Enhancing food security through improved agricultural productivity


Integrated Water Resource System


Marginal Quality Water Resources


Capacity Building and Knowledge-sharing

ANNUAL REPORT 2010

(1431-32H)

INTERNATIONAL CENTER FOR BIOSALINE AGRICULTURE

Mission

To demonstrate the value of marginal and saline water resources for the production of economically and environmentally useful plants, and to transfer the results of our research to national research services and communities.

Mandate

ICBA will help water-scarce countries improve the productivity, social equity and environmental sustainability of water use through an integrated water resource system approach, with special emphasis on the effective use of marginal quality water.

INTERNATIONAL CENTER FOR BIOSALINE AGRICULTURE

Enhancing food security through improved agricultural productivity

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Contents

Applying the research in …

Foreword

The endeavors of stakeholder institutions, the Islamic Development Bank, the United Arab Emirates Ministry of Environment and Water and the Environment Agency – Abu Dhabi, to negotiate a revised funding model for the International Center of Biosaline Agriculture came to fruition in 2010.

With the funding allocations defined, ICBA was able to implement the new model and respond to a subsequent review of the mandate and achievements over the last ten years. ICBA welcomed the review conducted by a team of experts established by the United Arab Emirates Ministry of Environment and Water and the Environment Agency – Abu Dhabi. Reviews such as this provide ICBA with the opportunity to reflect and re-affirm its direction to ensure clear focus and strong commitment to its mandate.

ICBA's ability to translate its mandate into scientific achievements to benefit the water-scarce countries to improve their agricultural productivity thus enhancing food security is only possible due to the support of the host country, the United Arab Emirates, and the Islamic Development Bank. Additional funding is made possible by the generous support of donors, such as the International Fund for Agricultural Development (IFAD), the Arab Fund for Economic and Social Development (AFESD), OPEC Fund for International Development (OFID) and the Ministry of Agriculture in Oman, amongst others.

Throughout the year the ICBA team has worked assiduously to ensure that its extensive research programs in the host country and partnering countries continue to make a major contribution to this research and its application in the Arab region.

The success of ICBA's projects in driving innovation and sustainability in the water sector in the MENA Region was acknowledged officially in November when ICBA won the award for Best Water Consultancy at the inaugural H2O Water Awards. Organized by CPI Industry, the awards celebrate the outstanding achievements of the Middle East and North East Africa water industry by recognizing projects and programs that have made significant contributions to the advancement of the region's water industry through demonstrating a high standard of excellence, quality and sustainability. The award recognized that initiatives using marginal water developed in ICBA's consultancies have already had an important impact on reducing the use of limited freshwater resources.

It is with great pride and pleasure that we introduce this annual report for 2010 which outlines ICBA's achievements in striving for food security through improved agricultural productivity.

Fawzi AlSultan
Chairman, Board of Director, ICBA

Dr Shawki Barghouti
Director General, ICBA

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Dr Shawki Barghouti (*ex-officio*)
Director General
International Center for Biosaline Agriculture (ICBA)
Dubai UAE

From left to right (front): Mr Abdelrahim Mohammad Alhammadi, Mr Fawzi AlSultan, Mr Mohammad Jamal Al-Saati and Her Excellency Razan Khalifa Al Mubarak; (back): Dr David J Molden, Dr William Sutton, Mr Adel Abdulla Alhosani, Dr Mahmoud Solh and Dr Shawki Barghouti

ENHANCING FOOD SECURITY THROUGH IMPROVED AGRICULTURAL PRODUCTIVITY

Enhancing food security through improved agricultural productivity

Available renewable water resources per capita in the Arab world are among the lowest in the world; a situation exacerbated by the high rates of economic growth, rapidly growing populations, and climate change. This combination of conditions impact significantly on not just water availability but also water quality. One unfavorable outcome of diminishing available and quality water is increasing soil and water salinization, which in turn has a major impact on agricultural productivity and thus food security.

To meet these challenges many countries in the region are augmenting conventional surface and subterranean water resources by investing in desalinated water, for example, and non-conventional water sources. As well improved crop varieties and other salt-tolerant plants are being introduced into production systems, whether through natural selection or modern technologies.

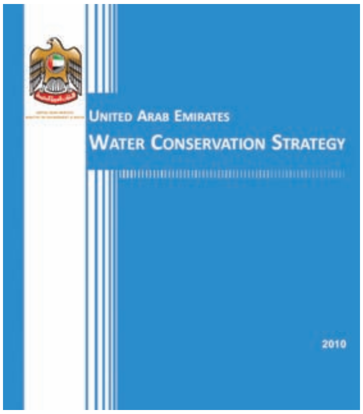
Successful examples of ICBA's initiatives using marginal quality water and agricultural production systems are widespread throughout the Arab region. During 2010 ICBA's consultancy work included the use of salt-tolerant cropping practices in seven MENA countries; development of national strategies for managing water and soil salinities in countries such as Iraq and Turkmenistan and Tajikistan in Central Asia; feasibility studies of using marginal water quality for biosaline agroforestry, in agri-silvi-horticultural and silvi-pastoral systems; and feasibility studies of using treated wastewater in managed aquifer recharge systems or in protected agriculture. Within the host country, ICBA applied its expertise in policy and governance development in non-conventional water sources with the formulation of fundamental policy instruments such as the *United Arab Emirates Water Conservation Strategy*, the *Recycled Water Strategic Plan for Abu Dhabi Emirate* and *Sustainable Irrigation Development with the UAE*.

The success of ICBA's programs in driving innovation and sustainability in the water sector in the MENA Region was acknowledged officially in November with ICBA winning the award for the Best Water Consultancy. It is always gratifying to have the public and private sectors recognise ICBA's high quality contribution to policy studies and technical advisory services in managing and improving saline agriculture and improving crop and water performance.

ICBA's ongoing research and development program is made possible through the support of its host country, the United Arab Emirates. The United Arab Emirates has adopted modern technologies and undertaken scientific research in order to develop the agricultural sector in this water-scarce region. ICBA is proud to build a strong partnership with the UAE and the Arab region to deliver quality and quantity in agricultural production to encourage food security.

Sustainable policy and governance strategies

Throughout 2010, ICBA has been steadily increasing its role in the policy and governance arena of the water sector in the United Arab Emirates. Policy documents such as the *United Arab Emirates Water Conservation Strategy*, the *Recycled Water Strategic Plan for Abu Dhabi Emirate* and *Sustainable Irrigation Development within the UAE* add to the body of knowledge about the UAE. The policy instruments and research findings are also highly relevant to other water-scarce countries in the region.



The United Arab Emirates Water Conservation Strategy

Conserving water resources

The *United Arab Emirates Water Conservation Strategy* identified basic initiatives to manage water resources sustainably in order to conserve water resources from exploitation and pollution. The focus on water conservation is a significant step in the water development process because previous plans had focused primarily on meeting unregulated and unconstrained demand for water. Based on an integrated approach that anticipates meeting future water demand from a mix of investment in new water infrastructure and efficiency improvements of existing water supplies (natural resources, desalination and reclaimed water), the Strategy identified the key questions, assumptions and areas of risk to future water development. The Strategy's main report and annexes were prepared and finalized after feedback from the Ministry of Environment and Water and then presented to the Minister. The Report's findings and outcomes will inform national policies, rules and regulation designed to improve the sustainable management of the nation's precious water resources and enhance their contribution to the economic growth of the country.

ENSURING SAFE DISPOSAL OF BRINE FROM REVERSE OSMOSIS DESALINATION PLANTS

The lack of freshwater resources is a serious constraint to agricultural development in the United Arab Emirates. In inland areas as well as the coastal zone, saline groundwater is available for use in agriculture although it is not suitable for growing cash crops, such as vegetables which are mainly grown in greenhouses. To overcome this problem, about 400 small-scale reverse osmosis (RO) plants are used to desalinate groundwater to produce date palm or cash crops in greenhouses or to supply drinking water to animals and poultry. The use of such technologies requires proper brine concentrate management and disposal practices to minimize groundwater pollution. ICBA was commissioned by the Minister of Environment and Water to undertake a thorough review/analysis to identify suitable environmentally friendly brine disposal options.

