Annual Report 2006
(1426-27H)

International Center for Biosaline Agriculture

ICBA Annual Report 2006 (1426-27H)

Our 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.

Our Mandate

To develop sustainable water management systems to irrigate food and forage crops and ornamental plants with marginal and saline water, and to encourage the use of suitable plants for socio-economic development.

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International Center for Biosaline Agriculture

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Cover photograph: *Genetic diversity within and among plant species provides options to effectively address the problem of salinity in agricultural production systems.* *(Photo: Ghazi Al Jabri.)*

Contents

Foreword

The year 2006 was a milestone for ICBA. The retirement of Director General Dr Mohammad Al-Attar and the recruitment of his successor were significant events. Dr Al-Attar, who had been at the helm of the Center since its inception in 1999, had done an excellent job for ICBA. A Search Committee identified four suitable candidates, all of whom were interviewed in September. The committee selected Dr Shawki Barghouti, whose name was submitted to the Islamic Development Bank (IDB) for approval. We were happy to approve this excellent nomination.

But perhaps an even more important change for ICBA was an emerging new mandate. In anticipation of a modification in the center's mandate, ICBA commissioned, with full support from the IDB, a high-level team of consultants to develop a strategy to guide the center's research agenda over the 5-year period from 2008 to 2012. The team consisted of three eminent scientists familiar with ICBA and the problems of water in arid regions: Dr Shawki Barghouti, a Jordanian national who at the time was working for the World Bank and who had earlier served as Director General of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT); Dr David Seckler, an American economist and former Director General of the International Water Management Institute (IWMI); and Dr Donald Suarez, Director of the United States Department of Agriculture's Salinity Laboratory in Riverside, California.

The new strategy developed by this expert team of consultants, which has the unequivocal support of the IDB, calls for a significant expansion of ICBA's activities in the direction of water quality and the management of marginal water. Importantly, its present focus on biosaline agriculture will be retained. The team visited the region several times and submitted several iterations of strategy after consultations with ICBA scientists, management and stakeholders in the national research systems as well as other experts. As the year drew to a close, a milestone meeting was arranged for early February 2007 in Dubai, to which an array of stakeholders in ICBA's future was invited. It was expected that the new Strategic Plan would be ratified after this meeting.

In May, ICBA was well represented at the Annual Meeting of the IDB in Kuwait. ICBA hosted a seminar on the importance of biosaline agriculture in the mandate countries of the Bank. The seminar, which was chaired by Dr Amadou Cisse, the IDB's Vice President Operations, was very informative and well attended.

In September, I was delighted to visit ICBA's headquarters in Dubai, where I was able to discuss the evolving trends with His Excellency Dr Saeed Al-Kindi, the United Arab Emirates' Minister of Environment and Water, as well as with Mr Fawzi AlSultan, ICBA's Chairman of the Board of Directors. As the saying goes, *seeing is believing*, and I was very favorably impressed by what I was shown by the ICBA management and staff.

A special thank-you goes to the host country, the United Arab Emirates, for its continued support to ICBA.

I wish all success to the ICBA staff in their efforts to alleviate the difficulties faced by the inhabitants of the Islamic world and beyond.

Dr Ahmad Mohamed Ali
President, Islamic Development Bank
Chairman, Board of Trustees, ICBA

MESSAGE

The IDB, in cooperation with the Government of the United Arab Emirates, established ICBA in 1999. The research mandate they articulated specified scientific investigation into biosaline agriculture for a period of 10 years. The accomplishments made by the center, especially in managing saline water and associated agricultural production systems, have been significant and well appreciated by both the Bank and the host country. Based on these achievements, ICBA was encouraged to expand its research agenda to include new dimensions covering water quality and integrated management of water resources. A team of experts was recruited to explore how this expansion could best be done.

