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

1. Elagib T. Y., A. M. Ali, H. H. Geiger and H. K. Parzies (2009). Potential of adapted Sudanese sorghum landraces for hybrid breeding based on testcross performance. Euphytica (Submitted).
2. Elagib T. Y., A. M. Ali, H. H. Geiger and H. K. Parzies (2009). Genetic diversity of Sudanese sorghum landraces based on SSR markers. Plant Breeding (submitted)
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