*Use of brine in landscaping plants (*Conocarpus erectus *L.) in the central region of UAE*

Subsequently twelve plants in inland areas and three plants in coastal areas were studied to evaluate the performance of membrane technology, irrigation management and brine disposal practices. Brackish groundwater, salinity varying from 4 to 37 dS m^{-1}, was used as feed water. The depth of water table in the investigated sites varied from 8 to 50 m; usually lower water tables were recorded in the inland areas (i.e. Liwa, Al Ain or Al-Dhaid). Higher groundwater salinity was observed in coastal areas due to sea-water intrusion. The capacity of ROs varied from 28 to 325 m^3 d^{-1}. The salt rejection values of ROs varied from 69 to 99 percent; and the flow recovery percentage varied from 30 to 87. Such a wide range of performance values is due to variations in feed water salinity, pressure applied, and membrane characteristics.

Surface drippers were used for irrigating vegetables in both greenhouses and fields. Field irrigation techniques include micro-sprayers (for forages), furrow/basin (for vegetables/forages) and bubblers/hose pipe (for date palms and fruit trees). The chemical analysis of brine showed trace existence of heavy metals but high concentrations of NO_3-N.

The methods of brine disposal include surface disposal (to excavated/non-excavated pits, mountain terrain or steep edge of sand dunes), which is the most common practice (>50%) in the selected sites followed by well injection or dug well (>13%). Other disposal methods are a pipeline to the sea; the

Small RO plants used at farm level

irrigation of salt-tolerant plants or blending brine with feed water for irrigating date palms; the use in the cooling pads of green houses; and wadi beds.

Among the disposal methods, surface disposal and dug well near the plants are critical as feed water can be further polluted by brine and chemicals used in RO plants. These disposal practices could be replaced, salinity levels permitting, by environmental friendly methods such as non-leaking evaporation ponds and biosaline agriculture. Evaporation ponds are relatively easy to construct and operate and are suitable in the areas of high evaporation rates. Community-based evaporation ponds, where several farms dispose of brine to a common pond, could be developed; they also have the potential for aquaculture thus generating additional income for farmers.

Use of RO plant in UAE farms could be directed to grow high value cash crops in green houses

Higher concentration of NO_3-N in brine is an additional advantage for growing biosaline agriculture. To optimize this advantage that may not be suitable for very high saline brine, attention has to be given to maintain soil salinity at an acceptable level and implement appropriate irrigation scheduling to reduce deep percolation. Another alternative could be brine reduction using secondary RO plants as most of the existing plants generate brine volume more than 50% of average feed water quantity. This would definitely help in capturing additional water for growing crops and vegetables.

Some regulating procedures, especially the issuance of permits for installation of RO plants, are recommended to safeguard water and soil health from further degradation. In any case, appropriate regulations or guidelines, monitoring and capacity building are essential for better utilization of RO plants in the agricultural production system in UAE. Research findings and recommendations have been presented to the Ministry of Environment and Water.

Capturing, re-cycling and re-using water

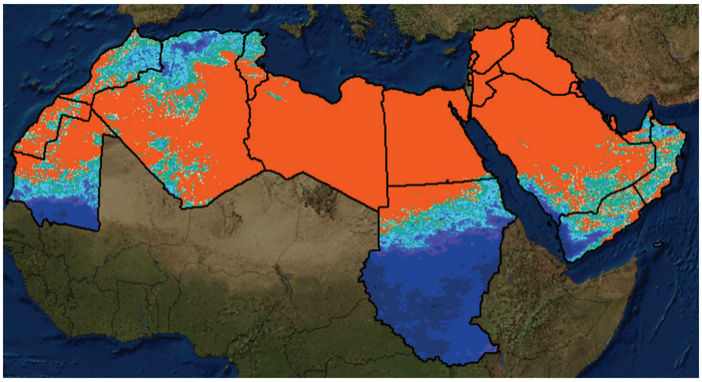
In 2010 water experts from The Netherlands, UK, Oman, Palestine, UAE and ICBA collaborated to develop a comprehensive strategy to capture, recycle and re-use municipal and industrial wastewaters in Abu Dhabi Emirate. Renewable water resources are limited in Abu Dhabi Emirate as rainfall is less than 100 mm per year. Consequently recycled water could provide a sustainable water resource instead of desalinated water, which is produced at great cost, and/or fresh and brackish groundwater which is heavily depleted due to exhaustive use.

With advanced treatment and management, recycled water could be a reliable long-term water resource: for agriculture; in the landscaping and forest sectors, where the current reuse practice should be continued; in commercial floriculture which also offers a new dimension for profitable recycled water; in industry for such purposes as processing, washing, and cooling in facilities that manufacture products; and in groundwater recharge which could be used for both groundwater replenishment and salt-water intrusion control by establishing a hydraulic barrier in the coastal areas. In addition, recycled water could also be used as Abu Dhabi's strategic water reserve.

The quantity and quality of recycled water are, however, governed by the policy and governance directions affecting water use in households, the energy use and efficiency of wastewater treatment plants and its distribution network. Thus, the outcome of ICBA's evaluation of the existing guidelines and policies is a sustainable recycled water strategic plan covering wastewater collection, treatment and reuse for the Emirate.

Improving water data information and systems

The importance of water data information and systems across the region has been acknowledged and boosted significantly with the establishment of a hub at ICBA to develop data that will support decision-making in water and food security at country and regional levels throughout the Middle East and North Africa. During the year, with the generous support of USAID, ICBA established the sophisticated IT system for the Middle East North Africa - Land Data Assimilation Systems (MENA-LDAS) modelling and appointed three researchers to evaluate, verify and develop the NASA model for the regional water situation. As well, formal links have been established with the Emirates Institute of Advanced Science and Technology to collaborate in downloading through their ground-receiving station the satellite images that will be used in the modelling. During 2010 ground data has also been collected to help in the calibration and verification of the model, thus developing new data and insight into groundwater and surface water and energy flows as well as into agricultural land use.



The Middle East North Africa - Land Data Assimilation Systems

Achieving irrigation efficiencies and sustainability

ICBA expanded in 2010 its research on existing irrigation water use in the United Arab Emirates in order to recommend to decision makers and planners strategies for sustainable irrigation development in different agro-climatic zones of the UAE. The agriculture sector in the UAE is the main consumer of water (60%), followed by the domestic and industrial (32%) sectors with the remaining 8% being wasted or lost. Groundwater, which has been used extensively for agriculture, has long been overexploited, resulting in falling well yields and increasing water salinity. These constraints, exacerbated by increasing soil salinity, have resulted in rendering many areas incapable of supporting cultivation of anything other than a few salt-tolerant crops such as Rhodes grass and dates. Moreover, groundwater is being polluted by nitrates from the excessive use of chemical fertilizers in agricultural farming. In many aquifers, nitrate levels exceed drinking water health guidelines.

The current irrigation practices in the country are based on extensive water use rather than water demand management. This practice, which provides considerable socio-economic support to citizens, has been encouraged by large government subsidies. Its development over the last 20 years has been largely unplanned and has not taken into consideration the suitability of soil and water resources. This study calls for sustainable agricultural development by using (i) marginal water such as saline groundwater and reclaimed municipal wastewater; (ii) salt-tolerant crops (particularly those with a local advantage); and (iii) water saving measures via irrigation water management and application techniques.

During 2010 ICBA researchers collected data on soils, agro-climate, field crops, irrigation practices, and groundwater quality from three distinct agro-climatic zones of UAE - sub-humid, arid and hyper-arid. Preliminary analysis suggests that there is a distinct difference in crop evapotranspiration, cropping pattern and soil hydraulics among the agro-climate zones, thus substantiating agro-climatic-based agricultural planning in the UAE. The performance of irrigation technologies were evaluated to recommend further improvement.