The team, assisted by senior officials in ICBA's partner countries as well as by the center's staff, developed a Vision and Strategy Document during the course of the year. This document was debated and ultimately approved by the center's stakeholders during a special workshop. The key element in the new mandate is water. The new ICBA will assist national research programs in conducting field studies on integrated water resources and water quality. Importantly, the center's traditional mandate of biosaline agriculture will be an integrated part of the new Strategic Plan.

This Annual Report highlights the main findings of ICBA's research on biosaline agriculture and updates the following important research thrusts:

- The multi-donor, multi-country Forage Project funded by the International Fund for Agricultural Development (IFAD), the Arab Fund for Economic and Social Development (AFESD) and the OPEC Fund for International Development (OFID).
- The collaborative project combating land and water resource degradation in Kazakhstan, Turkmenistan and Uzbekistan funded by the Asian Development Bank (ADB).
- The soil survey for the Emirate of Abu Dhabi undertaken in partnership with Environment Agency-Abu Dhabi (EAD).
- Ongoing research on forage and livestock with United Arab Emirates University (UAEU).
- Bilateral work with Bangladesh, Egypt, Jordan and Pakistan.

For the last few years, the IDB, which was once our sole benefactor, has encouraged us to seek contributions from other donor agencies with a stake in agricultural development. The Bank's support for our efforts in this regard is thoroughly appreciated, and the success of our efforts to mobilize new resources is shown by over USD 1 million from new donors.

We would like to commend Dr Mohammad Al-Attar for his sterling work as Director General over the past seven years. We wish him every success in the next chapter of his life. Our profound thanks go to Dr Ahmad Mohamed Ali, President, and Dr Amadou Cisse, Vice-President for Operations, IDB, for their unflagging support.

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Chairman, Board of Directors

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The ICBA Board of Directors (left to right)

Seated:
Dr Solh
Mr AlSultan
Dr Al-Attar

Standing:
Mr Ennifar
Eng Rafia
Eng Al-Asam
Mr Al Mansouri
Dr Barghouti

Missing:
Dr Bishay
Mr Hareb

Technical Programs

Plant Genetic Resources Program

Acquisition and conservation of plant genetic resources (GR01)

Duration: Ongoing
Collaborators: National and international genebanks
Resources: Core

483 accessions of 10 species were acquired, increasing ICBA's genebank holdings to 8853 accessions

Significance of the project

Productive use of saline lands requires genetic resources of salt-tolerant plant species. ICBA has been assembling germplasm of species with proven or potential salinity tolerance to provide a source of genetic diversity to scientists working on problems of salinity in agricultural production systems. To ensure long-term viability and continued availability to the users, the assembled germplasm is conserved in the genebank under controlled environmental conditions and monitored for quality and quantity at regular intervals. Genebank management involves a series of complex and inter-related activities. In order to improve the operational efficiency of the genebank, storage of associated information must be undertaken in a systematic manner using appropriate documentation management systems.

Objectives

- Identify and acquire germplasm of proven or potentially salt-tolerant germplasm.
- Securely conserve and manage the germplasm for continued availability to users.
- Develop an information management system to improve operational efficiency of the genebank.

Achievements in 2006

A total of 483 germplasm accessions of 10 species were assembled from various sources (Table 1). With the new additions, the total number of accessions conserved in the genebank increased to 8853 (Appendix 1, page128).

As a first step in the development of an information management system, a database was created using

Salt-tolerant chickpea in flower

Table 1. Plant accessions procured in 2006

Genus/species	Common name	No.	Source
Atriplex amnicola	River saltbush	1	Kimseed International Pvt Ltd, Australia
A. nummularia	Old man saltbush	1	Kimseed International Pvt Ltd, Australia
A. undulata	Wavy leaf saltbush	1	Kimseed International Pvt Ltd, Australia
Brassica napus	Canola	100	Regional Plant Introduction Station (RPIS), Ames, Iowa, USA
Cajanus cajan	Pigeonpea	137	ICRISAT, Patancheru, India
Cicer arietinum	Chickpea	10	ICRISAT, Patancheru, India
Cyamopsis tetragonaloba	Guar	99	Plant Genetic Resources Conservation Unit, Griffin, Georgia, USA
Helianthus annuus	Sunflower	100	Regional Plant Introduction Station (RPIS), Ames, Iowa, USA
Vigna ungiculatus	Cowpea	23	International Institute of Tropical Agriculture, Ibadan, Nigeria
Asparagus officinalis	Garden asparagus	11	Plant Genetic Resources Unit, Geneva, New York, USA
Total		**483**	

