four labs: Genomics, GE, GM detection and Bioinformatics. The BBC will be opened by June 2009.

The ARC has strong connection with all of the international and regional Centers and Organizations working in agriculture such as: ICARDA, CYMMIT, ICRISAT, IAEA, FAO, etc.. In addition, the ARC has bilateral MOU for collaboration with a number of overseas university and research centers in Japan, Germany, China, Finland, Kenya, Uganda etc.

Besides the ARC, a laboratory was established at the Commission of Genetic Engineering and Biotechnology (CGEB) in Khartoum which has some of its research activities related to plant tissue culture and molecular markers in addition to microbiology and environment. The Ministry of Science and Technology is developing a Central Lab at Soba, Khartoum which is intended to provide access to advance and expensive equipments as a common facility with special focus on Biotechnology related equipments such as sequencers, GLCs, HBLC etc.

In the last five years, some of the universities such as University of Khartoum, Gezira, Elnilain, Joba and Sudan have established department for biotechnology which provides undergraduate (BSc) and MSc degrees. Most of these departments have a nucleus of a biotechnology lab with basic set of equipments to at least provide some practical skills to the students. However, only few of these universities could provide sustainable practical course in Biotechnology due to shortage in funding.

Commercial tissue culture labs for mass propagation and distribution of clean planting materials were established at Ministry of Agriculture (2006), Linna Company and Kenana Sugar Company. Another public-private sector partnership is reflected in a well equipped tissue culture lab at Shambat Research Station which is owned by the ARC and a private sector. These facilities have been used for distribution of planting materials of improved cultivars of Banana, Date palm and other fruit trees.

A virology laboratory at Shambat Research Station, ARC, Khartoum, has been used for testing of viral diseases on winter legumes, potato and citrus. There is another laboratory in the Plant Pathology Center, Faculty of Agricultural Sciences, University of Gezira, Wad Medani. This laboratory is a leading one in it is research activity in Sudan due to the collaboration with international research institutes (INRA-France, ICARDA-Syria) in the research programs. Methodologies for virus indexing and production of antisera for vegetables and food legumes viruses are produced in this lab.

Status of genetically modified crops:

Currently genetically modified crops are not produced or grown in Sudan. However, some of genetically modified foods may have its way in the country through food aids. The ARC is collaborating in a regional project to produce drought tolerance maize for East and Central Africa supported by ASARECA Biotechnology program (2005-2007). Promising materials were developed during this project, however, their further testing and evaluation in Sudan is pending to the functioning of the National regulatory system and availability of confined facilities. The ARC has signed a Memorandum of Understanding for technical collaboration with the Sudanese Standards and Meteorology Organization (SSMO) which commit the ARC Biotech Lab to conduct and issue certification for GMO detection. Currently, the ARC lab has established qualitative GMO detection system and expected to add a Real Time PCR very soon for quantitative detection. In addition, SSMO is currently handling procurement of equipments to initially establish two detection units within its laboratories at Khartoum and Port Sudan.

1.2. Animal and veterinary biotechnology

The animal resources constitute one of the major national sources of income in Sudan. It is, therefore, becoming increasingly obvious to provide the necessary prevention and control measures for these animal populations against various diseases. To improve herd health monitoring, production of vaccines against contagious and infectious diseases was initiated to facilitate vaccination programs. Thus, biotechnology was first applied in vaccine production in 1930. Vaccines were produced locally for immunization against diseases of Veterinary importance.

At this particular point in time, at least eleven viral and bacterial vaccines were produced in the Sudan. The vaccines are produced in the Central Veterinary Research Laboratory, Soba. Attempts to produce additional vaccines against parasitic infections are in progress.

Recombinant DNA vaccines are now being produced against viral and parasitic diseases. With the surge of new techniques in cellular immunology and molecular biology, even complex organisms like schistosomes became potential candidates for vaccine production. Schistosomiasis is an endemic disease in many parts in the Islamic world including the Sudan. Comparative studies were conducted on irradiated, killed and recombinant Schistosoma mansoni subunit vaccine expressing the glutathione-s-transferease (GST) gene in E.coli and yeast expression vectors. These studies were conducted at the Faculty of Veterinary Medicine, University of Khartoum, Sudan, in collaboration with the Department of Medical Helminthology, Pasteur Institute, France.

Theriogenology shows rapid expansion in biotechnology. Artificial insemination (AI) was recognized by animal breeders, long time ago. The Ministry of Animal Resources established the National Artificial Insemination Center in 1976. Subsequently, semen collection, evaluation and insemination of synchronized cows were made possible locally through importation of good quality semen. Currently, there is an ongoing research for artificial insemination project to improve the genetic make up and productivity of the Sudanese Nubian goats. The International Atomic Energy Agency (IAEA) funds this project. Research team in the Faculty of Veterinary Medicine, U of K, conducts the work. The Embryo transfer (ET) was started in 1983 in bovine. Successful delivery of a full term calf from ET was reported in 1984, Gezira University Farm. Nuclear transfer (NT) experiments were conducted both in mice and in cattle. Some of the teaching staff of the Department of Theriogenology, Faculty of Veterinary Science of the U. of K is expertise in NT. The Department of Theriogenology also housed a well-equipped laboratory for AI and ET. A modern laboratory for NT is expected to be fully installed in the near future.

Nucleic acid amplification technology was also applied to the area of molecular diagnostics and forensic medicine. Mitochondrial cytochrome-b gene (Mtcyt-b) PCR-based assay was developed for detection of animal derived contaminants in processed human food and in animal feed ingredients. This was done to address possible contamination of animal feeds with other animal protein sources, an important issue with the concerns associated with spread of bovine spongioform encephalopathy (BSE) in Europe, since bovine meat by-products were recycled as cattle feed. Similar studies are currently underway to evaluate the potential of the Mtcyt-b PCR for detec-

tion of pork or swine-derived products in processed human food, as accidental pork consumption is not uncommon, although prohibited in Islamic religion. These studies are conducted in the Molecular Biology Laboratory of the Department of Medicine, Pharmacology and Toxicology, Faculty of Veterinary Science, U of K .

Molecular Diagnostics

Conventional methods for isolation and identification of infectious agents represent the most accurate diagnosis for an active microbial infection. However, these methods are tedious, laborious and time consuming. Serology is useful to identify a previous infection in epidemiological studies. Molecular diagnostic techniques including the use of monoclonal antibody (Mab) in competitive enzyme linked immunosorbent assay (cELISA); cDNA probes and nucleic acid amplification technology, commonly known as polymerase chain reaction, (PCR) may improve the existing diagnostic techniques used for detection and identification of specific infectious agents. These emerging techniques provide the basis for better understanding of the epidemiology of diseases of veterinary importance. In addition, the application of biotechnology in diagnostic veterinary medicine will enhance herd health monitoring, vaccination and control programs, and will facilitate detection of active microbial infections during an outbreak of the disease among susceptible wildlife and domestic livestock.

Beside the laboratory at the Faculty of Veterinary Medicine in Khartoum, well-equipped molecular laboratories are also located at the Institute of Endemic Disease, University of Khartoum and the National Council For Research, Ministry of Science and Technology. The scientific research in these institutions is mainly focused around the molecular epidemiology of endemic diseases including malaria and leishmaniasis. Extensive experiments are currently conducted to study the genetic diversity among different isolates of leishmania parasite, the cause of cutaneous and visceral lishmaniasis. For the last 10 years, the major thrust of research efforts was directed towards the improvement of the existing techniques used for diagnosis of viral and parasitic diseases. Extensive studies were conducted on diagnosis of Orbiviruses, including bluetongue virus (BTV) and epizootic hemorrhagic disease virus (EHDV) and palyam serogroup Obivirus infections. Similar studies were conducted evaluate molecular diagnostic techniques for detection of Schistosoma bovis infection in cattle. We were able to use monoclonal antibodies (Mab) in competitive ELISA (cELISA) for detection and specific identification of EHDV-1 and EHDV-2.

1.3. Microbial/ Industrial biotechnology

There are very few activities related to microbial or industrial biotechnology. These are mainly conventional biotechnologies related to the use of microbes in food production, bio-fertilizers and bio-insecticides. Biofertilizer include the use of nitrogen fixing bacteria to enhance the productivity of food legumes. On the other hand, a Bt-source of Bioinsecticide in released for the Biocontrol of the Boll worm of cotton.

1.4. Biotechnology in the biomedical field

The medical field has the most advanced research applications of Biotechnology in the Sudan. Laboratories are well equipped and the activities are relatively well funded. There are laboratories functioning since the late eighties and early nineties. The laboratory of the National Center for Research in the building of the national health laboratory is one of the best equipped in the country. This lab was established as part of collaboration between Sudanese institutions and the Michigan Sate University and funded by the NIH In 1994 another laboratory was built in the biochemistry department of the Faculty of Medicine , University of Khartoum within the ongoing collaboration at the time with Denmark, followed soon by a laboratory at the National Health laboratory, which further consolidated by two extra laboratories through support from the IAEA. The Institute of Endemic Diseases is perhaps the best equipped, with 6 PCRmachines , automated sequencer, gel documentation systems, high speed centrifuges, MACs, and a phosphimagor. The pressure on its facilities are however enormous. Two laboratories in the faculty of science are currently under establishment. Most of the research activities include use of molecular techniques for diversity studies and diagnosis of endemic diseases. These instate have strong regional and International collaboration and support.

1.5. Biotechnology in the Academia

The current state of education in biotechnology was recently reviewed by AM Elhassan in the meeting organized by the group of alternative policies (GAPS) As far as biotechnology teaching at the graduate level, three universities offer biotechnology degrees; Faculty of Agriculture , University of Khartoum and the Faculty of Science , University of Elnilain and Faculty of Natural Resources University of Juba. The Institute of Endemic Disease University of Khartoum, Biotechnology research laboratories of ARC, Faculty of Science University of Gezira offer Masters and doctorate of philosophy in molecular biology. Despite the rapid expansion in the education of Biotechnology and Biosafety at graduate level there is a a serious limitation in practical component of the courses and the limited skills of the teaching staff. Yet the geat challenge is the job opportunity for the graduate. Now over 100s graduates of biotechnology are waiting for recruitment.

2. Physical facilities dealing with Biotechnology

2.1. Research Institutes

Table I shows the Institutes with facilities actively involved in Biotechnology applications, their staff, location and functioning status. These can be summarized in the following:

2.1.1. Agricultural Research Corporation (ARC)

The ARC is the oldest and biggest agricultural research institute in Sudan. It has been considering adoption of biotechnology applications in it is research programs since early nineties. The ARC has four facilities preforming Biotechnology applications; soil microbiology, tissue culture (TC), and Biotechnology lab (molecular) at Wad-Medani site and a TC at forest research station at Soba, Khartoum (Table.1). In addition, a more advanced Biotech and Biosafety Center is under construction at Shambat, Khartoum. The over all personnel working in Biotechnology at the ARC is 13 PhD and 18 MSc research staff. Beside these staff, the ARC has some of its research personal (6) breeders, (3) pathologist and other disciplines (3) had training in molecular and TC techniques. These additional trained researchers are making use of the existing facilities for some of biotechnology interventions in their research programs.

The soil microbiology lab is mainly used in research related to biological nitrogen fixation and biofertilizers. It has 2PhD and 1 MSc staff who had advanced training overseas. The TC lab was established in 1992 with support from the IAEA for application of in vitro mutation in banana. The lab has 3 clean benches, two Plastic-house and 4 culture rooms.

TC protocols for mass propagation were optimized for a number of fruit trees (banana, date palm, citrus, mango. etc.). The research staff and the technical personnel of the TC lab receive regular training through IAEA supported project. Funding for equipments and reagents has been mainly through international and regional projects.

The Wad-Medani molecular lab was established in 2002 largley by IAEA supported project for mutation breeding and related biotech applications such as molecular characterization of mutant and marker assisted breeding. The has 3 PCR machines, tissuelyzer, several electrophoresis tanks, centrifuge and other molecular markers related equipments. The lab has ful capacity to run RAPD, SSR and AFLP markers. The staff are 3 PhD and 6 MSc in addition to 2 BSc technical staff. The lab is working across cutting supporting the various research programs of the ARC and open to students from various universities. The research activities are mainly supported through

international and regional projects. The lab has strong link with Hohenhiem University in germany, Tottari university- Japan, ICARDA- Syria, ASARECA-Uganda, IAEA and FAO. The lab provides a service for GM detection to the regulatory agencies in Sudan.

A TC lab with 2 PhD and 2 MSc research staff was established in the Forest Research Center at Soba-Khartoum in 2008. The lab mainly focuses on TC propagation of high value forest trees. There is a plan to up grade the lab to run molecular markers.

A Center for Biotechnology and Biosafety research is under way at Shambat-Khartoum and expected to be opened by the end of this year. The Center has initially recruited 3 PhD and 3 MSc staff but expected to expand to 20 researchers in various field of biotechnology and biosafety applications. The Center is planned to start with sections for genomic, transformation, TC, proteomic, GM detection and bioinformatics. It is expected to under take the work related to GM evaluation, production, detection and biosafety related research.

Generally the funding in most of the biotech facilities in the ARC depend largely on overseas. There is fairly enough personnel who are well trained to start with but there is in adequate national funding which limit the research activities to collaborative projects. The ARC is also engaged in a regional collaboration project for production of GM maize tolerant to drought supported by ASARECA and the research performed at Kenyatta University.

2.1.2. Animal Research Corporation

It is considered as the main body responsible for the livestock sector and it consists of three main labs in Soba-Khartoum focusing on vaccines production and diagnosis. The over all research staff are 39 researchers 21 with MSc and 18 with PhD. The vaccine production lab has about 30 staff half of them with PhD. Additionally; the lab of Tick and Insect diseases has a 4 PhDs and 2 MSc holders. All of these labs are well equipped; a molecular biology lab for disease diagnosis has 6 PhDs and 3 MSc holders while the artificial insemination lab has 3 PhDs and 4 MSc. These labs are mostly funded from the national fund and service as a reference lab for the government in issues related to animal health and production.