At the Dubai research station, ICBA applied its technical expertise to improve irrigation planning and scheduling through precise assessment of all components of the water balance equation, thus ensuring that the goal of irrigation – to supply the correct amount of water required – is achieved. In the current year, barley was the crop tested in the weighing lysimeter to extend findings from ICBA's research program into the crop water use of different crops/forages and developing crop co-efficient values.

Combating salinity and protecting water resources

Elsewhere within the region, in Oman, ICBA scientists continued to collaborate with colleagues from the Omani Ministry of Agriculture to formulate national plans (strategic and action) to combat salinity, protect water resources from pollution and salinity and ensure the sustainable development of agricultural systems and the livelihood of farmers. As a result of water depletion and environmental deterioration, agricultural areas in the Batinah coastal plains have suffered from decreasing productivity, salinization of groundwater and intrusion by sea water. The combination of these factors has led to a dramatic deterioration and depletion of natural resources impacting severely the livelihood of farmers dependent on agriculture in the region.

ICBA scientists with their Omani partners

In 2010, ICBA and the Omani Directorate General of Agriculture and Livestock Research organized the first workshop on the review of the national strategic plan by a panel of national and international experts, and representatives from the various Omani stakeholders and partners. A steering committee and a technical committee have been formed as well as five working groups with the respective responsibilities: physical resources and modeling; biological/agricultural group/economics and planning group; capacity building and extension group; and the information database group. The working groups conducted 3 workshops during the year in March, June and October.

Box 1: Applying the research in Iraq

Another collaboration of research and development partners is taking place in central and southern Iraq where ICBA has been invited, along with the International Center for Agricultural Research in the Dry Areas (ICARDA), International Water Management Institute (IWMI) and Iraqi Ministries, to address salinity problems in Iraq. The extent of the problems and possible solutions had been identified in a scoping workshop initiated by the Australian Center for International Agricultural Research (ACIAR) in 2009. Iraq's agricultural sector represents a vital component of Iraq's economy as it is the largest employer (25 per cent of the labor force) and the second largest industry after oil (in terms of its contribution to GDP).

The deterioration of Iraq's extensive irrigation infrastructure and soil salinity in much of the irrigated areas of central and southern Iraq is compounded by the increasing levels of salinity of the irrigation water from both the Euphrates and Tigris Rivers due to changed water regimes.

The four partners in this project are undertaking studies at three different scales (basin, regional and on-farm) and will devise assessment, mitigation and adaptation strategies. Endorsed in late 2010, ICBA's role in the project will focus on crop improvement and production system management at the farm level.

Improving water storage through Managed Aquifer Recharge systems

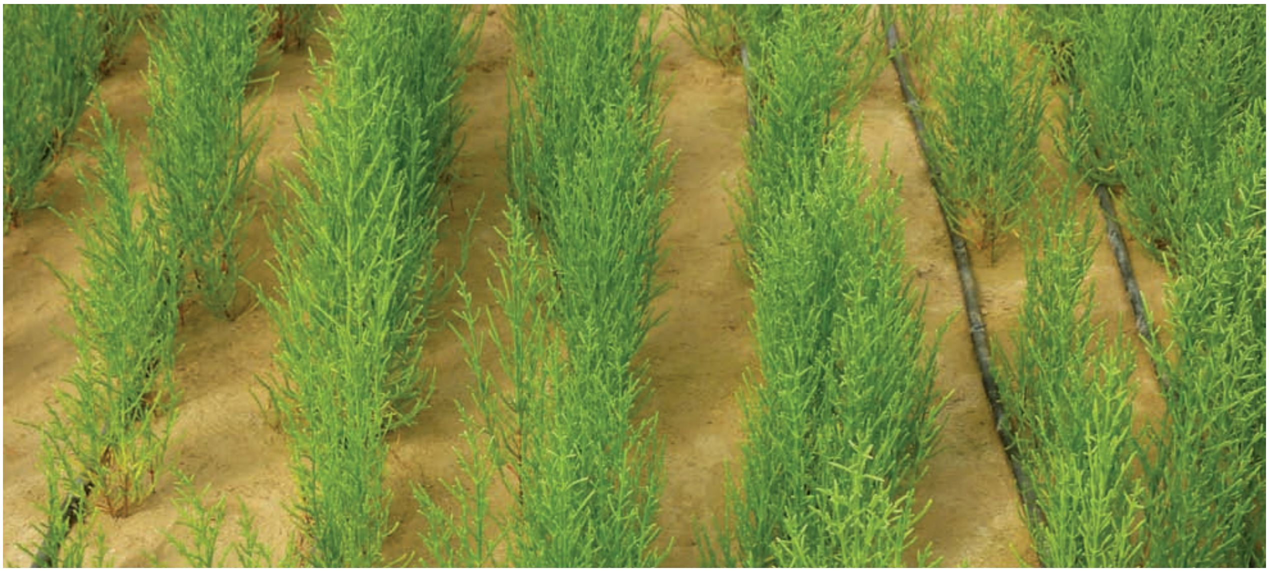
In research to improve water storage, ICBA is partnering with scientists in the Sultan Qaboos University to conduct a socio-economic and technical feasibility of Managed Aquifer Recharge (MAR) schemes in Oman, particularly in the Muscat area.

Such schemes are practised widely all over the world to store water during periods of water surpluses and withdraw during deficits from an aquifer. Aquifers are an appropriate means of storing water as storage below ground means that there are no evaporation losses; with reasonable care the water is protected from pollution; minimal land area is used; and there is no environmental damage. On the other hand, MAR has some disadvantages as often only some of the recharged water is recovered. Successful water recovery depends on aquifer characteristics, residence time of the recharged water, and the distance to extraction wells. Poor quality recharging water can cause changes in physical and chemical characteristics of the soil and aquifer.

Several countries such as Australia and the USA incorporate the use of MAR with treated wastewater as part of their overall water resources management. Currently groundwater recharge in Oman is practised using recharge dams only. During 2010, ICBA provided technical support in the planning and implementation of testing recycled water reuse in growing wheat cultivars in a field experiment to compare two potential irrigation methods (i.e. drip and furrow). The goal of the field trial is to increase irrigation efficiency and water productivity with treated wastewater from MAR schemes.

Producing bio-fuels with sea water and halophytes

In another project within the UAE, researchers at the Masdar Institute (MI), along with several companies like Boeing, Etihad Airways, and UOP Honeywell, are keen to evaluate the potential of growing *Salicornia* with sea water for use as a biofuel and maintenance of CO_2 equilibrium. A halophyte that grows in salty waters, the seeds of *Salicornia* are an abundant source of biofuel. Given ICBA's rich experience in the evaluation of genetic material and optimizing different types of production systems, MI has agreed on a collaboration to evaluate the potential of growing *Salicornia* in the UAE at seawater salinities, in addition to testing different agronomic characteristics. Preliminary trials are being conducted at ICBA followed by field trials on the coastline of Abu Dhabi. In 2010 ICBA surveyed and rejected one of the islands as a potential trial site. Although *Salicornia* can be productive at sea water strength, it is always preferable for it to be located at a coastal site where the soil is sandy, thus ensuring free drainage to maintain a salinity balance between the soil and the sea water.



Salicornia *experiments at ICBA Research Station*

Agricultural production systems impacts

Throughout the region and in the host country, ICBA is collaborating with partners to improve the livelihoods of rural communities in marginal lands through development of sustainable water, rangelands and livestock management.

Producing high quality food and forage crops under field conditions

Forage grasses

ICBA has studied *Cenchrus ciliaris* (Buffel grass) extensively as it is an important forage grass native to the Arabian Peninsula, is salt-tolerant and can be grown in poor soil and water conditions. In 2010, ICBA continued this research as part of its program to evaluate and select high yield genotypes that produce high quality forage under field conditions. Seeds have been collected and kept for distribution among national agricultural research systems (NARS) and other collaborators. Genetic material will be propagated by vegetative means for multiplication and distribution.