Microsoft Access™ and the existing passport information was exported into a structured data table. Data on the existing seed quantity were recorded, both for the original seed samples and those subsequently multiplied at ICBA, and added to the database.

Data quality improvement work was also initiated and the passport data of about 900 accessions conserved in the genebank were improved for alternate identification numbers, location coordinates and biological status through a search of the Genetic Resources Information Network (GRIN) database of the United States Department of Agriculture (USDA), who donated the material to ICBA.

Proposed activities in 2007

ICBA will continue to acquire germplasm of salt-tolerant plant species. Focus will be on halophytes and salt-tolerant germplasm of vegetable and tree species – these materials are presently under-represented in ICBA's collection. Exploration and collection missions will be undertaken in the Arabian Peninsula for indigenous plant species with potential for biosaline agriculture. The germplasm conserved at ICBA will be monitored for its germination capacity to identify accessions that require immediate regeneration. Data available from salinity evaluation trials will be compiled and added to the database. The genebank information management system will be fully developed for efficient management of the conserved germplasm.

Uzbekistani trainee in the genebank

Regeneration and dissemination of salt-tolerant germplasm (GR02)

DURATION: Ongoing
RESOURCES: Core

SIGNIFICANCE OF THE PROJECT

208 salt-tolerant accessions multiplied; 146 seed samples of 7 species disseminated

Genetic diversity contained in the germplasm collections assembled at ICBA provides the basis to improve economic yields of saline irrigated agricultural systems. However, continued access to the salt tolerant germplasm by researchers and other users requires that adequate seed stocks be maintained. Most often, the seed samples obtained from the donors come in small quantities, therefore, necessitating regeneration. Similarly, regeneration becomes necessary when seed viability of individual accessions declines beyond acceptable limits or the seed quantities fall to critical levels due to distribution to users. Germplasm regeneration is the most critical operation, requiring suitable conditions for growth to maximize seed yields and appropriate pollination control measures like bagging and isolation to minimize any loss in genetic integrity, especially if the species is cross-pollinating.

OBJECTIVES

- Regeneration/multiplication of germplasm accessions, ensuring maximum seed output and minimal loss in genetic integrity.
- Dissemination of salt tolerant germplasm to agricultural researchers and other users.

ACHIEVEMENTS IN 2006

Seed multiplication

Sorghum (*Sorghum bicolor*). Each of the 43 accessions that showed salt tolerance in previous trials were multiplied using standard agronomic practices. All produced seeds.

Pearl millet (*Pennisetum glaucum*). The 29 pearl millet accessions previously selected for salinity tolerance from trials conducted at ICBA were planted for seed multiplication. Because pearl millet is a cross-pollinated crop, genetic purity of individual accessions is maintained by sibbing. Seeds harvested from sibbed panicles

Atriplex *has significant potential for saline environments* were bulked for each accession for conservation and further use.

Wheat (*Triticum aestivum*). Of the 59 Omani wheat landrace accessions planted for seed multiplication, all but one produced seed.

Buffelgrass (*Cenchrus ciliaris*). Seed of 40 promising salt-tolerant accessions were multiplied. All produced seed.

Saltbush (*Atriplex* spp.). Of the 37 accessions of seven *Atriplex* species sown for seed multiplication, 31 germinated, of which 10 flowered and produced seeds by year's end. Plot yield up to 1kg was obtained in one accession (PI 357343) of *A. hortensis*. Flowering and seed setting is progressing in the remaining accessions, which appear to be both biennial and perennial.