2.1.3. National Research Center (NRC)

Three Institutions in the NPC have facilities performing biotech applications in plants, microbes, animals and medical field. These are the commission of biotechnology and genetic engineering (CBGE), Institute of Environment and the Institute of Medicinal plants. The CBGE has subunits for molecular biology, tissue culture, biochemistry and

biomedicine with overall 6 PhDs and 24 MSc staff. The CBGE is the focal point for the ICGEB and so gets support for training and small funding for research activities. The CBGE focuses mainly on natural resource, animal and microbial research. There is no research on GMOs production or detection. The molecular work is mainly for diagnostic and diversity studies. The biotechnology techniques at the Environment Institute is mainly for production of biofertilizers in collaboration with the ARC soil microbiology. The molecular lab of the Institute of Medicinal Plants has just started and still not fully functional.

2.1.4. Central Laboratory

The Ministry of Science and Technology has established a central lab at Soba-Khartoum to provide high capital equipment and more advanced research capabilities for other Research Institutes and National Universities. The lab has initially 4 PhD and 10 MSc staff in addition to BSc technicians. The lab is well equipped to do mass spect, GLCs, etc and has a molecular and microbiology sections. Still it does not contain automated sequencer and other high value molecular equipments. It focuses more on advanced analytical services.

2.2. Academia/ Universities

Four major universities have some activities related to biotechnologies. These are; University of Khartoum, University of Elnilain, Geziera and Sudan Universities. Each of these universities has a section or department for biotechnology:

2.2.1. University of Khartoum

The University of Khartoum has 2 plant TC labs at the Faculties of Science and Agriculture, and four molecular labs at the Faculties of Science department of botany, zoology, Faculty of Agriculture and Faculty of Veterinary Science. The over all staff engaged in biotechnology activities in the University of Khartoum are 27 PhDs and 13 MScs holders. These laboratories are suffering from funding and focus mainly on education and training of students.

2.2.2. University of Elnilain

University of Elnilain has TC and molecular lab at the Faculty of Science, department of biochemistry and biotechnology. It has 4 PhDs and 3 MSc staff. The labs are not fully functional and mainly focusing on training issues.

2.2.3. University of Sudan

The university has TC lab at the Faculty of Agriculture and a molecular lab for disease diagnosis at Faculty of animal production. The staff is 4 PhDs and 5 MSc holders.

2.2.4. University of Gezira

The university has a plant TC lab with 1 PhD and 1MSc and a plant pathology lab for diagnostic and molecular virology. The university has strong ties and collaboration with French institutes. Many of the biotechnology staffs were trained in France. Overall trained staff is 4 PhD and 2 MSc. There is no active research work and the activity is mainly educational.

2.3. Private sector (research, industrial production)

The involvement of the private sector is main in the area plant TC applications. There is three facilities for plant TC in Khartoum at Lina company, Date palm company and the Ministry of Agriculture. All of these labs focus on the production of planting materials for fruit trees (banana, citruses, date palm, etc), strawberry and flowers.

A fourth private lab is at Kenana Sugar Company for in vitro improvement of sugar cane. These private labs are minimally staffed (Table.1) and functioning at low scale due to limited market.

3. Facilities engaged in GMO research and development and detection

The surveys revealed that there is no research on production of GMOs in all fields at the local institutes. There have been no applications to import GMOs or their product. However, the only suspected source of GMOs products is the food aid to war and conflict affected areas.

The World Food Programme (WFP) has one of its largest food aid operations in Sudan. It provides cereals such as sorghum, wheat, split-peas, lentils as well as processed products like Corn Soy Blend (CSB), soy-fortified sorghum grits, non-fat dried milk and kidney beans and vegetable oil. Much of the food aid is donated by USA and processed products such as CSB are most likely derived from genetically modified (GM) varieties of corn and soybean grown there.

The Government of Sudan has expressed concern about the long-term effect of GM food on human health and environment. It had granted a waiver to WFP to import CSB and vegetable oil since 2003. The waiver was renewed annually without interruption until 2006. Early in 2007, the waiver was withdrawn and the Sudanese Standards and Meteorology Organization (SSMO) – the principle government agency for standards and controls requested that all WFP shipments were required to be accompanied by a certificate for Genetically Modified Organisms (GMO) testing from an international surveyor; otherwise they would be sampled and tested in Sudan.

This situation triggered the Biotech lab of the ARC Wad Medani to establish a system for GMO detection and offer technical service to the SSMO. The Lab has acquired procedure followed in Japan for GM detection and procured relevant reagents and plasmid containing most of the commercial available GM genes of Soya and corn to be used as standard. The adopted system is qualitative PCR detection method reflecting presence or absence of the GMO in the sample. The lab has assigned two graduate technicians to run this service.

A dispute had occurred in one of the lab results between the WFP and SSMO where by 3 of 5 samples from sorghum shipments tested positive for GMO. This led the SSMO to halt the distribution of the shipment. The dispute was resolved after another sample sent to an overseas sample brought beyond the detectable level of GMO result. It is known that GM sorghum is not commercially available however, the shipment contained adventitious soya and corm which were proved to be GM positive by the lab qualitative test. The shipment was released based on the foreign lab test.

Following these dispute the WFP invited technical mission from FAO to inspect the local lab detection capacity and see the gaps and provide technical advice on the WFP shipments. The mission took place in 17-22 June 2007 and the team visited various research institutes dealing with biotechnology and agricultural research in Khartoum and Wad Medani. The Team produced a report with conclusions and recommendations some of the related ones to GMO detection were:

Sudan researchers have the capacity to conduct molecular analyses of plant materials and the personnel are highly motivated professionals. However, the research environment is quite challenging due to the limited funding, poor infrastructure, and limited access to scientific information, and limited technical training in the specific methodologies. Thus, technical capacity training and long-term competence building is feasible given some investment in infrastructure and equipment.

For GM detection and analysis, the ARC-Medani is the most appropriate for GM seed detection while the Faculty of Medicine in Khartoum has the advanced equipment for GM food detection and testing. However, there are only a few who are trained in the area of GM detection in order to carry out the routine work.

With regards national capacity for GM food safety assessment, currently no such assessment has been carried out in Sudan. SSMO has a food lab in Khartoum and ARC has a food technology lab in Medani, which would be potentially able to conduct such assessment if they are set up to do so.

So far no biosafety research in environmental aspects of biodiversity has been conducted in Sudan and no data is available on the base line of sorghum gene flow, impact on nontargets or other environmental and microbiological impacts..Following the dispute with the WFP on the GMOs issue the Government decided to put the regulatory process of GM food from safety prprospective under the department of environment and food safety of the Ministry of Health DEFS. The DEFS established advisory committee from relavant institutes and experts to provide technical recommendation for decions on GM food and feed. The Biotech lab in Wad Medani remain the only GMO detection lab for both regulatory agency: DEFS for GM food and SSMO for other GM products.

- Gaps and Needs for GMO detection
- Limited technical capacity and skills only for qualitative detection system.
- Limited experience in sampling and results interpretations.
- Need for training in qualitative testing
- Lack of biosafety guide lines nd tolerance limit for GM level and adventitious presence.
- Need for Regional networking and accreditation

4. Biosafety Regulatory Status

The constitution of Sudan calls for the conservation of the natural resources of the country and the protection of its various environments against any hazards. Sudan is a party to the Convention on Biological Diversity (CBD), since 1995, which recognizes modern biotechnology as having a great potential for the promotion of human well-being, particularly in meeting critical needs for food, agriculture and health care. Sudan has acceded to the Cartagena Protocol on Biosafety since 2005. This protocol regulates movement of genetically modified organisms (GMOs) across borders with the aim of protecting the environment, the biodiversity and also human health from possible adverse effects of the products of modern biotechnology.

Sudan is a member of the African Union and therefore respects the provision of the African Model Law on Safety in Biotechnology (revised version 2007). Also Sudan is in the process of acceding to the World Trade Organization (WTO) and will therefore abide by the requirements of its agreements. Taking all the above into consideration, Sudan has set in place it National Policy on Biosafety application of modern biotechnology, in accordance with its national, regional and international obligations. The policy covers the following:

- Laboratory research and other contained uses of GMOs.
- Modern biotechnology applications in industry.
- Modern biotechnology applications in agriculture including confined trials and field releases.
- Trade in and transboundary movement of GMOs and their products.
- Food and feed containing GMOs, including relief and aid materials.

The policy aims at:

- Promoting the application of biotechnology as a tool in the sustainable development of the country to benefit the people of the Sudan.
- Ensuring the judicious and wise use of modern biotechnology in order not to jeopardize the environment and human health.
- Protecting Sudan>s biological diversity by preventing possible genetic contamination.
- Regulating the transboundry movement of GMOs and products thereof in accordance with the provisions of the Cartagena Protocol.

Sudan has developed national Biosafety framework (NBF) with a support from UNEP/GEF project for enabling capacities to develop NBF and currently participating in a capacity building project for establishment and operationalization of Biosafety Clearing House. The Higher Council for Environment and Natural Resources of Ministry of Environment and physical Development is the national Focal Point for Cartagena Protocal. The NBF is in the process of approval by the National assembly.

A project proposal is submitted to GEF for implementation of the NBF (2010-2013) and a regional complement for WANA countries. As an interm measures The Sudanese Standards and Metrological Organization and Federal Ministry of Health Directorate of Environment and food safety are acting as a regulatory body for transboundry movement of GMOs supported by an Institutional technical committee representing different sectors related to GMOs.

5. Situation analysis and conclusions

1. There is steady increase in the recognition of the role of Biotechnology in the development as indicated by the increasing in the number of functional lab and research staff.
2. Sudan has basic infrastructure and trained personnel for molecular biology in plants, animals and Biomedicine.
3. Tissue culture research is well established but need more focus and coordination to minimize duplication and deliver products.
4. There is National acceptance for the ARC lab GMO detection results and therefore it is the best to be considered for accreditation in GMO detection
5. Sudan can provide experience and share lessons with other member of the GMO detection Platform
6. Qualitative GMO detection system is crucial for the acceptance and direct interpretation of the results by the regulatory agency. It is no longer sufficient for these agencies to say the sample is GM positive. They need more information about the percent of GMo in the sample.
7. Inclusion of recognized international lab in the network of the regional Platform is crucial for the public acceptance and trust in the results provided by the local laboratories on GMO detection.

Table 1: Institutes performing Biotechnology in Sudan, staff and activities

Institution	Staff		Activities	location	status
	Ph D	MSc			
1. Research Institution 1.1. Agric. Research Corporation (ARC)					
1.1.1 ARC, TC lab	2	2	Mass propagation of fruit trees, wheat DH	W. Medani,	functional
1.1.2 Biotechnology lab	3	6	MAS, TC, GMO detection, GE	W. Medani,	functional
1.1.3 Soil microbiology Lab.	2	1	Biofertilizer	W. Medani,	functional
1.1.4 Plant Genetic Resources Unit	2	4	Characterization and conservation of genetic resources	W. Medani,	functional
1.1.5 Forest Research Center TC lab	1	2	TC for forest trees	Soba, Khartoum	Just started
1.1.6. Biotech and Biosafety Center	3	3	Genomics, GE, GM detection, BCH	Shambat, Khartoum	Under construction
Animal Research Corporation					
1.2.1 Vaccination Lab	15	15	Production of animal vaccines	Soba, Khartoum	Functional
1.2.2 Molecular lab	2	1	Diagnostic	Soba, Khartoum	Functional
1.2.3 Tick and Insect disease Lab	4	2	Diagnostic	Soba, Khartoum	Functional
1.2.4 Animal central lab	3	4	Artificial insemination	Khartoum	Functional
National Research Center					
1.3.1 Commission of Biotech and GE.	6	24	TC, MM, Microb., Biochemical	Khartoum	Functional
1.3.2 Envir. Institute	2	3	Biofertilizer	Khartoum	Functional
1.3.3. Institute of					
Medicinal Plant Molecular Lab	2	1	Diversity, Finger printing	Khartoum	Functional
1.4 Central Laboratory M of S &T	4	10	Molecular biology, Biochemistry, Microbial biotech	Khartoum	Functional
Academia					
2.1. University of Khartoum(U of K) 2.1.1 Faculty of science	11	4	Molecular biology, Biochemistry, Microbiology, TC, Zoology	Khartoum	Partially functional
2.1.2. U of K , Faculty of Agriculture	9	4	Plant TC lab, Molecular biology lab	Khartoum	Under testing
2.1.3. U of K, Faculty of veterinary science	7	5	Molecular biology lab, Artificial insemination lab	Khartoum	Functional
2.2. Nilain University, Faculty of Science	4	3	Plant TC (secondary metabolite), & Molecular for human diseases diagnosis	Khartoum	Just started
2.3 University of Sudan	4	5	Plant TC, Diagnostic	Khartoum	Partially functional
2.4. Gezira university	4	2	Plant TC,	W. Medani	functional
Private Sector					
3.1. Lina TC company	1	1	plant TC	Khartoum	Functional
3.2.Date Palm TC Co.	2	4	Plant TC	Shambat, Khartoum	Functional
3.3.Kenana Sugar Co.	1	2	Plant TC	Kenana	Functional
3.4. Ministry of Agric.	-	2	Plant TC	Khartoum	Functional

Sample of publications in Biotechnology and closely related disciplines from ARC researchers with some from collaborating overseas institutes