The response to salinity of two other grasses, *Lasirus scindicus* (indigenous Dhai) and an introduced African variety of *Cenchrus ciliaris*, is being investigated by ICBA scientists as part of its collaboration with the UAE Ministry of Environment and Water. With the increasing pressure on all types of water resources in the UAE, high water consuming plants for forage/fodder and other uses need to be replaced by water-efficient plants. *Lasirus scindicus* and *Cenchrus ciliaris* show better adaptability, growth and biomass under saline conditions than other introduced plant species. In 2010, research assessed the biomass productivity of these two grasses affected by different salinity levels and harvesting regimes. The research findings were that quality is better (less fibre and more protein) with repeated harvest forage; however, the total biomass is reduced due to stress from foliage regrowth. Soil samples have been collected to correlate the soil moisture and salinity to the overall biomass production.

ICBA has expanded research on other fronts to improve agricultural and water productivity by using seawater to irrigate grasses. Ongoing research into NyPa forage has concluded that NyPa grass has the potential to be grown as forage crops and landscaping grass in the coastal regions, where sea water can be used for irrigation. With proper management of soil and water, ICBA researchers have demonstrated that long term irrigation with sea water does not increase the soil salinity in the coastal area, as the salts are flushed with each irrigation. The use of marginal water such as sea water for growing some halophytic crops that have either economic values or for certain kinds of landscaping re-directs water usage from freshwater or marginal water such as groundwater, which is limited, for agriculture.

During 2010 NyPa grass was grown at different salinity levels (15, 25 and 40 dS m^{-1}) and irrigation treatments (ET_0x1, ET_0x1.25 and ET_0x1.5). Biomass from three harvests showed maximum dry biomass of about 23.69 t/ha, at irrigation salinity of 25 dS m^{-1} and ET_0x1.5. This is comparable to the values

Buffel grass experiments at ICBA Research Station obtained for earlier years, equivalent to 37 t/ha for four harvests at same levels of salinity and irrigation treatments.

Relationships drawn between soil salinity ($EC_{1:5}$ in dS m^{-1}) and dry biomass showed a sigmoidal relationship. Typical halophytic characteristics were observed by showing increasing trend (threshold salinity) in biomass from 7-13 dS m^{-1} at different irrigation levels.

Research findings identified that soil salinity also corresponded to the salinity of the irrigation water, thus confirming that seawater-based agriculture is possible with proper management practices and suitable sites.

High growth of NyPa forage

Forage crops

ICBA's evaluation of salt tolerance and yield in other forage crops such as barley, triticale, pearl millet and sorghum continued in 2010.

Barley (*Hordeum vulgare*) is one of the most salt-tolerant and fourth most important cereal crops in the world as it is a multi-purpose cereal eaten by humans and animals. High salinity is a potential constraint in dryland environments where barley can be a viable option for the farmers. Consequently ICBA, in collaboration with the International Center for Agricultural Research in the Dry Areas (ICARDA), is researching the productivity of salt-tolerant barley for use in sustainable production systems in saline and dry areas.

During the year 62 genotypes including four check varieties of barley were evaluated and germplasm including a set of genotypes selected from five ICARDA nurseries were bred for the various climatic conditions.

As well, the genotypes of Triticale (x *Triticosecale*), a hybrid of wheat and rye, were screened and selected for salinity tolerance and dry matter production. Most triticales that are agronomically desirable and breed true have resulted from several cycles of improvement. The use of triticale is increasing as it is an important feed crop for cattle, swine and poultry and can be used as an alternate for corn and soybean. Forage yield and quality of triticale is comparable to barley and oat. Recently farmers grew peas with spring triticale for silage. During 2010, when 37 accessions were evaluated under field conditions at three salinity levels, accessions exhibited a wide range of genetic variability for dry matter and grain yield. Many accessions have the potential to be used for dry matter and/or grain production across salinity levels.

Field screening of barley (left) and Triticale (right) genotypes

ICBA research into high-yielding grain and forage lines of pearl millet and sorghum for enhanced crop-livestock productivity in saline lands: phase II continued in 2010 with 35 genotypes of pearl millet being received from ICRISAT and evaluated under field conditions at three salinity levels. Forty-eight mini-core collection of sorghum were evaluated at three salinity levels under field conditions. This research followed earlier identification of suitable germplasm for marginal environments of WANA through screening, evaluation and selection of suitable germplasm and the development of crop management packages suitable for stressed environments. These packages were then given to NARS for further seed multiplication and distribution to local farmers in each country.

Field screening of pearl millet (left) and sorghum (right) genotypes

Two experiments on pearl millet were carried out during the growing season of 2010. Two sets of pearl millet genotypes comprising 30 and 50 entries in each group respectively, which represented diverse genotypic base like landraces, population bulks, hybrids, improved lines and germplasm accessions, were tested at three salinity levels under field conditions. Genotypes exhibited a wide range of phenotypic difference in dry matter production.

Forage crops are being further studied by ICBA through utilization of lysimeter studies to provide a model to study the different physical and chemical aspects of using drainage water in agriculture. Proper disposal of drainage water with a high concentration of salts and other chemicals such as pesticide residues and nitrates is critical; if controlled, drainage water becomes a very important resource as wastewater and can be used in agriculture to replace freshwater. ICBA's experiments focus on the analysis of the chemical contents of the drainage effluents and their interaction with salts for different plant species to determine ways to clean biologically drainage wastewater.

Box 2: Applying the research in the Near East and North Africa

The current year saw the commencement of a new project targeting crop/livestock diversification and sustainable management of marginal lands in the Near East and North Africa through the scaling-up and dissemination of high-yielding forage production packages that are better adapted to saline and marginal environmental conditions began. Farmers have been selected by the project team to learn efficient on-farm seed production and delivery systems of selected stress-tolerant forages.

Building on the successful outcomes of a previous regional project to improve the livelihood of farmers in the region, the project will target Egypt, Jordan, Oman, Syria and Tunisia to participate in all project activities. Gaza and the West Bank, United Arab Emirates and Yemen will be involved in specific activities relevant to their needs. Capacity building will be an important aspect of the project for all countries. During 2010, the Work Plan for the first 18 months was developed. Once project agreements were signed between ICBA and each NARS in the middle of the year, seeds of triticale and safflower were supplied to the NARS.

Date Palms

A crop of economic and cultural significance to the host country and in fact to the entire region is the date palm (*Phoenix dactylifera*). Building on its research into date palms to determine the agronomic and yield characteristics of local UAE and imported Saudi varieties, in 2010 ICBA tested two date palm varieties (Khalas and Khenizi) with two mycorrhizae and two fertility treatments over four salinity levels of irrigated water. As date palms are often grown under saline conditions (a major concern for plant growth), ICBA researchers are determining how well mycorrhizal symbioses could enhance their survival and growth. In general, the symbiosis confers numerous benefits to host plants including improved plant growth and mineral nutrition, and tolerance to diseases and stresses such as drought, temperature and salinity. Date palms, possessing a coarse and limited root system, depend highly on mycorrhizae symbioses for water and nutrient uptake.

Date palm trees irrigated with saline water

ICBA's research findings have been presented to the Khalifa International Date Palm Awards 2011; a prestigious award established in 2008 by President His Highness Sheikh Khalifa bin Zayed Al Nahyan to highlight the role of the date palm and its importance in the culture and heritage of the United Arab Emirates.

Achieving efficient integrated farming systems

Farmers' Services Center

Within the United Arab Emirates, farmers will be the beneficiaries of a long-term collaboration between the Farmers' Services Center (FSC) and ICBA formalized in late 2010. FSC and ICBA signed a Memorandum of Understanding and an agreement for three year covering Potential Cooperative Projects for Farming Systems, Technology Transfer and Capacity Building.

The FSC was established by the Abu Dhabi Food Control Authority (ADFCA) in 2009 as an intermediary between ADFCA and the farming community to achieve efficient integrated farming systems (including livestock) along with forages, vegetables and date production. The FSC also intends to reduce water usage in agriculture by up to 40% over existing levels through changes to the cropping patterns, adoption of improved water application techniques; and the updating of old and inefficient on-farm water systems. In the long-term the FSC seeks to improve marketing strategies for existing and new production systems and provide an education resource for farmers on agriculture, risks and compliance issues.