Bagging pearl millet heads to prevent cross-pollination

A total of 537 accessions were sown for seed multiplication during November on the ICBA farm. These included 341 newly acquired germplasm accessions: 100 sunflower, 100 canola, 99 guar, 9 pigeonpea, 23 cowpea and 10 chickpea. Also sown were 196 accessions already stored in the genebank: 121 quinoa, 46 barnyard millet, 17 fodder beet and 12 hyacinth bean. Moreover, a set of 73 salt-tolerant germplasm accessions was also sown in November for seed increase: 43 sorghum, 29 pearl millet and 1 barley. The growth was excellent in all crops, except guar, cowpea and barnyard millet.

Canola seed multiplication

In addition to the above, 25 accessions consisting of 20 lupine, 4 hyacinth bean and 1 Omani wheat, which failed to produce seeds in the field grow-outs, were sown in pots in the greenhouse for seed multiplication under controlled conditions. Germination and initial growth of hyacinth bean and wheat was good. The lupines germinated well, but the growth was retarded as the seedlings developed symptoms of nutrient deficiency.

Early flowering sunflower accession

Seed dissemination

A total of 146 seed samples were distributed to Egypt and Tunisia. These included 4 alfalfa, 38 buffelgrass, 4 canola, 1 elephant grass, 3 fodder beet, 29 pearl millet and 25 sorghum accessions to Egypt; and 2 alfalfa and 40 buffelgrass accessions to Tunisia.

Proposed activities for 2007

Germplasm accessions identified with critically low viability and/or low seed quantity (output from GR01) will be regenerated to ensure their continued availability to researchers. Seeds of promising salt-tolerant germplasm accessions (output from GR05) will be multiplied in larger quantities for dissemination to potential users.

Diversity in salt-tolerant buffelgrass germplasm

Germplasm characterization and preliminary evaluation for salinity tolerance (GR05)

Duration: Ongoing
Resources: Core

Significance of the project

Morpho-agronomic characterization and preliminary evaluation for salt tolerance are prerequisite in discriminating between accessions and identifying promising germplasm for further utilization. Morpho-agronomic characterization, which is conducted according to standard international descriptors, is usually undertaken when the accessions are first grown in the field for seed multiplication. Preliminary evaluation for different levels of salt tolerance is conducted in the laboratory and the greenhouse. ICBA has also been collaborating with the International Center for Agricultural Research in the Dry Areas (ICARDA) and other centers of the Consultative Group on International Agricultural Research (CGIAR) in conducting yield trials and observation nurseries of major crops to identify top-performing lines with tolerance for abiotic stresses for further use by the crop improvement programs.

Three observation nurseries and one yield trial of barley from ICARDA were planted

Objectives

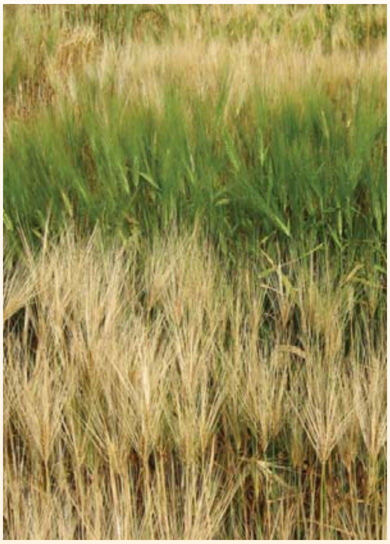
- Discriminate between accessions using morpho-agronomic characterization.
- Identify accessions tolerant of different levels of salinity through preliminary evaluation.
- Contribute to global research by improving productivity of salinity-affected areas.

Achievements in 2006

Three observation nurseries of barley received from ICARDA were planted during winter 2005. These included *Low rainfall areas (mild winter)*, *Moderate rainfall areas* and *International naked barley observation nursery*. One yield trial for *Low rainfall areas (mild winter)* received from ICARDA was also planted. The observation nurseries had 100 entries each, while the yield trial had 24 entries with 3 replications. Irrigation with fresh water and standard agronomic practices were adopted to optimize seed yield. Data were recorded for days to heading, days to maturity, height, lodging, susceptibility to leaf rust and grain yield and sent to

ICARDA. Seeds harvested from 36 promising lines were stored in the genebank to further evaluate for salinity tolerance.