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Syria

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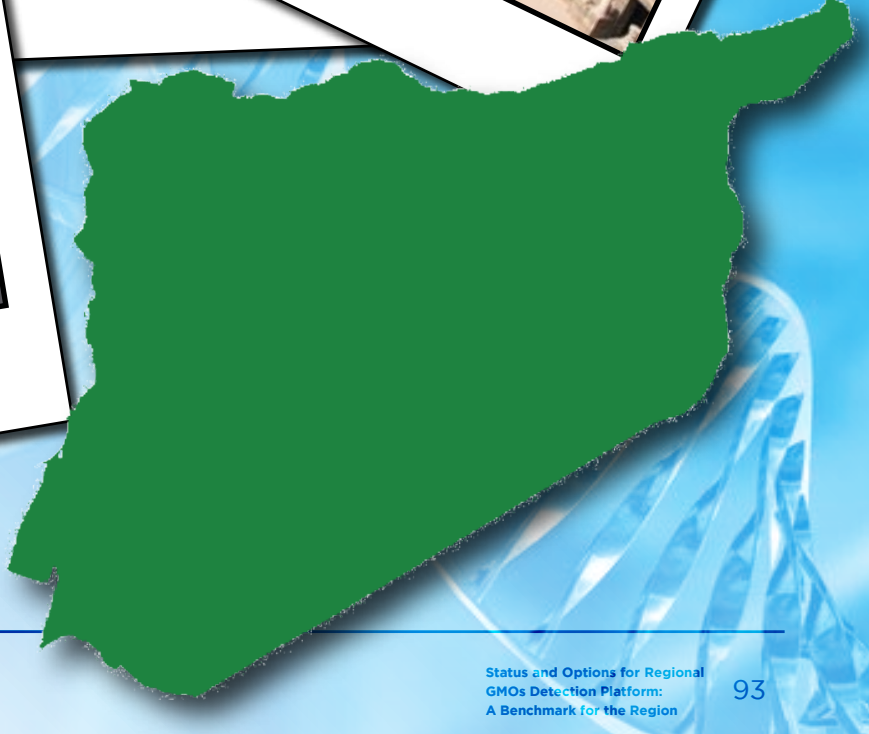

3.4. Syria

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.

United Arab Emirates

Mr. Rashed Borshaid

Ministry of Water and Environment (MWE)

3.4. United Arab Emirates

Introduction

FAO has approved a two year regional project (TCP/RAB/3202) entitled "Strengthening capacities towards the establishment of a regional platform for the detection of genetically modified organisms». The participating countries include Lebanon, Jordon, Syria, UAE, Yemen and Sudan. The aim of the project is to strengthen regional capacities and to enhance regional information exchange and dialogue in biosafety that would lead to the establishment of a regional platform for handling and managing GMO detection and related procedures through increased regional cooperation and standardization of GM detection and analysis procedures within the region.

Given the strong trade relations among the countries of the region, the shared borders, the heavy imports of food products, and new investments that the area is attracting; such a network could also represent an economic opportunity. It could reduce dependency and costs associated to GM detection activities on one side, and generate additional resources through the charges from the services provided by the reference laboratories on the other side. In addition, as GMO detection activities are necessary for the release of permits, the project will favor more balanced public-private sector collaboration for better organization and management of imports within the national regulatory frameworks and standardized procedures. Through the project it is expected that the six countries (Lebanon, Jordon, Syria, UAE, Yemen and Sudan) will reinforce the ties between agriculture and environment at national and regional levels, increase training opportunities, share experience and know-how. It will also aim to increase North-South and South-South collaboration in this area.

The project started its activities with an inception workshop held in Central Khartoum, Sudan from 17 -18 December 2008. The meeting was attended by participants from FAO Rome, ICARDA, AARINENA, and National Project Coordinators (NPCs) from Lebanon, Syria, Jordan and Sudan. The NPCs from Yemen and UAE could not attend this meeting.

The main outputs of the Inception Meeting were:

- A thorough review of the work plan adjustment to fit to the time frame of the project.
- National consultants proposed and nominated for each of the participating countries.
- Finalization of a common format for country stock taking of existing capacities in GMO detection, biotechnology and biosafety.

- International consultants proposed and agreed that FAO Rome will initiate contacts and take final decision.
- Consultants should start immediately the surveys and submit their reports as indicate in their TOR by March 2009.

Consultation in Biosafety, Institutional Collaboration and Partnership Building

Under the general supervision of the Regional Representative for the Near East (RNE), the technical supervision of the Officer-in-Charge of the Seed and Plant Genetic Resources Service (AGPS) and in close collaboration with the AGPS and the Research and Extension Unit (NRRR) technical officers and the NPCs, Prof. Dr. Magdy Madkour was selected as the International Consultant to anchor and provide the perspective and vision in developing the Regional Platform for GMO detection through preparation of documents, participation in meetings, interaction with partners on all aspects of GMO detection procedures and related institutional aspects.

Mr. RASHID BURSHEED, Director of Research, Ministry of Environment and Water, Dubai, UAE in his capacity as the National Project Coordinator, together with Prof. Madkour formed the team which was tasked to conduct the National assessment on the status of biotechnology, biosafety and GMOs in the United Arab Emirates .

A series of meetings, interviews and visits with Ministry of Environment and Water officials, Academic staff, Private Laboratories and International Organizations working in the UAE were made possible through the efforts of Mr. Bursheed. The assembled data has led to a comprehensive presentation of major aspects relating to biotechnology and biosafety in the UAE, identifying existing gaps and thus suggesting recommendations and the way forward.

The outcome of the consultation and discussions with all concerned is hereby highlighted in this National Assessment Survey for the UAE.

Meetings Held:

Meetings with Ministry of Environment and Water officials:

Individual meetings were arranged with the following high officials at the Ministry of Environment and Water:

- HE. Dr. Rashid Ahmed Bin Fahd, Minister of Environment and Water (MEW)
- Dr. Mariam Al Shanacy, Advisor to HE Minister of Environment and Water
- Mr. Obaid Al Matrohi, Assistant Deputy Minister for Fisheries,
- Mr. Abdallah Al Moalla, Assistant Deputy Minister for Water and Land,
- Mr. Sultan Abdallah Olwan, Assistant Deputy Minister for Agriculture Affairs,
- Eng. Mansour Ibrahim Mansour, Director of Agriculture, MEW.

Meeting with the International Center for Biosaline Agriculture (ICBA) officials:

- Dr. Shawki Barghouti, Director General
- Dr. Ahmed Almasoum, Deputy Director General,
- Dr. Faisal Taha, Director of Technical Programs
- Dr. K. Rao Manduri, Plant genetic resources specialist
- Dr. Rachael McDonnell, Water policy and governance scientist

A visit to the laboratories and experimental field station of ICBA and discussion with several scientists from the center took place on May 6, 2009.

Meeting with ICARDA's Director of the Arab Peninsula office, Dubai:

Dr. Ahmed Tawfik Moustafa, Regional coordinator, ICARDA regional office, Dubai

Meeting with the Advanced Biotechnology Center (ABC), Dubai:

- Dr. Mohsen Sulaiman, Director and DNA fingerprinting expert (by phone)
- Dr. Sanjeet Mishra, Technical Manager and Deputy Director.

After the meeting, the laboratories of the ABC center were visited and the equipment used in DNA fingerprinting, sequencing and molecular characterization was inspected.

1. Biotechnology in the United Arab Emirates (UAE)

The United Arab Emirates (U.A.E.), proclaimed on 2 December 1971, is set up of seven Emirates with Abu Dhabi the capital of the State. U.A.E., with a total land area of 83,600 km² (including approximately 200 islands) is inhabited by 2.443 million.

Climatically, the country is divided into two ecological zones, which greatly influence the agricultural production: These are the coastal region with hot and humid summers and warm winters, and the inland region, which is dryer.

1.1. Parameters of the Investment Environment in UAE

During the year 2006 UAE has realized a rate of development which has matched 10.7% measured by the real price, against 4.5% realized during 2002 i.e. an increase rate of about 237%.

- The GDP amounted about US$ 190 billion during 2006 against US$ 75 billion during 2002 i.e. an increase of about 135%.
- The Balance of Trade has realized a surplus that amounted US$ 56.3 billion against a surplus of US$ 14.2 billion during 2002 i.e. by a rate of increase of 296%.
- The per capita income during 2006 has reached about US$ 31700 which was doubled fourteen times compared with the per capita income of US$ 2200 in the Middle East & North African regions as a whole.
- UAE enjoys a political, economical, financial and fiscal stability. The economical system is deemed as free and open while the banking system contains a broad spectrum of credit facilities packed with enough liquidity which is free of any limits in foreign exchanges. Moreover, the entry visa issue policies to UAE allows for easy importation of foreign workers and employees.
- There are no direct taxes on profits earned by companies or on personal incomes (except for the fixed rate of 55% to be paid by oil companies and 20% levied on foreign banks' branches out of the net profit earned). As for custom duties it is 4% with many exemptions provided also it is allowed to transfer 100% of the capital of the professional companies, the foreign companies' representative offices and of the free zones companies.
- A fit and deep-rooted legal frame of work is envisaged in the companies' Act together with a clear ownership basis allowing expatriates for property rights up to 49% of the capitals of companies and 100% of the professional companies, foreign company's representative offices and free zones companies. On the other hand UAE has one of the best infrastructures worldwide, the matter that has contributed to attract international companies those who have enhance UAE's boom.

- UAE has occupied a leading position amongst Arab countries in terms of competitiveness in international markets and has positioned in the sixteenth rank in the international competitiveness index issued by the International Economic Forum of 2005/2006 also UAE has lead Arab countries in terms of the standards regarding technological development, public organizations management, overall economic stability, the degree of business competitiveness and the local business environment.

1.2. Date palm in the UAE

”Provide me with sustainable agriculture, i will ensure you a civilized society”

His Highness The Late Sheikh Zayed bin Sultan Al Nahyan

His Highness Sheikh Khalifa Bin Zayed Al Nahyyan, gives agriculture in general and date palms in particular huge care and put it on the top of his priorities. This Generous auspice comes as a continuation of the philanthropic demarche established by His Highness the late Sheikh Zayed bin Sultan Al Nahyan. This special attention of His Highness, The President, is clearly demonstrated in the increasing efforts exerted to improve Date Palm plantations all around the Emirates in terms of quantity, quality, productivity and the exploitation of available resources, which led to the leading position in the Date Palm business worldwide that the country is enjoying nowadays where the actual date tree population in U.A.E. is about 40 millions, of which 8.5 in AL-AIN region.

The annual date production in U.A.E. has jumped from less than 8,000 metric tons (MT) in 1971 to more than 240,000 MT in 1995, an increase of about 30 fold. The date fruit import had consequently dropped from 100,000 MT (1989) to 12,000 MT (1994). The decline corresponds with an increase in the country’s production of 100,000 MT over the same period. The export of dates had also jumped from zero (0) in 1971 to above 50,000 MT in 1998 with a value of US$ 15 million.

The U.A.E. date harvested area has increased from less than 60 hectares (ha) in 1971 to 31,005 ha in 1996. This increase in area is about 48 times and allowed the country to be internationally classified as the Seventh major producing country with six percent of the world date production. This date palm area constitutes 15% of the total cultivated land (about 200,000 ha).

1.3. Physical facilities dealing with Biotechnology:

Most physical facilities and Laboratories dealing with biotechnology in U.A.E concentrate on various aspects of Micropropagation and tissue culture of date palms. These facilities belong to Academia and private sector. Besides the commercial units, most of the institutions are targeting the establishment and development of biotechnology techniques to encourage and strengthen higher education and research, as well as training and industry support

Examples of such facilities and its description are presented below.

1.3.1. Date Palm Tissue Culture Laboratory (DPTCL)

The DPTCL, founded in February 1989, belongs to the UAE – University in Al Ain and took several years to reach its technical establishment. A new and adequate facility was built in 1993. The DPTCL receives the continuous attention of H.H. Sheikh Nahayan Mabarak Al Nahayan, Minister of Higher Education and Chancellor of the UAE – University. The DPTCL is internationally recognized as one of the major commercial Date Palm Mass Propagation Unit, The application of tissue culture techniques for date palm, also called in vitro propagation, has many advantages in comparison to the two traditional techniques (seed and offshoots propagation). The following are a few highlights to describe the Project.

Budget and Infrastructure

Annual Operational Budget	2.6 Million AED
Laboratory Superficy	2,400 m^2
A date palm gene pool area	20 hectares
Hardening facilities	17 Greenhouses and 7 Nurseries (5 hectares)
Growth Chambers	Eight (8) with 90,000 cultures capacity for each
Working Stations for Cultures and Subcultures	32 (16 Air Laminar flow Hoods)

Personnel

Laboratory Technicians & Assistant Technicians	77
Greenhouses and Nurseries Staff	16
Laboratory & Hardening Supervisors	2
Managerial Staff (Director, Assistant Director & Financial / Administration Officer	3

Production Capacity

So far the DPTCL had produced and distributed about 400,000 date palms of different varieties. The actual project aims to strengthen the existing unit and targets an annual production of one million date palms as from 2008. A second working shift is to be installed along with new laboratory extensions and buildings.

Varieties Mass Propagated

The following date palm varieties are in vitro propagated in the DPTCL: Khlass, Barhee, Rziz, Sakii, Jech Ramli, Maktoumi, Lulu, Nmishi, Chichi, Sukkari, Khisssab, Abu Maan, Sultana, Nabt Sabif, Khadraoui, Hilali, Khenezi and a male named MY2.