Initiating preliminary screening plots at farmers' fields

To achieve this ambitious reform program benefiting farmers, the FSC has sought broad long-term collaboration with ICBA to sustain farm-level productivity in the Western Region of Abu Dhabi by introducing improved farming management practices. FSC and ICBA recognize that farmers' participation will speed up the selection and introduction of these new crops to diversify the production systems and so are developing capacity building for extension officers and farmers. ICBA will conduct an introductory course for extension staff during April 2011 to familiarize them with the challenges of salinity, measurements, new crops and management.

Box 3: Applying the research in Central Asia – Turkmenistan and Tajikistan

ICBA has been collaborating with local institutions in the Central Asian countries of Turkmenistan and Tajikistan to improve the livelihoods of rural communities in saline desert environments. Extreme drought, high temperature extremes, climate change, rapid expansion of irrigated agriculture and intensification of human activities have severely impacted the dryland ecosystem of Turkmenistan and Tajikistan resulting in marginalized unproductive lands. Fresh irrigation water in these marginal areas has inevitably declined because of increasing demand from agricultural and non-agricultural users.

In late 2010, ICBA and the Institute of Desert Flora and Fauna and the Turkmenistan Ministry of Nature Protection established a partnership targeting the efficiency of non-conventional water use in agri-silvi-horticultural and silvi-pastoral systems to meet the forage demands and develop adaptation strategies for vulnerable communities. Various low cost biosaline technologies for crop diversification, efficient marginal quality water use, feed and livestock production and rangelands management will be evaluated and adopted. The impact of water saving, drain-water use and crop diversification on feed livestock production will be assessed at the demonstration sites in the northern (Dashauz) and southern (Mary) provinces in Turkmenistan. Farmers, animal breeders, agro-pastoralists and householders will develop in both provinces a model of a *Learning Alliance* for 'Joint Arid Biosaline Food and Forage/Livestock Production'.

Similarly in Tajikistan, land is becoming more marginal and unable to support production due to resource mismanagement exacerbated by climate change. On-farm management of land, water and plant resources is a key strategy for using these marginal lands.

ICBA and the Tajikistan Academy for Agricultural Sciences are collaborating to establish suitable production systems using native trees and shrubs on marginal land and winter/summer conventional and non-conventional crops (multi-purpose trees and shrubs). These measures, plus bio-drainage, will facilitate agro-forestry and forage crops, thus benefiting small, remote, rural communities.

During 2010, ICBA introduced varieties of sorghum, pearl millet and alfalfa screened at salinity levels of 4.5 - 11.5 dS m^{-1} mg/l – these showed significantly higher biomass than the local varieties in Tajikistan.

Among the early-maturing, tall sorghum accessions tested, Speed Feed and Sugar Graze showed significant improvement as compared to local varieties in seed germination (85-90%), growth rate, plant height and green biomass. These two dual-purpose two-cut varieties can play a significant role to fill gaps in the farm productivity and crop-livestock systems in the salt-affected areas of northern Tajikistan.

Fresh biomass of pearl millet varied from 7.1 to 7.4 kg/m^2 with a plant density of 65-90 plants/m^2. Height of plant varied between 175-280 cm and the number of basal tillers ranging 13-32. Experimental trials in the Ash district revealed distinctive features such as high morphologic diversity in grain size and number of grains/panicle for these two screened varieties of pearl millet.

At Yangiobod, promising results were obtained for alfalfa. The varieties, Eureka and Sceptre from the ICBA germplasm pool, were well adapted to the prevailing climatic and highly saline environments and were markedly different in performance when compared to the local variety 'Vakhsh-300' in growth rate, number of inflorescence, size and number of pods and number of seeds/pod.

Evaluation of 6 multi-purpose tree species (MTS) showed a high survival rate, quick relative growth rate for *Populus euphratica*, *P. pruinosus*, *P. nigra* var. pyramidalis, *Elaeagnus angustifolia*, *Armeniaca vulgaris* and *Diospyros virginiana* L. cultivated in mixed stands with various conventional salt-tolerant fodder crops.

During 2010 FSC initiated preliminary screening and then conducted with ICBA a survey of farm salinity, which will determine the location of demonstration and model farms. Demonstration farms will cover 0.5 donums (0.05 ha) in the different agricultural regions (Liwa, Madinat Zayed and Ghayathi) and different salinity levels (low 5-10, moderate 10-15 and high 15-20 dS m^{-1} and above). Model Farms will operate in the same regions and at the same salinity levels, but on the whole farm-level (excluding date palm growing and livestock areas) and ranging from 23-40 donums (2.3-4.0 ha).

Thirteen different farms were surveyed from the following three regions for different soil and water characteristics: 1) Madinat Zayed (6 farms); 2) Liwa (5 farms); and 3) Ghayathi (2 farms).

Soil samples were collected from the root zone, between the emitters and the profile at 0-50, 50-100 and 100-200 cm, to diagnose: (1) in depth soil salinity heterogeneity; (2) water table within 200 cm; and (3) hardpan/dense layer within 200 cm. Soil and water samples were analyzed at the Central Analytical Laboratory at ICBA as the basis for selection of demonstration and model farms.

Three demonstration farms were planted with different accessions of five winter forages (barley, fodder beet, safflower, mustard and quinoa). All crops/accessions showed 100% germination and establishment, with the exception of one variety of fodder beet. Yield data showed high biomass in Ghayathi farms (#12 and 13, both at low and higher salinity level) ranging from 4.03-6.13 t FW/ha in the case of barley; 4.01-7.94 t FW/ha for fodder beet; 1.86-2.17 t FW/ha for safflower; 3.37-5.07 t FW/ha for mustard; and 3.80-7.60 t FW/ha for quinoa. Some of the forages were harvested by the land owners/farmers; as a result no data could be recorded.

Based on the survey and discussion with FSC staff, ICBA has proposed four model farm areas in the three regions representing the three different classes of salinity levels (slight, moderate, high):

1. Farm #2 (Madinat Zayed) (EC_{iw}: 17.27 dS m^{-1}; EC_e (0-200 cm): 10.16 dS m^{-1})
2. Farm #10 (Liwa) (EC_{iw}: 16.03 dS m^{-1}; EC_e (0-200 cm): 11.23 dS m^{-1})
3. Farm #8 (Liwa) (EC_{iw}: 10.86 dS m^{-1}; EC_e (0-200 cm): 4.77 dS m^{-1})
4. Farm #13 (Ghayathi) (EC_{iw}: 5.89 dS m^{-1}; EC_e (0-200 cm): 6.77 dS m^{-1}).

These model farms will utilize the entire farm areas excluding the date palm and livestock areas. Details of farms and inventory of materials needed has been submitted to FSC for approval and legal agreement with the farm owners. Production systems with different annuals and perennials (crops, grasses, shrubs, and trees), irrigation systems (drip, bubbler, and mini-sprinklers) will be demonstrated with saline groundwater. The annuals will include different accessions/lines of sorghum, pearl millet, cowpea, pigeon pea, guar and Sesbania, whereas the perennials will include lines of *Cenchrus*, *Panicum*, *Sporobolus*, *Distichlis* (grasses), *Atriplex* spp. (shrubs) and Acacia (tree). The allocation of these forages to specific farms will be finalized once the respective farms are selected.

Boosting farm income and productivity through Agroforestry Systems

ICBA's expertise in evaluating different kind of plants in marginal quality water is being strengthened by research into agroforestry systems, such as alley-cropping, silvopasture, windbreaks, riparian buffer strips, and forest farming for non-timber forest products. Integrating trees and shrubs with the other enterprises on a farm can generate additional sources of income and increase the productivity of all enterprises through nutrient and water management. An additional benefit of the agroforestry system is better nutrient management since absence or loss of nutrients significantly affects the productivity of plants. Under marginalized situations, the success of any type of production system will depend on the cost-benefit ratio and hence a stable biological system that can manage nutrient efficiently adds economic benefits. In general, tree species are grown with other crops and/or other shrubs/forbs. These types of system benefit the different components, mainly through nutrient and water management.