In 2006, ICBA received seeds of three observation nurseries from ICARDA. These included *Barley low rainfall areas (mild winter) nursery* (100 entries), *Chickpea elite nursery* (35 entries) and *Lentil drought tolerance nursery* (29 entries). In addition, a mini-core collection of pigeonpea consisting of 132 accessions, representing the genetic diversity in the global collection, was received from International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) to evaluate for adaptation and salinity tolerance. All the samples were planted in mid-November. Germination and initial growth were good in all crops.



Differences in maturity of barley

PROPOSED ACTIVITIES IN 2007

Data on plant characteristics such as days to flowering/maturity, plant height and grain yield will be collected from the observation nurseries received from ICARDA. The best-performing lines will be identified for subsequent experimentation. The newly acquired sunflower, guar, cowpea, canola and pigeonpea accessions (Table 1) will be evaluated for tolerance for different levels of salinity using *in vitro* or hydroponic screening methods.

Lentil plot at ICBA farm

Production and Management Systems Program

Sustainable land and water use

Demonstration of biosaline agriculture in salt-affected areas of Bangladesh (PMS09)

Duration: 2003-07
Collaborator: Bangladesh Agricultural Research Institute (BARI)
Resources: BARI, Restricted Core

Significance of the project

Bangladesh is a developing country with a population of 140 million. To meet the food demands of the increased population, salt-affected lands estimated at 0.88 million hectares must be brought under cultivation.

The average annual rainfall in various parts of Bangladesh is 3,000 mm. Most of this precipitation occurs during the monsoon season, which begins in June. During the driest months of March and April, salinity problems resulting from seawater intrusion are acute and lands are commonly left fallow because crop production is inhibited.

Economic cash crops in Bangladesh – tomato, watermelon, cucumber and chili – can be grown with proper management of soil and water. One such technology is the use of drip irrigation on raised beds. This combination permits proper leaching of salts from the root zone.