The project is implementing an annual program to introduce new date selected varieties and to reintroduce the previous ones in order to continuously have young cultures available

1.3.2. AL WATHBA MARIONNET LLC – U.A.E.

«Al Wathba Marionnet LLC» is a leading plant bio-technology company established in Abu Dhabi in 1997, as part of the U.A.E. Offsets program between France and the United Arab Emirates. It is considered to be one of the world's most important producers of Date Palms through plant tissue culture technology. Al Wathba owns a laboratory in Al Ain city where it propagates high quality varieties of date palm in mass quantities to satisfy the increasing demand locally and internationally. Thus, making U.A.E. an important center to supply the region and the world with pest-free, true-to-type tissue cultured date palms. Al Wathba Marionnet propagates more than 14 date palm varieties with origins from; U.A.E, Saudi Arabia, Iraq and Morocco. Additionally, Al Wathba looks into the rare date palm varieties of superior quality and propagates those which thrive under the climatic conditions of U.A.E. and the region. Hence, making rare varieties of date palm available to farmers in big quantities and at reasonable costs.

Superior varieties produced:

Zamli, Nawader, Ashal Al Hassa, Ashal Khalas, Um Ed Dahan, Mumtaza in addition to the males: Ghannami and Al Sekka. In the other hand, Al Wathba Marionnet dedicate itself on producing high quality date palm trees. This shows clearly in its strict and accurate production protocols and procedures, which are kept updated with the latest developments of Tissue Culture technology.

As part of its commitment in ensuring the genetic constancy and true-to-type state of the trees, Al Wathba Marionnet attaches a great importance to monitor their genetic stability all along the in-vitro process through carrying out genetic finger printing tests. These tests are regularly carried out on random samples of plants at several growth stages by the G.E.V.E.S. «Group for Control and Survey of Varieties and Seeds» which belongs to the French Ministry of Agriculture. Nowadays, hundreds of thousands of Al Wathba Marionnet palms are producing tons of high quality dates in different parts of the U.A.E. along with 16 other countries all around the world

Al Wathba Marionnet propagates more than 14 date palm varieties with origins from; U.A.E, Saudi Arabia, Iraq and Morocco. Additionally, Al Wathba looks into the rare date palm varieties of superior quality and propagate those which thrive under the climatic conditions of U.A.E. and the region. Hence, making rare varieties of date palm available to farmers in big quantities and at reasonable costs. Of these rare superior varieties Al Wathba produces: Zamli, Nawader, Ashal Al Hassa, Ashal Khalas, Um Ed Dahan, Mumtaza in addition to the males: Ghannami and Al Sekka.

1.3.3. Green Coast Nurseries

Green coast nurseries is based in Fujairah, one of the seven emirates forming the United Arab Emirates. We are into the production, management and selling of «Tissue Cultured Date Green Coast nurseries Palm Plants», tender coconut palms, other palms like Livistonia, Brahea, Royal Palm, Blue Palm, etc. and a vast array of fruit and ornamental plants.

Our specialization is in the production of high quality (female) date palm plants which have been propagated (spelling) through the technique of «Tissue Culture» and special variety of male date palm yielding the highest & best quality of dates. These plants have been produced in our laboratories in close collaboration with a UK. Company who have been in this field since the last 30 years and have successfully researched for the development and production of date palms. Our company’s reliable, well controlled system generate commercial quantities of high quality, genetically uniform plants of the most select and desirable varieties

Growth and development of tissue cultured date palms

Growth and development of tissue cultured date palm plants go under several steps:

I. Importation of the highest quality of date palm trees from around the world for the sole purpose of propagation using state of art tissue culturing technology.
II. The active heart tissues are taken from the selected plant and under the highest hygienic conditions are then planted in a proper media in our labs.
III. From the developing embryo to a green plant takes place in our labs equipped with a proper life support system controlled by temperature, humidity and light & closely monitored.
IV. The newly developed plant is then taken to the glass houses where it is gradually hardened and accustomed to the normal environment in which it will be planted in. This process takes almost 3 months.

The nursery period takes 3 to 6 months time in which the plant is developed and accustomed to the real life temperature and conditions and is closely monitored by our trained specialist and engineers in our Bidyah site. After this period the plants are ready to be planted anywhere.

1.3.4. Al Rajhi Laboratory

Varieties Mass Propagated in Al Rajhi Laboratory

Khlass, Barhee, Rziz, Maktoumi, Khadraoui

Production capacity

50, 000 trees per year

1.3.5. International Center for Biosaline Agriculture (ICBA)

The establishment of the Center was based on a strategic decision in the early 1990s to build a research and development institute focusing on the problems of salinity and using saline water for irrigated agriculture.

The Islamic Development Bank under the visionary leadership of its President, Dr Ahmed Mohamed Ali, took the lead in establishing the Center to build world class modern research facilities and to recruit international scientists to conduct research on improving the well-being of poor farmers cultivating under marginal conditions. A team of dedicated staff from the Islamic Development Bank and the Government of the United Arab Emirates worked hard to establish the Center in Dubai. The Center Government of UAE, the Arab Fund for Economic and Social Development, the OPEC Fund for International Development, the International Fund for Agricultural Development and the Municipality of Dubai to support the Center's activities.

Over the last ten years, the Center has been able to evolve strategically from the initial focus on applied research and technology development in saline irrigated agriculture, to the broader mandate of improving agricultural production within an integrated water resource system approach. Significant support from donors and fellow researchers and partners in national programs has encouraged this evolution in the Center's research agenda. ICBA is presently conducting over 15 projects at its Research Station covering the broad areas of its mandate in marginal water and biosaline agriculture.

Location

The International Center for Biosaline Agriculture (ICBA) is located 23 km from Dubai on the Dubai-Al Ain Highway and is easily connected to the rest of the UAE through the nearby Emirates Highway and Dubai Bypass Road.

Land area

The total area of ICBA>s headquarter is about 100 hectares, out of which 65 ha of mainly 2-5 meter high sandy hummocks is left undeveloped for the protection and rehabilitation of natural ecosystems common in the area. Fully developed for research, the remaining 35 ha are divided into 14 blocks, 2.5 ha each. Field salinity control can be achieved up to the plot level. Fields supplied with low salinity water are allocated for plant propagation and seed multiplication. Of the soil taxonomic class, the native soils are loose, nonsaline, fine sand in texture, very deep, somewhat excessively drained, moderate to rapidly permeable, strongly calcareous and moderately alkaline. Hardpan is also encountered in some areas.

Facilities

- Auditorium and training building
- Genebank
- Central Analytical Laboratory
- Seed unit
- Greenhouses
- Shadehouses
- Storage facilities
- Plant processing and drying rooms
- Machinery and workshop building

Investigation of elite date palm varieties for salt-tolerance

The objective is to evaluate the long-term impact of irrigation with marginal quality water on the growth, fruit yield and quality of elite date palm varieties in the Arabian Peninsula. Ten common varieties in the United Arab Emirates and 8 from Saudi Arabia are used in the trial which commenced in 2001-2002. Salinity levels used are 5, 10 and 15 dS m-1 (3,500- 10,500 ppm). The field is laid out in a split split plot design with three replications and five trees in each replication. All varieties showed promising growth under saline irrigation. Among local varieties, plant trunk height varied between 65.1 to 126.9 cm and fruit yield between 3.9 and 25.8 kg/plant. Lulu had the maximum trunk height (126.9 cm) crown diameter (316.3 cm) and maximum fruit yield followed by Barhi. Among Saudi varieties, Sukkari had the maximum plant height, crown diameter and fruit yield (22 kg/plant).

Conservation and sustainable use of plant genetic diversity to improve productivity of marginal ecosystems

The main objectives of the program are to promote agricultural production, energy generation, environmental greening and ecosystem rehabilitation in marginal environments by identifying, introducing, conserving and distributing suitable plant species. For the last ten years, ICBA has been assembling the germplasm of species with proven or potential salinity tolerance to provide a source of genetic diversity for researchers to mitigate problems of salinity in agricultural production systems.

In line with the new strategy to include other marginal quality waters such as wastewater, ICBA is acquiring, conserving and distributing germplasm of high value species such as vegetables and ornamentals. Over 9400 accessions of 220 proven or potentially salt-tolerant species, originating from 134 countries, are conserved in the ICBA genebank (at controlled environment of 5-7°C and 30-40% RH). A majority of the accessions are forage grasses and legumes. However, crops such as sunflower, mustard, guar, quinoa, asparagus, canola, pigeonpea, sesbania, cowpea, tomato, hot pepper and okra are recent acquisitions. Among the newly acquired crops, quinoa, asparagus, pigeonpea, guar, mustard and cowpea showed good adaptation and excellent potential for crop diversification in the Arabian Peninsula.

Following preliminary evaluation, using low quality water irrigation (salinity, 3 dS m-1; 2,100 ppm) on the research station, several cultivars with high yield potential were identified for further testing and possible introduction as promissing alternative crops in the region. Seed multiplication is underway in over 100 salt-tolerant germplasm accessions of forage crops including, pearl millet, sorghum, buffel grass, sesbania and triticale. About 320 newly acquired accessions of tomato, hot pepper, okra, eggplant and ornamental species are also being grown for seed increase and to evaluate their

performance under field conditions. In the United Arab Emirates, ICBA undertook 14 germplasm exploration trips and collected 220 samples of 70 economically important species for conservation and sustainable use. Many of these species have great potential for economic exploitation and because of their natural adaptation, they are more appropriate for use in landscaping and habitat restoration programs. Seed multiplication is underway to ensure their continued availability for research and other uses. Showed high potential for biomass and seed production. Promissing accessions produced high dry matter and seed yield.

Evaluation of native and introduced genotypes under local conditions

The process of domesticating wild species into the agricultural production system has been one approach to using wastelands, and poor quality water for irrigation. The approach involves the evaluation, selection and introduction of species to provide the necessary information about their salt tolerance, productivity and uses. Subsequently the potential species can be subjected to different management practices including irrigation, fertilizer, pre-and post-harvest methods to optimize productivity and increase the quality of the material. Results indicate that native plant species are more adaptable to the local environments as compared to the introduced plant species. ICBA leads in the testing and evaluation of both native and introduced genotypes under local conditions.

The major objectives and milestones are:

(i) Identification of salt tolerant genotypes

(ii) Management systems related to soil, water and plants

(iii) Uses and economics of the tested production systems

Propagation and multiplication of halophytes and salt tolerant plants for fodder, bio-energy and landscaping

There are two groups of plants that are salt tolerant and have potential to be used for fodder, bio-energy and landscaping: (i) the conventional and cultivated genotypes; and (ii) the wild plant species/accessions. In many cases, seeds are not available through commercial seed suppliers. Since these plants differ from conventional plant species, their mode of propagation and multiplication also differ. ICBA has started an extensive program for propagation and multiplication of these germplasms, both in greenhouses and under field conditions.

The main purpose is to have sufficient material (seeds and/or vegetative cover) of halophytes and salt tolerant plants for the trials at ICBA and for dissemination with partners through collaborative projects. Many of these germplasms may require specific methods and/or treatments for germination, after which they are subjected

to gradual increase in salinity treatment - a process referred to as <hardening>. Some of the material are genetically highly salt tolerant and may establish even without any hardening process. In cases of grasses, they may show highly salt tolerance in vegetative stage, but either develop very poor embryo and seeds, or do not develop at all. In such cases, vegetative propagation is much better and rapid as well.

Biosaline agroforestry: Remediation of saline wastelands through production of renewable energy, biomaterials and fodder

Growing trees on saline wastelands provides an unique opportunity to produce timber, biomaterials and biomass for energy on land that is of little economic value for food production, thus avoiding competition for food resources. The BIOSAFOR (Biosaline Forestry) research investigates the productive potential of biosaline agroforesty systems in the saline environment from the selection of trees to an optimized management and the development of economically feasible value chains. The BIOSAFOR project integrates different disciplines based on case studies, experimental trials and modeling studies. A number of salt tolerant genotypes are screened through an extensive process to determine the salinity threshold and the slope of growth (and biomass) reduction.

The data are then related to case area studies in different arid regions, where same or similar genotypes occur. This data is combined with climatic, groundwater (and other water resources) and soil data to prepare digitized maps identifying where suitable genotypes could be grown for producing biomass - bioenergy. animals, is also a source for bio-energy. The plant provides a favourable environment conducive for under-storeyed plants. ICBA initiated a trial using A. ampliceps with two other salt-tolerant grass species, Sporobolus arabicus and Paspalum vaginatum to evaluate the responses of salinity treatments and fertilizers, on growth and productivity of the test plants.

The average of four years results shows that the difference in biomass percentages between non-fertilizer and fertilizer treatments (at all salinity levels) were minimal for both the grasses. In case of S. arabicus, the increase in dry biomass were 11.9, 9.4 and 5.06% for 10, 15 and 30 dS m-1 salinity levels respectively, for fertilized plots as compared to non-fertilized treatments. For P. vaginatum, the differences were 11.5, 8.5 and -2.3% for same salinity levels and fertilizer treatments.

Central Analytical Laboratory (CAL)

Analytical laboratories are the backbone of any applied agriculture institute supporting research, extension, soil resource management and environmental protection. ICBA houses a Central Analytical Laboratory at its headquarters to provide independent services for in-house projects and external agencies. To date CAL has analyzed a number of soil and water samples, and provided services to external organizations such as the Environment Agency - Abu Dhabi (EAD); Tourism Development and Investment Company (TDIC) of Abu Dhabi; GRM International Australia; and Shell International.

1.3.6. APRP/ICARDA

The Arabian Peninsula Regional Program (APRP) of ICARDA serves the seven countries of the Arabian Peninsula, namely, Bahrain, Kuwait, Qatar, Saudi Arabia, the Sultanate of Oman, the United Arab Emirates, and the Republic of Yemen. The Program addresses three priority themes (i) rangelands, forage and livestock; (ii) protected agriculture; and (iii) water resources management.