ICBA has been studying *Acacia ampliceps*, which is one of the most successful plant species tried in many partner countries, from Central Asia to North Africa. The plant fixes atmospheric nitrogen, provides forage/fodder for animals, is also a source for bio-energy and provides a favorable environment

Agroforestry system improves farm productivity

conducive to under-storey plants. ICBA's research over the last six years has demonstrated the compatibility between A. ampliceps to two salt-tolerant grasses, *Sporobolus arabicus* and *Paspalum vaginatum*, in response to different salinity treatments and fertilizers.

Studies showed that *Acacia ampliceps* plants are able to fix nitrogen under different salinity levels (10-30 dS m^{-1}), thus supporting the nutrient requirements for the two grasses studied. Based on average values over the project duration, the unfertilized plots showed a reduction between 7-13% for *S. arabicus* and insignificant difference for *P. vaginatum*. The average yield of these grasses varies from 22-28 tons dry matter/ha/yr. In addition, the foliage from the trees harvested at 2 m from the ground surface additionally provides ~ 10 tons dry matter/ha/yr.

Attempts were made to check the nodulation status in *A. ampliceps* trees under different salinity levels and isolate/characterize the bacteria (if *Rhizobium*). The results showed nodulation even at 30 dS m^{-1} with the bacteria showing the characteristic feature of gram negative Rhizobium. Attempts are being made to multiply the bacteria and test through cross-inoculations at different salinity levels and crops.

While agroforestry systems clearly offer economic and ecological advantages, they involve complex interactions which complicate their management.

Exploring and exploiting Genetic Diversity

Critical to ICBA's research is its plant genetic resources program. Genetic diversity contained in the germplasm assembled at ICBA is the basis to improve the productivity of degraded environments such as salt-affected areas. Morpho-agronomic characterization and preliminary evaluation for adaptation, yield potential and tolerance to prevailing abiotic stresses such as salinity help in the identification of promising germplasm for further utilization. Germplasm is then disseminated to national programs for research and other uses.

Initially ICBA's focus had been on assembling the germplasm of salt-tolerant forages; however, recently the program has started to acquire and conserve germplasm of high value crops such as vegetables and ornamentals (eggplant, okra, quinoa and mustard) to study their adaptation to local conditions and tolerance to marginal quality water irrigation.

Box 4: Applying the research in Bangladesh, India, Pakistan, Spain, UAE, Germany and the Netherlands

ICBA's expertise in remediation of saline wastelands through biosaline agroforestry is facilitating the production of renewable energy, biomaterials and fodder. In a collaboration spanning seven countries (Bangladesh, India, Pakistan, Spain, the UAE, Germany and the Netherlands), the BIOSAFOR (biosaline agroforestry) project is an investigation into the productive potential of biosaline agroforestry systems in degraded lands. Project outputs range from the selection of trees to optimal management and the development of economically feasible value chains.

The project has seven different work packages (WP) from experimental trials to case studies, leading to global characterization of saline/sodic wastelands. Trials over the last three years for WP1 continued in 2010 at ICBA and other partners (Bangladesh Agricultural Research Institute (BARI), Central Soil Salinity Research Institute (CSSRI), Centro de Investigación y Tecnología Agroalimentaria de Aragón (CITA), and the University of Agriculture, Faisalabad (UoF)). The evaluation of salt-tolerant germplasm was carried out in pot studies using coarse sandy to sandy-loam soils and irrigated with water salinity ranging from 0-40 dS m^{-1}, with five replicates for each treatment. Data related to water, soil and plant growth were entered into the salt model database for analysis and preparation of salinity curves to determine the Ct, C50 and C0 salinity levels.

For WP2, the emphasis has been to collect and collate all information on salt-tolerant trees growing in different salinity conditions and in different case study areas (in Bangladesh, India and Pakistan with ICBA as the regional coordinator). These cases were studied in depth for soil characteristics, tree growth and productivity. Replicate trees for selected species of Prosopis and Eucalyptus were harvested by partners in CSSRI (Lucknow and Hisar sites) and at NIAB (Faisalabad site) for determining the biomass components.

For WP's 4-6, ICBA liaised with University of Utrecht (UU), ACACIA Institute, Universität Hohenheim (UHOH), Organization for Agriculture in Saline Environments (OASE) and national partners for discussions on land categorization, availability of data and digitized maps and other organizational matters. ICBA led the preparation of the deliverable documents (especially for WP's1 and 2).

Salt tolerance of vegetables is important because of their high cash value. Although germplasm tolerant of temperature extremes, drought, etc. has been identified and advanced breeding lines developed in major vegetable crops, salinity has not received as much as attention as other abiotic stresses. Furthermore, climate change predictions for the Arabian Peninsula forecast increased temperatures and higher rates of evaporation, which will exacerbate land and water resources degradation with adverse affects on vegetable production. Thus, identification of germplasm, which could produce good economic yields under the harsh climatic conditions and with saline water and soil resources, will be crucial to sustain vegetable production in the region.

Landscaping plants are also being affected by the same climatic constraints. In recent years, the availability of good quality water for the gardens and landscapes is becoming increasingly restricted due to the rising demand for domestic use of the scarce fresh water resources. Consequently, landscape architects are searching for landscaping plants that perform well with saline groundwater and treated wastewater. To date, only limited systematic work has been carried out to study the tolerance of landscaping plants to higher levels of salinity.

New facilities for vegetable and ornamental crop research

During 2010, field- and greenhouse-based facilities were developed for systematic screening and identification of salt-tolerant germplasm of the vegetable and ornamental crops. Since vegetables are less tolerant of salinity than forages, the new screening facilities will allow the use of lower water salinities to screen germplasm without interfering with the ongoing experiments which use higher levels of salinity.

Screening germplasm for salt tolerance

Screening for identification of salt tolerant vegetable germplasm is at different stages in several crops. During 2010, pot and preliminary field screenings of cowpea and guar were completed. Seeds harvested from individual plants that survived at higher salinities are being further evaluated in replicated field trials irrigated with saline water at 5, 10 and 15 dS m^{-1}.

In okra, 20 accessions were screened at three levels of salinity (EC_w 4, 8 and 12 dS m^{-1}) in pots. While none of the accessions survived and/or produced fruits at high salinity (12 dS m^{-1}), growth and fruit bearing were found to be low at 8 dS m^{-1}, but with no obvious differences among accessions.

Tomato, pepper and lablab (hyacinth bean) were found to be more tolerant than okra as no mortality was observed when evaluated at 12 dS m^{-1}. Similar to okra, differences among accessions for growth and fruit yield were not very obvious, probably because the plants have grown older by the time water salinity was increased to 12 dS m^{-1}. In all these crops, screening will be repeated with the application of highly saline water from very early stages of growth to be able to discriminate tolerant accessions.

Results from the 2010 program confirmed the previous findings that sesbania, quinoa and mustard have excellent potential for diversification of production systems in the Arabian Peninsula. The program also isolated and characterized rhizobial germplasm in order to determine their tolerance to major environmental factors. The natural rhizobia in the UAE soils are expected to exhibit higher tolerance to prevailing adverse conditions like salt stress, elevated temperature and drought. Isolation and characterization of these stress tolerant rhizobial strains would be of potential value for agriculture in the region.

Field screening of genotypes: okra (top), quinoa (middle), tomato (bottom left) and pepper (bottom right)

Building Capacity and Sharing Knowledge

ICBA has continued to incorporate into the design of projects wherever possible a significant component of capacity building and knowledge-sharing. By the end of 2010, over 900 individuals from 44 countries have been trained.

Sharing Soil Research Findings

The outcomes of the Abu Dhabi Soil Survey, a project jointly conducted by EAD, ICBA and GRM, were discussed at the International Conference on Soil Classification and Reclamation of Degraded Lands in Arid Environments with 250 participants from 35 countries. The conference was also the forum for a workshop on the utilization of soil survey data in land use planning and policy implications to discuss the directions of soil research after the Abu Dhabi Soil Survey and the launch of the Survey report.