These themes are supported by research in agroecological characterization and stress physiology. Emphasis is also placed on institutional strengthening and capacity building, human resource development, and promotion of the use of information technology. APRP is financially supported by the Arab Fund for Economic and Social Development (AFESD), the International Fund for Agricultural Development (IFAD), and, more recently, the OPEC Fund for International Development.

Goal:

The development of more productive and sustainable rangeland and irrigated production systems, including protected agriculture, through the more efficient use of the natural resources of the Arabian Peninsula, in particular water, energy and indigenous plant species.

Objectives:

- Improved targeting of research and technology transfer, land use planning, and environmental management based on the characterization of the specific potentials and constraints of the diverse agroecologies and associated land use systems of the Arabian Peninsula.
- Improved water use efficiency and optimal utilization of available water resources in open field irrigated production systems.
- Development of integrated range, forage and livestock production systems and management practices for rangeland rehabilitation.

- Development of a protected agriculture industry for the region that meets the national demand for more efficient and sustainable production systems and techniques.
- Strengthened national institutional, human resource capacity and enhanced technology transfer

1.3.7. Advanced Biotechnology Center (ABC), Dubai

The advanced Biotechnology Center is a private laboratory facility based in Dubai. Its main mandate is to run and execute routine analysis of biological materials as well as quality control of water and various measures for food safety.

Recently, ABC has engaged in routine fingerprinting of Date palm produced via tissue culture and micropropagation techniques using state of the art molecular biological techniques such as PCR, AFLP, RAPD etc. Although the facility is not very large, but the quality of services rendered are of high standards.

1.3.8. DuBiotech

Dubai Biotechnology and Research Park (DuBiotech), a member of TECOM Investments was officially launched in February 2005 by His Highness Sheikh Mohammed bin Rashid Al Maktoum, as part of Dubai's 2010 vision to establish a knowledge-based economy. The Park is the world's first Free-Zone dedicated to Life Sciences.

DuBiotech accommodates the entire Life Sciences value chain by providing key facilities, investing in infrastructure and creating a unique free zone that incorporates industrial, academic, commercial and residential projects.

The park incorporates special tailored facilities that include the BIO Headquarter Towers, the Nucleotide Lab Complex and warehousing facilities to support the rigorous requirements of research and development, manufacturing, distribution and high added value services.

As part of its commitment to Corporate Social Responsibility (CSR), all DuBiotech buildings are classified as LEED certified 'green' buildings. This extends not only to the headquarters and laboratory complexes, but also to the manufacturing and community service buildings that will be part of the park. The BIO headquarter Towers, once fully complete, are expected to be one of the largest 'green' buildings globally.

In addition to the park's facilities and infrastructure, DuBiotech also offers services such as regulatory affairs management, partner development, registration & licensing, government services and leasing services; thus consolidating all services under one roof for the client's convenience.

DuBiotech is actively building affiliations and alliances with distinguished universities, specialist hospitals, world regulatory bodies and other research parks to link the DuBiotech community with the global Life Sciences industry.

In alignment with its philosophy to be the major life science hub in the Middle East, DuBiotech features a community of Biotechnology, Pharmaceutical & Research companies including global leaders like Pfizer, Amgen, Merck Serono and Genzyme. Many small and medium businesses are also part of the community.

DuBiotech offers a unique business environment through a mixture of incentives such as advanced infrastructure, support services, freedom of capital movement, tax-free income and easy access to different markets. All of these together position DuBiotech as the strategic and ideal location for life science companies.

Vision Statement

The Dubai Biotechnology and Research Park will be the premier Life Science Hub in the region, comprising Industry, Research and Education through national and international collaboration.

Mission Statement

Contribute to Dubai's knowledge based economy by creating, developing and advancing an integrated life science cluster within a specialized and regulated environment.

DuBiotech Research Park

Dubai Biotechnology and Research Park (DuBiotech)is the Middle East's first and foremost Science and Business Park dedicated to global Life Science, DuBiotech is a hub fostering collaborations and innovation through its commitment to Life Science research, education and industry nationally and internationally.

DuBiotech, upon completion, will cover 30 million square feet of built-up area. It is strategically located in a prime area of Dubai. The 22 million square feet Park is divided into zones that are dedicated to various initiatives and companies of all sizes from across the Life Science value chain with an emphasis on Research and Development.

DuBiotech's headquarter is a 22 stories twin towers stands forth as an icon for the Biotechnology and Research Park. It is designed to be efficient, cost-effective and to create best in-class facilities to host life science companies interested to grow their business in the Middle East region.

The 600,000 sq ft headquarters recently won the Design and Sustainability Honour Award from the American Institute of Architects (AIA) for the technologically complex headquarters and it's poised to be one of the world's largest green buildings.

Bio HQ's unique design reflects DNA movement in a gel electrophoresis, a technique commonly used in the life sciences industry. The two towers are flanked through a Jewel Case which accommodates retail facilities and a Business center.

Designed for multi-tenancy with flexible subdivision, the facility is located in the middle of the DuBiotech complex in a very convenient part of Dubai, that is easily accessible from the new airport and from the major attractions and residential areas.

Normal Office Space (core + shell)

It consists of a variety of occupancies including Tenant Offices, Government Support Services, and Tenant Support Services. Tenant Office space is available to a variety of prospective clients interested to be part of the major biotech cluster in the Middle East. The normal office space is modular, flexible, and can accommodate a variety of tenant sizes.

Business Center (Fitted-out)

It provides incubator offices for small and innovative life sciences companies. The Centre offers total office solutions (fully furnished) and a variety of space types from touch-down stations to office suites. All the startup companies incubated in the Business Center enjoy the same Partner Development Management services – PDM provided to all DuBiotech Business Partners.

Retail Services (core + shell)

It is the vibrant, active centre in the HQ Complex, where people can get out, meet and mingle with each other. It's a great place to get to know your neighbors. The retail services include food and beverage outlets, general retail and convenience shops and fitness center.

Licensing & Activities

DuBiotech has identified a broad range of licensing categories and activities under which companies are allowed to perform within the Park.

- **Therapeutics** – Pharmaceutical, Biological and herbal products used to treat and/ or manage human or animal diseases, but not limited to, antibiotics, vaccines and gene therapy.
- **Diagnostics and Analysis** – Activities related to clinical testing, food, environment, forensic, agricultural, and/ or other biological/ chemical analysis.
- **Agricultural, Forestry, Horticulture, Food** – Novel crop varieties or animals, pesticides, trees, tissue culture products, fertilizers, food products, beverages, ingredients, etc.
- **Environment** – Including, but not limited to, waste treatment, bioremediation, energy production and environmental assessment.
- **Speciality Supplies** – Including, but not limited to, enzymes, DNA, RNA, oligonucleotides, amino acids, oligopeptides, polypeptides, proteins, cells, research animals, gases, etc.
- **Equipment** – Hardware, software, bioreactors, furniture, and/ or consumables utilized for research, education, training, production, and/ or manufacturing.

- **Life Science Consultancy** – Firms supporting or carrying out technical scientific, financial and economical studies pertaining to the life science industry in the areas of manpower, planning, advising, market research and analysis, performance analysis, due diligence, and in designing life science buildings such as laboratories, clinical trials and manufacturing facilities.
- **Life Science and Biomedical Associations (Non Profit)** – Non Profit International, regional and/ or national establishments comprised of scientific and/ or biomedical professionals that focus on enhancing best practices, quality, professionalism, standards, regulations, awards, exposure placement and creating business opportunities in their particular field.

The Nucleotide Lab Complex

The Nucleotide Complex, spanning an area of 256,000 sq. ft, comprises state-of-the-art laboratory buildings that are purpose-built for scientific and industrial R&D, diagnostics, analytical testing, equipment training activities and after sales services among others.

Features of the Nucleotide Complex The LEED certified Core and Shell Lab Space of the Complex, accommodates up to 160 laboratory units, which are designed to meet class III Bio-safety Standards/Guidelines. The laboratory units allow flexibility and ease in layout customisation and are equipped with a dedicated space for a Biological Safety Cabinet and an exhaust system to enable air filtering. The lab facilities are also fitted out with water systems, drainage systems, compressed gas systems and vacuum/air systems.

The air exhaust and ventilation system are specifically designed to prevent cross contamination from leaking/circulating between lab spaces. Additionally, acid resistant drainage along with pH neutralisation systems allows for safe discharge of chemicals/waste and sterilized high quality stainless steel mechanical equipments ensure high standards of hygiene.

1.4. Biotechnology constraints and challenges

There is no doubt that agricultural biotechnology has opened up new possibilities, particularly in crop and livestock development. However, there are major challenges that need to be addressed and tackled especially in the developing countries, in order for these countries to maximize their benefits from biotechnology in solving the urgent problems of food supply, protecting the environment, and reducing poverty. The main constraints and challenges that need consideration and actions are in the followings:

1.4.1. Clear biotechnology agenda and supporting policies

There is a need for Arab countries to develop clear and time-bound national agenda for biotechnology research and development (R&D) and commercialization. This could be achieved by linking science and technology with industry, and having both well tuned to market demands. Similarly, there is a need for policy initiatives to accelerate investments by technology holders and adoption by the farming communities.

These policies include the registration and approval of GM crops and funding and infrastructure support for public-private partnership programs in plant biotechnology, and other related areas. The supporting policies should also provide the framework for research and business institutions, and outline the trade and investment guidelines for the newly emerging biotech sector, which should be in agreement with the international guidelines, including the necessary biosafety measures and tests for new or introduced genetically modified crops.

1.4.2 Intellectual property rights (IPRs)

Patenting and IPR are promoting privatization of scientific research in agricultural biotechnology, and might increase the gap of biotechnology know-how and its applications between developing and industrial countries. Most Arab countries, especially those joined the Trade World organization (WTO) develop their IPR policies and regulation which suppose to cover those of the biotechnology products.

Significant achievements have been made on IPR protection for genetic engineering in general and for plant biotechnology particularly in the developed countries. However, problems and challenges are emerging with the implementation of IPR policies and regulations. Areas that need attention particularly in the developing countries include: Public awareness on IPR, capacity building on IPR protection, implementation on IPR protection, and enforcement of laws and regulations related to IPR.

1.4.3. Biosafety regulations

Increasingly tedious and expensive biosafety regulations are a major cause in slowing down the progress that is expected from biotechnology. In the United States, the cost of obtaining regulatory approval of a new transgenic crop variety can be as much as $30 million. Even the big companies are abandoning research programs if the size of the market does not warrant this level of investment. Small seed and biotechnology companies are essentially priced out of the market unless they partner with the multinationals, and the public sector may be left out as well. The situation in the developing countries is still not clear, because their biosafety regulations have not been developed in most countries.

Arab countries, however, face a number of challenges, including low levels of awareness about the Cartagena Protocol and a lack of necessary human, institutional and technological capacities. There is an urgent need for countries and organizations, in a position to do so, to provide additional financial and technical assistance and facilitate access and transfer of technology to enable Arab countries promote awareness and build their capacities.

There is a need in the Arab countries to Issue and approve national legislations regarding the GMOs and ways to handle them in terms of: their importations to the country, trading, GMOs variety release regulations at the national level and their monitoring and evaluation procedures, biosafety measures for health and environment for the crops and their products, and biosafety regulations for the importation and testing of transgenic crops, with regulations for field tests.

1.4.4. Public acceptance

Public acceptance of biotechnology products, especially transgenic crops and genetically modified (GM) food, is a major constraint to the adoption of plant biotechnology. Public awareness programs and campaigns should be organized to educate the public on the benefits of biotechnology products.

1.4.5. Capacity building

One of the most challenging matters for the biotechnology implementation is the human building capacity and qualified personnel capable of handling and carrying out biotechnology research and applications

2. Finding and Recommendations

During discussions it was evident that the Government of the United Arab Emirates (UAE) recognizes the importance of biotechnology, especially in regard to food trade. Special emphasis is placed on the cooperation with international organisations, such as FAO and WHO, and among the States of the Gulf Cooperation Council (GCC). The UAE, as well as other GCC countries, highlight their special situation as net food importers, and their need to be adequately equipped and prepared to test imported foods for their nature, quality and safety, indicating that current testing for GM foods in imported products is only sporadic and on a case by case basis. The use of analytical kits, particularly for the application of ELISA technique to GMO food detection is indeed well known, but further training on the proper application of these kits is needed. Furthermore, at least one laboratory should seek and obtain accreditation in GMO food analysis from an internationally recognized institution as this is important for international food trade.

It was also apparent that a monitoring and surveillance system should be put in place to check on the presence of GM foods in imported food shipments. In UAE capacity building is urgently needed to strengthen the ability to control and test GM foods and foster research in the area of biotechnology. There is also a need to strengthen capacities both at regulatory and institutional level and to improve partnerships and dialogue at the regional level through strengthened technical, institutional, international cooperation on biotechnology and biosafety.

Moreover, the United Arab Emirates which are not signatory to the CPB so far, lack these specific skills within its regulatory system. Indeed, currently, countries as single entities and the region as a whole cannot fully address the problems deriving from uncontrolled movements of GMOs in the area which could produce unpredictable effects on the regional biodiversity and human health. This is mainly due to the:

- Lack of full technical expertise in GMO detection and the evolving methodologies and practices;
- Lack of standardized procedures for the management of GMOs at various ports of entry;
- Lack of trained staff in GMOs detection and monitoring;
- Lack of equipment and containment facilities; and
- Lack of technical information or access to information in Arabic as a preferred language

Accordingly, there was a consensus that there is a need to:

- Develop a critical mass in terms of human resources and laboratory facilities
- Strengthen biosafety research capabilities
- Strengthen collaboration with international, North-South and South-South collaboration

- Establish a regional mechanism for sharing experiences, expertise and know-how
- Harmonise laboratory procedures, standards, and techniques of GMO detection
- Train relevant officers and technicians at national level in the subject, and develop a platform for information sharing and networking amongst technical staff in GMOs detection laboratories.