GRM International Australia, in partnership with the Environment Agency – Abu Dhabi (EAD) and the Ministry of Environment and Water (MOEW), is implementing a soil survey for the Northern Emirates of the UAE. In recognition of Central Analytical Laboratory's past services to EAD and GRM International in the Soil Survey of Abu Dhabi Emirate, the GRM has signed an agreement with ICBA to provide partial analytical services for the Northern Emirate soil survey project for one year.

ICBA's scientific reputation to conduct such applied research and analysis has been enhanced by the undertaking of soil mapping of the ICBA research station. The report to provide soil data classified with the USDA Soil Taxonomy was completed in December.

Desert sandy soils are infertile due to low levels of clay and organic matter and have low water holding capacity. To improve soil quality by improving plant beds for better crop production, a number of inorganic and organic based materials are available in the market, for example, compost, rhizosphere bacteria, mycorrhizal fungi and fertilizers. These materials were tested in the pot experiments, but in future will be tested in the field. The project findings to date were presented at the International Soil Conference in Abu Dhabi. Temperature sensors were acquired and installed at various depths to monitor temperature dynamism over project duration and data logged and a weather station installed to collect rainfall and temperature data.

Training opportunities

During the year, ICBA conducted the following workshops:

- *Regional Symposium on the Scientific Outcome of the Project: Saving Fresh Water Resources with Salt-tolerant Forage production in Marginal Areas of the West Asia and North Africa Region: An Opportunity to Raise the Incomes of the Rural Poor,* Damascus, Syria, 30-31 May 2010.

Participants at the International Soil Conference in Abu Dhabi

- Training Workshop on *Biosaline agriculture technologies for arid and semi-arid regions with reference to Africa* was conducted in French at ICBA Headquarters in Dubai during 23 May-3 June. Funded by the Arab Bank for Economic Development in Africa (BADEA), the course was attended by 19 delegates from Benin, Burkina Faso, Burundi, Cameron, Chad, Congo, Guinea-Bissau, Ivory Cost, Madagascar, Niger, Senegal, and Togo. The practical course followed the success of another training opportunity held at ICBA in 2007 which was also funded by BADEA - a financial institution funded by the governments of the Member States of the League of Arab States to strengthen economic, financial and technical cooperation between Arab and African countries.

Participants of the BADEA training course

- Regional workshop on *Genetic Enhancement, Seed production and Crop Management of Pearl Millet and Sorghum*, Jordan, October 17-19, 2010.
- Regional Training Workshop on *Biosaline Agriculture Technologies and their Roles in the Mitigation of Climate Change in the Arab Region*, Cairo, Egypt, 25-28 October. The course was organized in collaboration with the Arab Center for the Study of Arid Zones and Dry Lands (ACSAD) and Desert Research Center (DRC) and attended by 28 delegates from Egypt, Jordan, Iraq, Kuwait, Oman, Sudan, Syria, Tunisia and UAE.

Participants of the training workshop in Egypt visiting a private agricultural farm

Networking

The **Global Biosalinity Network** (GBN) promotes collaboration between individuals involved in research and development on biosaline agriculture. An on-line registration form is available at www.biosaline.org/join.cfm

The **Inter-Islamic Network for Biosaline Agriculture** (INBA) was established during the 10th General Assembly Meeting of the Organization of Islamic Conference of the Standing Committee on Scientific and Technological Cooperation (COMSTECH) in Islamabad, Pakistan, in 2002. Since then, the network has provided a forum for mutual collaboration and cooperation among the members of the Organization of Islamic Countries (OIC) in the field of biosaline agriculture. Dr Shoaib Ismail is the ICBA representative contributing to the project.

INBA targets national, regional, and international institutions in developing and developed countries, and aid agencies, in particular those in the OIC member states. Network members will include ministries of agriculture and water resources, universities, national, regional and international agricultural research and development agencies, extension services, and end-users, including farmer groups and non-governmental organizations (NGOs).

APPENDICES

Appendix 1

Audited financial statements (*in United States Dollars*)

STATEMENT OF ACTIVITIES – FOR THE YEAR ENDED DECEMBER 31 2010		
	2010	2009
Grants and contributions		
Grants unrestricted	**4,444,081**	4,407,146
Contributions for training courses and research	**2,385,869**	1,737,638
Other income	**23,694**	12,627
Total grants and contributions	**6,853,644**	6,157,411
Programs and other expenses		
Employees' salaries and benefits	**(3,603,526)**	(3,263,536)
Expenses on training courses and research	**(2,385,869)**	(1,737,638)
Travel	**(114,958)**	(51,686)
Depreciation of property and equipment	**(320,729)**	(380,853)
Supplies and utilities	**(207,310)**	(212,678)
Maintenance	**(105,090)**	(139,683)
Contract services	**(49,969)**	(47,134)
Board of Directors expenses	**(47,809)**	(62,719)
Assets written off	**--**	(144,798)
Other expenses	**(18,384)**	(116,686)
Total programs and other expenses	**(6,853,644)**	(6,157,411)
Excess of revenues over expenses	**--**	--

STATEMENT OF FINANCIAL POSITION - AS OF DECEMBER 31 2010		
	2010	2009
ASSETS		
Current assets		
Cash and cash equivalents	**7,494,478**	6,143,069
Short-term deposits	**2,038,043**	
Due from employees	**--**	3,298
Prepayments	**111,257**	38,682
Other receivables	**18,682**	5,570
Total current assets	**9,662,460**	6190,619
Non-current assets		
Property and equipment	**5,825,311**	5,879,456
Total Assets	**15,487,771**	12,070,075
LIABILITIES AND NET ASSETS		
Current liabilities		
Donors' payables	**--**	907,281
Accruals and other payables	**502,355**	401,126
Total current liabilities	**502,355**	1,308,407
Non-current liabilities		
Provision for employees' end of service indemnity	**266,467**	192,128
Total Liabilities	**768,822**	1,500,535
Net Assets		
Unrestricted unappropriated		
-Property and equipment	**5,825,311**	5,879,456
-Others	**122,189**	378,621
Unrestricted - appropriated	**4,950,882**	2,177,143
Temporarily restricted	**3,820,567**	2,134,320
Total Net Assets	**14,718,949**	10,569,540
Total Liabilities and Total Assets	**15,487,771**	12,070,075

Appendix 2
Donors

Major donors (unrestricted funding)

Ministry of Environment and Water, United Arab Emirates(MOEW)
The Ministry of Environment and Water (MOEW) endeavors to provide an optimal environment for the inhabitants of the United Arab Emirates through balanced and sustainable development.

Environment Agency-Abu Dhabi (EAD)
The Environment Agency-Abu Dhabi (EAD) is a governmental agency established in 1996 with an overall mission to protect and conserve the environment and promote sustainable development of Abu Dhabi Emirate, the capital of the United Arab Emirates.

Islamic Development Bank (IDB)
The Islamic Development Bank (IDB), established in 1975, is an international development finance institution whose purpose is to foster the economic development and social progress of member countries and Muslim communities, individually and jointly, in accordance with the principles of Islamic law.