3. Conclusions

Plant biotechnology offers an unprecedented opportunity to address some of the world's most serious issues, including hunger, poverty and disease. This is because biotechnology can circumvent the species barriers that prevent useful traits being introduced into plants by conventional breeding. By transferring genes from bacteria, fungi, animals and sexually-incompatible plants into our food crops and medicinal plants, it is possible to improve their agronomic traits and provide them with additional metabolic abilities.

Genetic engineering and biotechnology provide good opportunities for the investment and improvement of food security and food production in the Arab countries, however, it has it is own challenges that need to be considered by the Center.

The following questions are relevant to be asked not only as related to Arab countries, but also for the developing countries in general:

What opportunities exist for biotechnology to contribute toward improving agricultural productivity, expanding markets, and stimulating employment and income generation in Arab countries, and what are the constraints that limit capturing these opportunities and in using biotechnologies approaches?

What challenges do these countries face in realizing these opportunities and in mitigating the risks associated with the use of biotechnology?

Considering the important challenges that encounter the agricultural sector and its sustainability in the Arab countries, it seems that the new biotech crops applications offers enormous potential benefits in the second decade of commercialization, 2006 –2015, in terms of meeting increased food, feed and fiber demands in the Arab World and contributing to more prosperity for both producers and consumers. Of particular importance are the genes for drought tolerance that are under development in both the private and public sector. The genes for drought tolerance are genes that very few farmers in the world can afford to be without and this is particularly true for

the rainfed dryland areas that typify much of the land in the Arab countries for which ICARDA (International Center for Research in the Dry Areas) has a regional mandate, and where biotech research is undertaken on drought tolerance. The first commercial variety with drought tolerance is expected to be drought tolerant maize in the US in 2011. The drought genes have already been introduced into several crops and early field tests are underway; for example, drought tolerant wheat is being field-tested in Australia.

In this regards it is evident that the decision to invest in agricultural biotechnology is timely and appropriate and is of great strategic importance at a time when the new technologies can contribute to:

- an increased sustainable supply of the most affordable and nutritious supply of food, feed and fibre, which is critical for facilitating prosperity for both producers and consumers in the Arab States;
- sustainable crop production in the dry-land areas to alleviate poverty of the rural poor who are farmers and the rural landless who are dependent on agriculture for their lively hoods
- Speeding the crop breeding that will mitigate the new challenges associated with climate change when droughts will become more severe and prevalent, temperature changes will be more variable, and when agriculture which produces up to 30% of greenhouse gases, must be part of solution rather than part of the problem

On the another hand, investment opportunities in biotechnology in the region are highly needed and required a strong partnership and alliance between the public and private sectors which have a visible and potential strategy to boost the adoption, investment and industrialization of biotechnology and their products for better sustainable agriculture and economy, healthy, safe, and sufficient food and feed, and safe environment.

In order for the region to be able to invest in biotechnology, certain requirements are needed:

- Outstanding centers which are run by good scientific personnel and very well equipped with all necessary facilities and instruments.
- Identification of the important products and their needs and demands with availability of investment environment.
- Developing a strategic research platform.
- Strong collaboration between public and private sectors.
- Good marketing strategy.
- An enabling policy and investment environment that will enhance and encourage the investment in this field.

Yemen

Dr. Hamoud Mokbel

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3.5. Yemen

Introduction

1. Status of Biotechnology in Yemen

Biotechnology existed long before there was a special word for it. Many of the principles and some of the techniques involved in biotechnology are ancient. For example, fermentation, in which microbes are used, has been practised for thousands of years to produce beer, wine, cheese, bread and yoghurt. Traditional animal and plant breeding techniques are also a form of pre-industrial or modern biotechnology. Biotechnology defined as “any technique that uses living organisms or substances from those organisms, to make or modify product, to improve plants or animals, or to develop micro-organisms for specific uses”. Therefore, biotechnology involves tools and techniques including those of recombinant DNA technology and it is multidisciplinary contain a variety of natural sciences and molecular biology.

Modern biotechnology is relatively a new issue in many developing countries in the region. In Yemen, it is one of the least developed issues as it is completely new. Consequently, there is poor understanding and little background knowledge on modern biotechnology and associated Genetic Engineering and as well their basic techniques such as Molecular Markers, Marker Assisted Selection, Recombinant DNA techniques, cloning, Transgenic Techniques, Genomics, Proteomics, Bioinformatics and other tools for genomic and proteomic analysis as together with the possible objectives, applications and impacts of these modern sciences on development of various economical sectors. Similarly, knowing the nature and extent of risks come from adopting these sciences in environmental, agricultural and public health sectors is also limited.

However, the risk and negative impacts on biodiversity associated with transfer of Genetically Modified Organisms (GMOs) and use its products is the most issue have been discussed in the report document of the National Biosafety framework (NBF) of Yemen with the acknowledgement of this document in the fact that, there is poor background knowledge in terms of all issues responsible for handling and precautions as well as safety of transgenic organisms transfer and its products.

These deficiencies combined with presence of negative attitudes seeded by the local media that enhance the fear from Biotechnology among policy makers and stakeholders including those working in closely related fields of biotechnology. For many journalists, biotechnology is restricted only on uncontrolled gene manipulation of embryonic cells in Human kind. The media misjudgment on biotechnology and molecular genetics terms is reflected on public attitude as well as negative image in many

policymakers in the country.

In fact, Yemen has many agricultural and environmental problems that increase the importance of biotechnology for Yemen as science and tool that can play an important role in addressing agricultural problems and contribute in agricultural development. For this purposes, there is a great need for adopting biotechnology together with necessarily policies and legislation framework regulating uses and objectives of biotechnology in the country.

Moreover, the actions that would be taken in this regards on different aspects of biotechnology and biosafety framework in Yemen should be developed according to the most important challenges and priorities. On the side of education and research aspects, there is a need to improve education and scientific capacities and technological infrastructure together with more attention given to training issue to those working in all biotechnology fields and particularly to people working in risk management for existing environmental, health, and agricultural systems.

Therefore, Sufficient funds, incentives and facilities need to be provided and strong collaboration between both local and regional related institutions should be established to enhance corporations and mutual benefits exchange that might cover the shortage in mentioned needed facilities. Aiming to further facilitation of that cooperation between the mentioned institutions.

Yemen need to establish a national biotechnology center as central institution for the whole country to coordinate, monitor and enforce biotechnology and associated biosafety issues in all related institutions alongside the country. This center will also help FAO and other international related organizations to achieve their future projects in the country. Policy makers and government officials must be involved in this project to provide sufficient support and to fund the operation of this center. The established center may also help in changing the stakeholders and community negative attitude on biotechnology in collaboration with social authorities to clarify the field of biotechnology as science, tool and industry. This center as it is mentioned before will be the cornerstone for international cooperation toward mutual exchange benefits to ensure fast development of biotechnology knowledge and capacities among the whole region. If we reach this point of development, then we may need to find a way to involve private sector in all issues of biotechnology mentioned before especially the industrial and investigation issues. Then private sector might be encouraged for creation and financing of local private biotechnology enterprises and promote local public research and development.

1.1 Plant biotechnology:

Local Plant Genetic Resources for Food and Agriculture (PGRFA) is the main subject in plant biotechnology in Yemen as many national statistics and reports have confirmed that, local crops varieties such as: wheat, maize, lentil and millet are yield and quality are deteriorating as a result of introducing high yielding varieties as well as extensive use of pesticides and agrochemicals.

The national reports ensured that, the used indigenous breeding methods for selections for new genotypes to improve species productivity and adaptability to different agro-ecosystems were approved to be responsible for crop preservation and improvement in the past and confirm the previous inference by the examples selection processes currently used widely in Tihama, Taiz, Ibb and Lahj in sorghum, and show improvement in seed's color and size with super early maturation and free of pests. It is also mentioned that, inherited knowledge and experience will lead to better understanding of natural resources and consequently better investment for them towards the productivity of various crops, animal and plant species.

However, these reports concluded; 1) lack of national breeding programs for the endogenous species. 2) no plan for sustainable use of agro-biodiversity depends. 3) Some genotypes of the endogenous species have excellent unique genetic characterizes. The report reached to the following recommendations:

1. More researches are needed to collect and conserve local genetic materials.
2. Assessment the potent of resources to improve the sustainable use of agro-biodiversity.
3. Improvement of genetic resources depends on research work and selection of breeding method based on sufficient evaluation process.
4. Establishment of genetic resources centers in the Agricultural Research and Extension Authority and in the Faculty of Agriculture of Sana'a is an important step toward genetic resource conservation and assessment in Yemen.

These centers have initiated processes to collect and preserve genetic resources for cereals, vegetables, and other crops in order to study genetic behavior of the collected species and their potential for species improvement.

In spite of the necessity of Modern biotechnology and Molecular Genetics for addressing and solving all the previous mentioned agricultural problems, no report have mentioned these modern techniques as fast and efficient scientific tools in agricultural research contributing in agricultural development if, there are basic facilities and capacities for biotechnology both at the academia and research centers. Moreover, in

the national report there is no indication to the possible use of modern biotechnology and molecular genetics in plant improvement program for population studies as well as fast genome analysis for evaluation assessment of the local varieties as well as the associated causes of the high level of destruction on plant biodiversity and endemic species. This is may explain the reason why until this moment, there is no single research have been done in both Academia and Research Centers on plant Molecular Genetics and associated Molecular marker although, these kind of researches are required to evaluate the local Genetic resources in terms of threat, quality, utilization, conservation, restoration or regeneration, etc.

In tissue culture aspect, Faculty of Agriculture at Sana'a University has good lab space as well as good facilities for this technique. However, the there is lack of reagents and chemicals needed for running this technique. Moreover, establishment of tissue culture unit in Faculty of Science at Sana'a University is in the progress now. On the other side, initiation tissues culture facilities are available in AREA headquarter laboratory in Dhamar but no reagents are there and no work was carried out in tissues culture there. New tissue culture laboratory, recently, established in Eastern plateau research station (Sayoun) for date palm propagation and another one will be established in Tihama coast research station (Alkadan). The government along with the private sector has recently started a partnership in this field.

Research in this field is restricted on propagation of plant trees that is very difficult to reproduce vegetative. In this type of research there is very good results have been seen in the laboratory of Sana'a University. However, protoplast fusion is the direct issue in tissue culture for GMOs, still absent in country research.

2.2 Animal and veterinary biotechnology:

The situation in animal and veterinary biotechnology is not different from plant, in that, there have not been any breeding research programs and/ or biotechnology research plan to evaluate, characterize and improve local strains, except a single project in chicken improvement at Southern Upland Agricultural Research Station. For example, the introduction of chicken breeds caused large reduction in local strains. Moreover, working on veterinary biotechnology for diseases studies, vaccination and drugs discovery, drug treatments or any other related research topics are beyond the reach even in the near future.

1.3 Microbial/ Industrial biotechnology:

Although the field of Industrial biotechnology is completely absent in Yemen, it can play an important role in economy enhancement if either public or private interest

is taken toward investment in this field. All the local indicators show that, for example, algal biotechnology is one of the most promising issues in Yemen although algal and marine biodiversity haven't been studied in Yemen. Because, investigations of marine algae will provide us valuable products that could even be as important as oil Algal biotechnology has made major advances in the last decades and several algae and algal products. Moreover, the most needed factors for successful of such investigation are existing in Yemen such as, existence of marine commercial algae, open coastal areas for open bond cultivation, stable and high temperature along the year, high light intensity cheap labor costs, etc. (Borowitzka, 1992).

Although, there have been no survey for marine algae, However, many algal cultivars are distributed along the coastal regions in Yemen and have been used by fishers to feed their animals. Red algae are one example of these algae that can be used as rich source for production of commercial iodine and agar. This industry almost spread among eastern regions where the previous required factors are exist.

1.4 Fishing and Algal Biotechnology:

There are several companies working in fishing and fishing cages industry that is combined with algal industry. Although this kind of investigation (growing fish in cages together alga) is representing threat for living organisms in the Yemen sea as it has been reported by Staniford at the European Parliament's Committee on Fisheries public hearing on 'Aquaculture in the European Union: Present Situation and Future Prospects', 1st October 2002, who reported that, "Modern aquaculture practices are largely unsustainable: they consume natural resources at a high rate and, because of their intensity, they are extremely vulnerable to the pollution and disease outbreaks ." He added: If sea cage fish farming is to have any long-term future it must be forced to treat its wastes and focus on non-carnivorous species that do not lead to a net deficit in fisheries resources. Closed containment systems may solve the waste and escapes problems but the final fatal flaw lies in feed and food issues. Far from being a panacea for the decline in wild fisheries and the need for healthy food, sea cage fish farming serves only to compound the current crisis.

However, this kind of investment has been introduced to Yemen with no previous studied of its impact over benefits. Moreover, the global agricultural scenario has been witnessing a sea change for the last two decades. New issues such as global warming and climate change, new pests & diseases, natural resource depletion and degradation, house hold nutritional security, slowly growing farm profitability, food safety, trade competition etc. have arisen. Therefore, there should be more attention on such invests that might cause drastic effect thousands of times more than what we expect from the GMO effects.

2. Physical facilities dealing with Biotechnology

2.1 Research institutes:

In general multidisciplinary sciences as well as modern fields of science are almost rare in a whole country although, some national and private universities are somehow working in biotechnology research. Major Biotechnology courses are given by the Faculties of Science, Agriculture and Medicine. However, the courses given in modern biotechnology and molecular genetics and other related subjects are limited and base mostly on theoretical issues. The faculties in the previous departments are not equipped with sufficient facilities and equipments. The overall capacities and facilities of above mentioned department in National Universities are not even enough for basic work and assessment. For example, there still no Polymerase Chain Reaction (PCR) unit in some of these faculties. Some institutions on the other hand, have lack of any capacities and facilities for any kind of research especially newly established universities and institutions. On the other hand, some institutions in Yemen such as have some of the previous facilities for basic research in biotechnology (Mostly brought to Yemen through international related agencies). In addition, AREA, recently, supply biotech laboratory in Dhamar by modern equipments like real time PCR, a single mini agarose gel with power supply, a large agarose gel system as well as a PAGE gel and ELISA reader (Baum, 2009)

However, these limited facilities are still either in their packages ore used one time as these institutions limited of national experts and trained technicians who are able to do the basic work of such as GMO's detection and other genetic approaches for any related assessment. In addition, run costs of these facilities are expensive as they can be bought through single agent upon request. For example, the institute of Veterinary in Sana'a has PCR unit with no any other related chemicals and enzymes. Moreover, they never use it for any purpose until this moment. Therefore, there is an urgent need for all local universities, institutions as well as other related governmental agencies to further develop their capacities in infrastructure, training and education as one the first step toward assessment and management of biodiversity and biosafety.

The Ministry of Agriculture and Irrigation through AREA and the National Universities (faculties of science and agriculture) are the key players in modern biotechnology and biosafety. The departments of botany, biochemistry and microbiology of these faculties in addition to other faculties like medicine and environmental sciences in all Yemeni Universities can contribute in modern biotechnology and genetic researches as well as associated the risk assessment and management of GMOs through specialist closely related to DNA Technology.

We can conclude from the previous situation that, the powerful tools provided by speed progress in Biotechnology and associated that can introduce magic solutions for the chronicle problems in Yemeni agricultural, and environmental sectors and to contribute to food security and safety as well as environmental sustainability and conservation still in its emergence. Therefore, there is a need to further develop the capacities and engagement in biodiversity and biosafety in national institutions.

2.2 Research and Academia/ Universities Functional Laboratories:

The main institutions involve in research in Yemen are three:

1. Agricultural Research and Extension Authority is the oldest and the largest in the country,
2. University of Sana'a and
3. University of Aden.

The rest of universities and institutions interest are only in either educational or technical services providers for local communities. The survey summary of the existed national institutions, functional laboratories and related information were modified from the data reported in NBF (2005) and summarized in (Annex 1).

We can conclude from the previous information that, Personnel for Biotechnology, Genetics, Breeding and risk assessment of plant and other organisms are few. As result of this, genetically modified basic knowledge and techniques are rare. Furthermore, no genetically modified crops or microorganism were imported, no facility to produced and poor facilities to detect it exists at any Yemeni institution, but biotech laboratory of AREA could be the first on detecting GMO,s if covered its limitation on equipment and reagents (Annex2).

2.3 Access to consumables, reagents and supplies:

Generally the access to consumable and reagents is difficult and expensive as these materials are not widely used in the country. However, most of the companies dealing with drug importation can supply these reagents upon the request of beneficiaries. For example, the Eppendorf, Fermentas, and Biogen companies have agents in Yemen which is NATCO Company that has the highest reputation in Yemen the most. So, access to consumable and other supplies is not a problem as long as you are ready to pay more and to wait more.

2.4 Access to information:

Generally, Yemeni institutions and other research centers have rare to moderate information accessibility. In this regards, Libraries in Yemen often exist in universities. The local research centers are limiting of these libraries and they some times depend on the libraries of main universities such as Sana'a University and Eden University. However, the current references books are extremely old. For scientific journals, the situation is worse as there are no available journals since 1990. The Ministry of Higher Education and Scientific Research now lunch the National Electronic Library project that will join all Yemeni institutions. The project is still in its progress. The Yemeni Information Center has small library that only provide help to the workers in health sector through several medicinal journals in collaboration with Iran government.

In this regard, Yemen never got benefits from the donations provided by some international publishers and libraries. For example, there are many publishers as well as international libraries are providing their publication with limited costs and or for free to non-profitable organizations in developing and least developed countries such as, AGORA, Henri and INSAP library.

2.5 Obstacles facing development of Biotechnology:

The main factors affecting the development of modern biotechnology in Yemen are:

1. Limit of qualified human resources.
2. Weakness of institutional capacities.
3. Inadequate financial resources that led to difficulties in providing adequate human and material resources
4. Weak administrative capabilities to administrate the available cadres.
5. Limit of technical and institutional capacities in the lab and in the field.
6. Absence of an appropriate collaboration and coordination and information exchange mechanisms among institutions and concerned agencies.
7. The previous factors are also coupled with other sub factors affecting the psychology and peace mind of cadres such as low salaries, and inadequate resources allocated for their capacity building improvement.

3. Facilities engaged in GMO research and development

Similar to the status of research in Biotechnology, there is no research work on GMOs at the national level and no such crops are produced locally not only in Yemen but also in the whole region except in Egypt where the first genetically modified crop was produced last year. The awareness level is low and presently no authority has been assigned to regulate research and monitor safe utilization and application of GMOs.

Therefore, in order to foster this situation and halt any further biodiversity destruction, a lot of work should be done on the current national ecosystem in order to regulate the utilization and application of Modern Biotechnology and GMO as the need for modern biotechnology together with conventional breeding increases to its upper level to stop the degradation in natural plant populations as well as to help in restoration of the degraded green mountains that seems to be chronically problems in this time.

There is also need for building a database on local varieties and their natural Genetic information that should be taken for granted when decision is made in exportation or creation of related GMOs. Because, germplasm specificities will determine the degree of the negative effect of GM crops genetically near to them. Therefore, there is a need to develop adequate database on national biodiversity to help in formulation suitable precaution policies and legal frameworks. Similarly, there is a need to strengthen technical, institutional, international cooperation, research and social aspects in biotechnology and GMOs. Because, the lack of policy and legislation framework regulating uses and investment in plant natural resources as well as the absence of powerful biotechnological tools, high level of risk on the country fragile ecosystems and its germplasm will increase especially endemic species.

Moreover, the unreasonable high level of fear from GMOs and ignoring the benefits of Genetic and GMO will deprive the country from the benefits of this technology for assessment and evaluation of local genetic resources as well as finding possible solutions for all problems related to agricultural and environmental sectors. Technical capacities and institutional capabilities need to be further improved and public awareness needs to be enhanced.

National Capacity Self-Assessment (NCSA) have develop an excellent category that, classify capacity development efforts into three interconnected levels that involve; 1) Capacity development at the individual level, that rely on harnessing the individual knowledge and developing skills through training in order to change the attitudes and behaviors that raise to increasing of trainee performance in management, motivation,

morale, and accountability and responsibility levels. 2) Capacity development at the institutional level, aim to enhance the functioning capabilities of institutions in terms of tools, guidelines and information management systems. 3) Capacity development at the systemic level, interested in the overall policy, economic, regulatory, and accountability frameworks that will guide both institutions and individuals.

3.1 Ongoing and Planned GMO research and Development efforts:

Yemen is planning to create an integrated system dealing with all of issues related to biotechnology, GMOs and biosafety such as, applications, notifications and authorization, labeling information, and regulations on import and export of GMOs as well as identification and facing emergency situations and PGRFA characterization. Based on this, all applications to import, export, development, handling, field testing and release of GMOs or their products shall be submitted to the institutional biosafety committees (IBCs) identifying or tracking number must be assigned be used to distinguish this application from all others, which in turn shall forward such applications to the secretariat of the NBC to take the necessary and appropriate procedures. All records relating to the applications are stored under the tracking number, which is used to make information readily available to interested parties. The design of this database can facilitate easy information sharing of risk assessment reports and decision documents should provide information on:

a. Mechanisms for internal safety monitoring;
b. Safeguards to prevent any unintentional release;
c. Safeguards to prevent any unintentional trans-boundary movement;
d. Procedures for post-release treatment and control;
e. Procedures for immediate notification and emergency response in case of an unintentional release; and
f. Any other measures that the NBC, in cooperation with the concerned bodies, may require.

In regard PGRFA characterization government, has to start to establish capacity building, financial mechanism to apply the modern biotechnology and molecular approaches. Utilization of modern Biotechnological and Molecular genetics approaches for sustainable plants investigation and development through desired characteristic simple and quantitative traits for agro-diversity conservation, displaced areas restoration and forestry improvement for food security under divers> geo-ecological conditions. Application of Molecular Marker Techniques on plant genetic resources characterization, identification and utilization, for plant population studies for: (i) Characterization of genetic structure toward studying the indicators of recent bottlenecks in population size, the ease with which genes are recombined, out-crossing, and the

level of gene flow between populations as well as threat assessment and conservation strategies. (ii) Application of physiological Biochemical and Molecular phylogenetic markers on plant genetic resources characterization, identification and utilization, for wide adaptability to biotic and abiotic stressors such as drought, salinity, pests, diseases nutrient uptake deficiency etc.) under various types of agro-ecosystems (ie. rainfed, irrigated, and dry lands). (iii) Developing of natural multi-purposes plants varieties such as, shrubs or trees for protection of desertification & degradation and restoration of deserts ecosystems and degraded arid lands.

AREA, Faculties of Agriculture in Sana'a and Aden University start strengthening capacity building for the molecular characterization of PGRFA through Rainfed Agriculture and Livestock Project (RALP). The capacity assessment for those agencies which done by Baum (2009) indicated that the molecular characterization of PGRFA could be started in AREA Biotech Lab if the project/ AREA insure the shortage equipments and reagents (Annex 2).

3.2 Possible Gaps affecting GMO Research /Development:

There are a lot of obstacles or gaps facing GMO research and development in Yemen, NBF (2005) summarized some points to overcome these gaps and establishment the GMOs R& D. The suggested points are following:

1. Capacity building in traditional biotechnology is badly needed in Yemen. This should go hand in hand with building the capacities in modern biotechnology.
2. Improving the regional stations through provision of trained experts in modern methods and upgrading the available infrastructure.
3. Establish a national center for biotechnology serving different fields: agricultural, medical and environmental. The national center should be provided with trained staff and infrastructures. This center should be affiliated directly to the ministry of high education and scientific research. The MSc and PhD programs should be organized within the center to activate scientific research and development.
4. Provide scientific data bases in all related fields and activate the role of scientific publication and internet connections.
5. Rehabilitate scientific and research institutions and supply them with modern biotechnology facilities.
6. Formulate a natural scientific research policy.
7. Review the agricultural policies to fulfill the national needs and to eliminate the conflict between the scientists' interest and community needs. These policies should consider the country economy and investors interest, in addition To activating the universities and government institutions roles in related fields of research and development.

8. Review the university curriculum in agriculture and science faculties with emphasis on life sciences and environmental sciences. This could be achieved through, updating the curriculum to cope with needs in technical fields like tissue culture molecular biology to micro-propagate and to characterize biodiversity at molecular level, and to use the modern biotechnology to conserve the endangered species.

4. Biosafety Regulatory Status

The general term of Biosafety is defined in National Biosafety Framework (NBF) report as a concept referring to the need to protect human health and the environment from the possible adverse effects of the products of modern biotechnology, and particularly genetically modified organisms (GMOs). Moreover, the NBF document confirmed the necessity of high level of attention must be paid to biosafety issues which basically linked with the concern in preservation of Yemeni unique biodiversity and carry the responsibilities for economic employment of natural resources potentialities.

This document also acknowledged Yemeni responsibility towards Cartagena Protocol, as well as many other environmental conventions, treaties and protocols, provided that, they will play positive role in resolving the environmental issues such as biosafety. Due to this, Yemen show willingness for any kind of collaboration and cooperation with all countries in the world in terms of biosafety and biodiversity issues such as GMOs, taking into consideration the expected impacts on the bio-ecology of Yemen. Moreover, the document expressed the willingness of Yemen as other developing or under-developed country definitely need to invest in technologies of genetic engineering in order to improve productivity and ensure nutritional needs of our people.

4.1 Status of Biosafety framework in the country:

Ministry of Water and Environment (MWE) through Environment Protection Authority (EPA) is the coordinating agency of NBF project assisted by a National Coordination committee. The NBF document consists of six main parts related discussing several aspects of biosafety framework including (i) Yemeni national international biosafety commitment. (ii) National policies and strategies in biosafety (iii) deals with the future national biosafety by-law intended to be ratified and issued before the end of 2005. (iv) The guidelines on GMO handling and risk management as well as the challenges and constraints in monitoring and enforcement and future plans in GMO issues. (v) Monitoring and enforcement and (vi) The public awareness and participation. For detail see UNEP web site.

4.2 Compliance with International Conventions and Protocols:

Yemen has been involved in many memberships with several international agreements, conventions and protocols:

4.2.1 The Convention on Biological Diversity

The Convention on biological diversity (CBD) launched in 1992 at the United Nations Conference on Environment and Development is a major international forum to managing the Earth's biological resources. Its objectives are: the conservation of biological diversity, the sustainable use of its components; and the equitable sharing of its benefits. Agricultural biodiversity was given a special attention at the Conference of Parties 3 (COP3), held in Buenos Aires in 1996, particularly in the use of relevant genetic resources and genetically modified organisms (GMOs) from biotechnology. The COP3 have decided to establish a program on agricultural biodiversity to "promote the positive effects and mitigate the negative impacts of agricultural practices on biological diversity".

The government of Yemen ratified the CBD in 1995. The National Biodiversity Strategy and Action Plan for Yemen (NBSAPY) were prepared in 2005 as a first step toward the enhancement of the biodiversity components, including agricultural biodiversity.