Other donors (restricted funding)

Arab Bank for Economic Development in Africa (BADEA)
Arab Fund for Economic and Social Development (AFESD)
Australian Agency for International Development (AUSAid)
Australian Center for International Agricultural Research (ACIAR)
Dutch Ministry of Foreign Affairs (MFA)
European Union (EU)
Farmers' Services Center in Abu Dhabi (FSC)
International Fund for Agricultural Development (IFAD)
Ministry of Agriculture and Fisheries in Oman (MAF)
OPEC Fund for International Development (OFID)
United States Agency for International Development (USAID)
World Bank (WB)

Appendix 3

Collaboration with research organizations

Regional and international

Arab Center for the Study of Arid Zones and Dry Lands (ACSAD)

Centro de Investigación y Tecnología Agroalimentaria de Aragón (CITA)

International Atomic Energy Agency (IAEA)

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

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

International Institute of Tropical Agriculture (IITA)

International Rice Research Institute (IRRI)

International Water Management Institute (IWMI)

The World Vegetable Center (AVRDC)

National

Abu Dhabi Food Control Authority (ADFCA), UAE

Abu Dhabi Future Energy Company (MASDAR), UAE

ACACIA Institute, Vrije Universiteit, The Netherlands

Central Soil Salinity Research Institute (CSSRI), India

Desert Research Center (DRC), Ministry of Agriculture and Land Reclamation, Egypt

Directorate General of Agriculture and Livestock Research (DGALR), Oman

Emirates Institute of Advanced Science and Technology (EIAST), UAE

Farmers' Services Center (FSC), UAE

General Commission for Scientific Agricultural Research (GCSAR), Ministry of Agriculture and Agrarian Reform, Syria

Institute of Desert, Flora and Fauna (IDFF), Turkmenistan

Institute of Vegetable and Ornamental Crops (IGZ), Germany

MASDAR Institute (MI), UAE

Ministry of Agriculture and Fisheries (MAF), Oman

Ministry of Agriculture, Iraq

Ministry of Agriculture, Palestine

Ministry of Education, Iraq

Ministry of Environment, Iraq

Ministry of Water, Iraq

National Aeronautics and Space Administration (NASA), USA

National Center for Agricultural Research and Extension (NCARE), Jordan

National Research Institute for Rural Engineering, Water & Forest (INRGREF), Ministry of Agriculture and Hydraulic Resources, Tunisia

Sultan Qaboos University (SQU), Oman

Tajikistan Academy for Agricultural Sciences (TAAS), Tajikistan

United Arab Emirates University (UAEU), UAE

Private Sector

BioMyc International Corporation, Germany

GRM International, Australia

Ocean Desert Enterprises (ODE), The Netherlands

Organization for Agriculture in Saline Environments (OASA), The Netherlands

Appendix 4

Senior and technical staff (*as of 31 Dec 2010*)

Director General Office

Dr Shawki Barghouti, Director General

Dr Ahmad Al Masoum, Deputy Director General

Mr Ibrahim Bin Taher, Government Liaison Officer

Ms Badryh Bochi, Administrative Assistant

Mr Tarek Sakran, Administrative Assistant – Abu Dhabi Office

Technical Programs

Prof Dr Faisal Taha, Director of Technical Programs

Dr Abdullah Dakheel, Field and Forage Crops Scientist

Dr Khalil Ammar, Hydrogeologist

Dr Nanduri K Rao, Plant Genetic Resources Scientist

Dr Nurul Akhand, Irrigation Management Scientist

Dr Shabbir Shahid, Salinity Management Scientist

Dr Shoaib Ismail, Halophyte Agronomist

Dr Ian McCann, Visiting Scientist - Water Management and Irrigation

Dr Rachael McDonnell, Visiting Scientist - Water Policy and Governance

Dr Henda Mahmoudi, Visiting Scientist – Central Analytical Laboratory

Mr Abdul Qader Abdul Rahman, Station Supervisor

Ms Baedaa Ismail Khalil, Communications Assistant

Mr Basel Ahmad Al-Araj, Irrigation Management Engineer

Ms Carla Mellor, Library Specialist/Acting Communications Specialist

Mr Ghazi Al Jabri, Communication Coordinator

Mr Ghulam Shabbir, Agricultural Engineer

Mr Karim Bergaoui, Modeling Researcher - MENA-LDAS Project

Mr Khalil Ur Rahman, Agricultural Engineer

Mr Mohammad Shahid, Agricultural Engineer

Ms Nancy Agizy, Administrative Assistant - DTP Office

Ms Sarah Grey, Data Collection Researcher, MENA-LDAS Project

Administration and Finance

Ms Alice Soliman, Administrative Assistant

Mr Bilal Al Salim, Government Relations Administrator

Ms Irene Galang Bolus, Senior Accountant

Mr Jamal Telmesani, Facilities Supervisor

Ms Suzara Naga, General Accountant

Mr Tarek Attia Ali, IT Specialist

Mr Yousef Hedar, Facilities and Administration Assistant

Oman Salinity Project Office (Muscat)

Ms Nirmala Rajendran, Administrative Officer - Oman Ssalinity Strategy

Central Asia Office (Tashkent)

Dr Kristina Toderich, Plant Scientist

Appendix 5

Publications

Papers in refereed journals and published proceedings

Akhand NA, Islam S and Akanda R. Improved irrigation and agronomic practices: An opportunity to grow cash crops under saline conditions. *In*: Proceedings of the International Conference on Management of Soil and Groundwater Salinization in Arid Regions; 2010 January 11-14; Muscat, Sultanate of Oman. Muscat: Sultan Qaboos University; 2010.

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Shahid SA, Abdefattah MA, Omar SAS, Harahsheh H, Othman Y and Mahmoudi Henda. Mapping and monitoring of soil salinization-remote sensing, GIS, modeling, electromagnetic induction and conventional methods – case studies. *In*: Mushtaque Ahmad and Salim Ali Al-Rawahy, editors. Proceedings of the International Conference on Soils and Groundwater Salinization in Arid Countries; 2010 11-14 January: Muscat Sultanate of Oman: Sultan Qaboos University; 1: 59-97.

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Appendix 6

Acronyms

ACACIA	ACACIA Institute, Vrije Universiteit (Amsterdam, The Netherlands)
ACIAR	Australian Centre for International Agricultural Research
AFESD	Arab Fund for Economic and Social Development
AVRDC	The World Vegetable Center (Taiwan)
BADEA	Arab Bank for Economic Development in Africa
BARI	Bangladesh Agricultural Research Institute
BioMyc	BioMyc International Corporation (Germany)
CITA	Centro de Investigación y Tecnología Agroalimentaria de Aragón (Spain)
CK	Capacity Building and Knowledge-sharing (ICBA program)
CGIAR	Consultative Group on International Agricultural Research
CSSRI	Central Soil Salinity Research Institute (India)
DGALR	Directorate General of Agriculture and Livestock Research (Oman)
DRC	Desert Research Center, Egypt
EAD	Environment Agency-Abu Dhabi
EIAST	Emirates Institute of Advanced Science and Technology
GRM	GRM International
IAEA	International Atomic Energy Agency (Austria)
ICARDA	International Center for Agricultural Research in the Dry Areas (Syria)
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDB	Islamic Development Bank (Kingdom of Saudi Arabia)
IDFF	Institute of Desert, Flora and Fauna (Turkmenistan)
IFAD	International Fund for Agricultural Development
IGZ	Institute of Vegetable and Ornamental Crops (Germany)
IITA	International Institute of Tropical Agriculture (Nigeria)
IRRI	International Rice Research Institute
IWMI	International Water Management Institute
IWS	Integrated Water Resource System (ICBA program)
LDAS	Land Data Assimilation Systems
MAR	Managed Aquifer Recharge
MASDAR	Abu Dhabi Future Energy Company (UAE)
MI	MASDAR Institute (UAE)
MENA	Middle East and North Africa region
MOEW	Ministry of Environment and Water (UAE)
MQ	Marginal Quality Water Program (ICBA program)
NARS	National Agricultural Research System
NASA	National Aeronautics and Space Administration
NCARTT	National Center for Agricultural Research and Technology Transfer (Jordan)
NENA	Near East and North Africa region
NIAB	Nuclear Institute for Agriculture and Biology (Pakistan)
NPC	National Prawn Company (Saudi Arabia)
OASE/ODE	Organization for Agriculture in Saline Environments / Ocean Desert Enterprises (Netherlands)
OFID	OPEC Fund for International Development
OSS	Oman Salinity Strategy
OWSC	Oman Wastewater Services Company
OPEC	Organization of the Petroleum Exporting Countries
PDO	Petroleum Development Oman
SQU	Sultan Qaboos University (Oman)
STP	Sewage Treatment Plant
TAAS	Tajikistan Academy for Agricultural Sciences
TDIC	Tourism Development & Investment Corporation (Abu Dhabi)
UAE	United Arab Emirates
UAEU	University of the United Arab Emirates
UoF	University of Agriculture, Faisalabad
UHOH	Universität Hohenheim (Stuttgart Germany)
USDA	United States Department of Agriculture
UU	University of Utrecht
WANA	West Asia and North Africa

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