4.2.2 Cartagena Protocol on Biosafety:

The Cabinet approved the Cartagena protocol on biosafety in 2005. The protocol has been presented to the Parliament for approval. A Presidential Decree No 64 for 2005 has been issued by the President stipulating the acceptance of Cartagena Protocol on Biosafety. The protocol is focusing in particular on the trans-boundary movement of GMOs, the protocol requires Parties to ensure that the development, handling, transport, use, transfer, and release of GMOs are undertaken in a way that prevents or reduces the risks to biological diversity and to human health. The adoption of this protocol leading to release the first legal document on Biosafety, which indicated for:

a. National Biosafety Committee (NBC):

There is a National Coordination Committee consists of members representing several Institutions, agencies and stakeholders groups:

1. The Minister of Environment: Chairman;
2. The Chairman of the General Environment Protection Authority: Vice Chairman;
3. The deputy Minster of the Ministry of Environment Member;
4. Representative of the ministry of Industry and Trade: Member;
5. Representative of the Ministry of Public Health and Population: Member;
6. Representative of the Ministry of Agriculture and Irrigation (AREA): Member;
7. Representative of the Ministry of Fishery Wealth: Member;
8. Representative of the Ministry of Defense: Member;
9. Representative of the Ministry of Interior: Member;
10. Representative of the Ministry of Higher Education and Scientific research: Member;
11. Representative of the Authority of Customs: Member;
12. Representative of the Yemen Authority of Specifications and measurements: Member;
13. Representative of the Union of Industrial and Commerce Chambers: Member;
14. Representative of the Consumer Protection Society: Member;
15. Legal adviser: Member;
16. Four specialized experts in agriculture, science, medicine, and marine sciences, selected for institutions and universities by the Minister upon the proposal of the chairman of the General Environment Protection Authority Members and
17. The Biosafety Project Coordinator (the NBC secretary). Member

The coordination committee is responsible for nominating the biosafety projects team when necessary. Usually members of these projects are consisting of available national consultant and experts with background knowledge related to the issue under discussion.

b. Institutional Biosafety Committees(IBCs):

The Presidential Decree indicated to establishment of institutional biosafety committees at concerned bodies (IBCs) which are represented in the NBC. Such IBCs shall be chaired by the NBC member of each concerned body. These shall have the following duties under delegation from the NBC:

- Receiving applications and requests;
- Processing such applications and requests;
- Reviewing risk assessment provided by applicants;
- Forwarding reports concerning applications, risk assessment and attached documents to NBC;

- Deciding on samples for field test and research;
- Implementing other duties prescribed by legislation of the concerned body;
- Submitting regular reports on mandated issues;
- Any other duties assigned to it by NBC.

c. The Scientific Committee (SC):

The decree indicated that, the Scientific Committee (SC) shall be formulated by a Ministerial resolution. The members of the SC shall not be less than nine members as follows: 1) A representative for each of the Agriculture College, Science College, Medical College, and Marine Sciences college of the recognized Yemeni universities, as well as the Agricultural Research and Extension Authority; and 2) Other members of the SC shall be chosen on the basis of scientific degree, qualification, and experience and in accordance with the specific conditions and terms contained in the executive ordinance regulating the works and activities of the NBC. Furthermore, the SC shall exercise the following duties:

- To undertake risk assessment in order to evaluate the benefits and risks resulting from the use of GMOs and their effects on the environment and society. In case of issuing a license after undertaking the probable risk assessment, the committee must carry out periodical review of the safety measures and standards that are followed to ensure that sufficient safety policies are followed. Therefore, the SC shall be responsible for undertaking risk assessment and to approve the issuing of licenses to conduct such experiments and their applications.
- To review or carry out the risk assessment and management submitted by the applicant.
- To review the procedures of risk assessment and management and to provide suggestions for modifying them.
- To undertake periodical assessment for the instructions and guidelines related biosafety and to review any decisions in the light of the latest developments related to import and export activities and/ or the local utilization and use of GMOs and their products in the Republic of Yemen.
- To monitor and control the activities of handling, transport, and the local utilization use of GMOs and their products in the Republic of Yemen and to ensure that the implementation and execution of appropriate procedures regarding such activities are fully and safely applied.
- To submit recommendations regarding the procedures of the contained use and the restrictions to be contained in the license and its duration as well as the mechanism of submitting reports and control procedures.

- To propose the formulation of permanent or temporary sub-committees of special nature of the concerned bodies.
- To perform any other tasks to be assigned by the NBC.

d. Regulatory Approvals:

The NBF and Presidential Decree illustrated the scientific methods for risk assessment and risk management which adopted from Cartagena Protocol and related documents of FAO and OECD. However, until now no single assessment is done due to the limitation of capacity building on GMOs detection. Therefore, the committees mentioned above are stagnant.

5. Capacities for GMO Detection

Regarding to capacities on GMO detection, it is very important to develop National Projects, which focus on the preparation of implementation of a National Biosafety Framework including regulatory, administration and decision making systems, and create active mechanisms for public participation and information. Here are some of valid or modified activities cited from NBF (2005):

- Gathering of necessary information concerning the use of modern biotechnology, existing legislation on biotechnology and/or biosafety;
- Activating and establishing Committees such as: National/Institutional Biosafety Committees, Scientific Committees, GM Advisory Committee, Review Committee, and GMO Approval Committee to enforce the Regulation;
- Training Biosafety Committees at both institutional and national levels to conduct scientifically sound biosafety reviews, etc;
- Developing National Biosafety Database and linkages to the Biosafety Clearing House;
- Drafting legal instruments as Guidelines for implementing the Regulation;
- Sharing experience on the organization and risk assessment and risk management with other countries, which are in a more advanced stage of implementation and enforcing biosafety regulations;
- Cooperating with other countries and international organizations in developing relevant educational, public awareness programs and intensive training on advance molecular biology.

Table 1: Summary of existence national institutions and functional laboratories and relate and information on; Year established, Mandate, Laboratories infrastructure/ equipment/ capacity, Funding sources, Human resources/Staffing/ Categories, Capacity building plans/strategy.

Institutions	Year Established	(Branch)	Mandate	Staff Laboratory & library	Facilities	Proposed Mission	Available Yearly Fund (USD)	# Published papers yearly/ Scientist
Agricultural Research and Extension Authority	1950s	8 Regional Stations + 5 National Centers	Conducting applied research to solve farmers problems in agriculture (crop + live-stock) Crop and resource management research Socioeconomic research	Ph.D 71 MSc. 87 BSc. 219 Distributed at the HQ and the branches	New lab facilities initi-ated for Biotechnology Tissue culture and Molecular	Research >85%, Education and Social Services	National and interna-tional fund (USD…)	Nil-rare Except 2-7 technical reports
University of Sana>a	1970	Faculty of Science	Academic Institution engaged in academic training in life sciences	62 Ph D (19 + 13)	Ordinary lab. Facilities No DNA manipulation facilities. Poor library No field station facilities	Education > 85 %, Research and Social Services	National (0.1-0.2 USD)	5-6
		Faculty of Agriculture	Academic Institution engaged in academic training in agricultural sciences	91 Ph D	Traditional teaching laboratories suffering from lack of chemicals and reagents	Education > 80%, Research and Social Services		2-4
		Yemeni Genetic Resource Center	Collection & preserva-tion of Genetic Resources	1 Ph D 2 MSc 7 BSc	Tissue culture Lab. Storage facilities Facilities for Genetic mapping Research farm	In situ and ex situ conservation Collection of Genetic Resources material		Nil
Ministry of Agriculture & Irrigation	1962	General Dep. Plant Protection	Protecting plants and controlling ag. Pests . Plant Protection Cam-paigns Plant quarantine	2 Ph D 29 MSc 132 BSc	Basic facilities in the plant quarantine lab.+Virus detection lab. Biological control lab. Pesticides residual effect (to be established)	Implementation of Research, and Technical services	National and interna-tional fund (USD…)	Nill

Institutions	Year Established	(Branch)	Mandate	Staff Laboratory & library	Facilities	Proposed Mission	Available Yearly Fund (USD)	# Published papers yearly/ Scientist
Ministry of Agriculture & Irrigation	1962	Central Veterinary Laboratory	Monitoring outbreaks of animal deceases Diagnosis of animal deceases Routine analysis of feed Campaigns against animal deceases	3 MSc 10 BSc 14 trained technicians	Well equipped laboratory Animal cell culture facilities	Animal vet Service oriented activities.	National and international fund (USD...)	Rare
University of Aden	1970	Faculty of Education Department of Life Science	Education Faculty engaged in academic training	13 Ph D 14 MSc	No facilities available in Biotechnology or Microbiology Library is outdated	Research, Education and Social Services	National	1-3
		Department of Chemistry	Academic degree training	11 Ph D	Poor lab facilities = outdated library	Research, Education and Social Services		
		Faculty of agriculture	Teaching and Academic degree training No Training in Biotechnology	44 Ph D in different disciplines	Teaching labs with ordinary facilities No facilities for Biotechnology training Outdated Library			
University of Taiz	1995	Faculty of Science Dep. Microbiology+ Dep. Life Sciences	Teaching and Academic degree training No Training in Biotechnology	5 Ph D (microbiology) 6 Ph D (Life Sciences)	Poor facilities	Research, Education and Social Services	National	Nill
		Center for Environmental Studies	Under establishment	2 Ph D	No lab. facilities yet available	Research and Studies		Nill
University of Hadhramout	1995	Faculty of Sciences	Teaching and Academic degree training No Training in Biotechnology	8 PhD and 3 13PhD, 4MSc	No lab. facilities	Research, Education and Social Services	National	Nill

Institutions	Year Established	(Branch)	Mandate	Staff Laboratory & library	Facilities	Proposed Mission	Available Yearly Fund (USD)	# Published papers yearly/ Scientist
	1995	Faculty of Environmental and marine Sciences	Teaching and Academic degree training No Training in Biotechnology	5 PhD and 2 MSc	Some lab. facilities	Research, Education and Social Services	National	Nill
University of Hudaida		Faculty of Marine Science	Teaching and Academic degree training No Training in Biotechnology	13 PhD, 11 MSc + Staff hired from Sana>a University + Arab expatriate staff	Limited lab facilities so far	Research, Education and Social Services	national	Nill
		Faculty of Medicine	Teaching and Academic degree training No Training in Biotechnology	14 Ph D + Staff hired from Sana>a University + Arab expatriate staff	Limited facilities inherited from a previous vet institute	Research, Education and Social Services		
University of Dhamar		Faculty of Agriculture + Veterinary Science	Teaching and Academic degree training No Training in Biotechnology	16 Ph D + staff hired from Sana>a University + Arab expatriate Staff	Limited facilities inherited from a previous vet institute	Academic degree training (BSc)	Not yet	Nill
University of Ibb	1996	Faculty of Science	Teaching and Academic degree training No Training in Biotechnology	12 PhD, 11 MSc	No lab. facilities yet available	Academic degree training (BSc)	Not yet	Nill
		Faculty of Agriculture	Teaching and Academic degree training No Training in Biotechnology	8 PhD and 6 MSc	No lab. facilities yet available			Nill
Private Sectors: Access to information YASAD	2006		Research & Training	8 PhD + 6MSc + 14 BSc	Limited	Research & Training		Not yet
Private Sectors: YAPB	2007		Research & Training	7 PhD +12 MSc + 23 BSc	Limited	Research & Training		Not yet

Table 2: Equipments required for AREA laboratory quantity and estimate price US$.

Item	Qty	Unit Price	Total Price
Thermal cycler with block for 0.2 ml tubes, 96 wells	1	4500	4500
Transilluminator	1	3000	3000
PAGE gel system	2	4000	8000
Power supply (channels 4)	1	3000	3000
Compact microcentrifuge with adaptors for 0.5 ml and 0.2 tubes	1	1500	1500
Stirrer, hotplate	1	600	600
UPS, Stabilizer, 3000 Ambers	1	2500	2500
A3 scanner	1	1500	1500
Microwave	1	1000	1000
Heat block with blocks for 0.2 ml, 0.5 ml and 1.5 ml tubes	1	1500	1500
Stand alone gel documentation system	1	1500	1500
Medium size horizontal electrophoresis unit, complete	1	600	600
Power supply for the electrophoresis unit	1	800	800
Shaking water bath, 20 – 24 liter	1	3000	3000
Micropipette 0.5 – 10 µl	2	250	700
Micropipette 10 – 100 µl	2	350	700
Micropipette 100 – 1000 µl	2	350	700
Shaker large size	1	3000	3000

Source: modified from Baum (2009).

Table 3:Reagents required for AREA biotech lab for in country training.

Reagents	Qty	Reagents	Qty
Ethanol absolute (100 or 96%) (mol bio grade) 1 L	3	CTAB (cetyltrimethylammonium bromide), 500g	1
Isopropanol, 1 L	1	Taq DNA polymerase, 10000 units	6
Chloroform, 1L	3	DNA marker (100 pb DNA Ladder (250 µl)	6
Phenol solution	2	Beta-mecraptoethanol (14 Mm), 100 ml	1
Isoamyl alcohol, 1L	2	Xylene cyanole, 10 ml	6
Hydrochloride acid (HCL) Concentrate, 1L	1	Mineral oil, 100 ml	1
Sodium hydroxide, 1000 gm	1	Bromophenol blue loading solution (3 x 1m)	6
Glycerol, 100 ml	2	dNTP's (10mM each)	5
Tris-base (Tris 500 g)	6	Tris-borate-EDTA buffer 10X concentrate 10 L	1
Ethylenediamine tetracetic acid (Na2-EDTA), 500 g	1	Tris-EDTA buffer 100-Con, 1000 ml	2
Ethidium bromide, 100 g	1	Parafilm	6
Bromophenol blue dye, 100g	1	AFLP, SSR, …etc primers	
Ethidium Bromide (10mg/ml), 10ml	1	Chemicals for silver staining kit plus components	
Boric acid EDTA, Na2 Salt, 1000g	1	Others reagents used for GMO's detection ?????	

Source: modified from Baum (2009).