Farmers showed keen interest in applying the demonstrated technologies

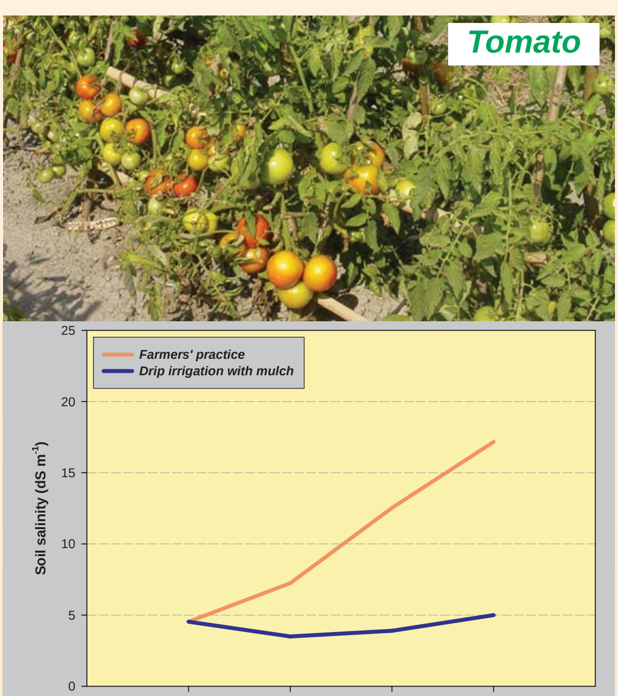


Figure 1: Farmers' practice vs drip irrigation with mulch in tomato

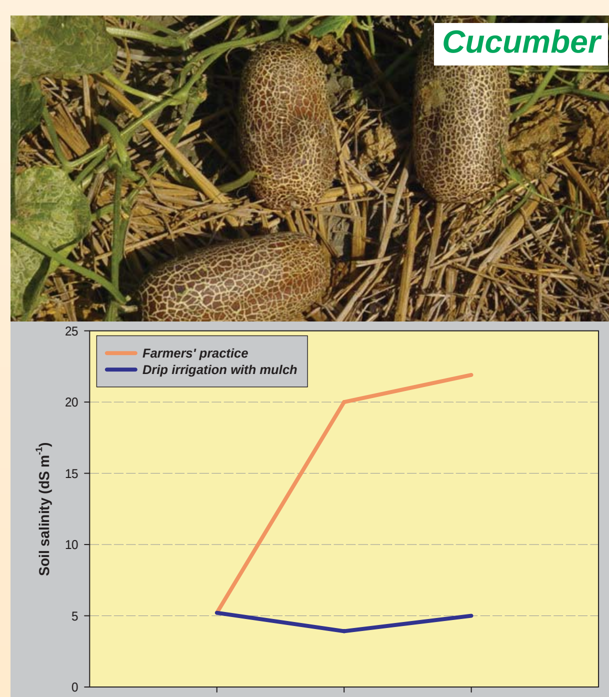


Figure 2: Farmers' practice vs drip irrigation with mulch in cucumber

Objectives

- Grow crops using drip irrigation on raised beds, and compare yield and soil salinity results against common agricultural practices.
- Convert yield data into economic returns and evaluate overall economics.
- Demonstrate the results to the farmers and non-governmental organizations (NGOs) during field days.

Achievements in 2006

Field experiments were conducted to evaluate the performance of tomato, chili, watermelon and cucumber under different irrigation management techniques in the saline soils of Charmajid, Noakhali district, during the dry season. The farmers' traditional practice, plantation in flat beds without irrigation or mulch, represented the control treatment. Results from the traditional practice were compared with irrigation treatments using traditional pitcher/can irrigation in raised beds with mulch, and drip irrigation in raised beds with and without mulch. The dripper discharge was maintained at 4.6 L h^{-1}. Rain-harvested water with an average EC of 0.48 dS m^{-1} was used for drip irrigation.

Rainwater harvesting provides a reliable source of irrigation water during the dry season. The ponds where water is stored can also be used for aquaculture. During 2006, pond water utilization analysis was done for a pond with a surface area of 0.43 ha and 3.5 m depth to

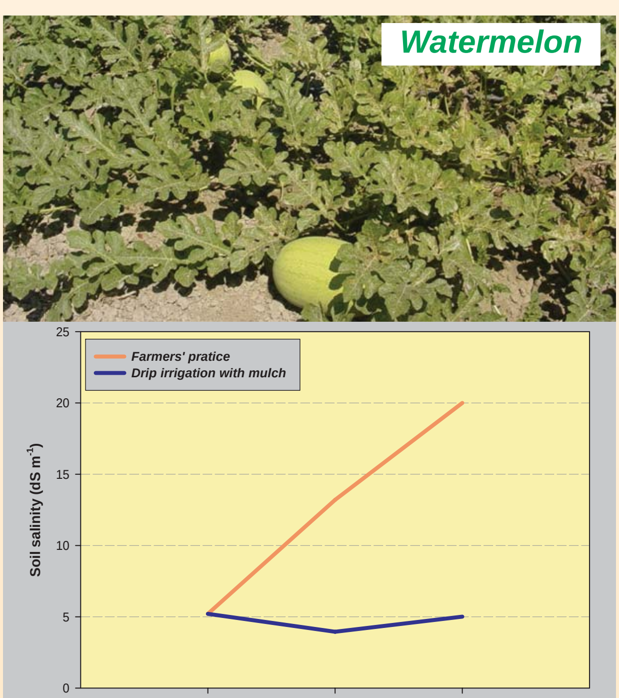


Figure 3: Farmers' practice vs drip irrigation with mulch in watermelon

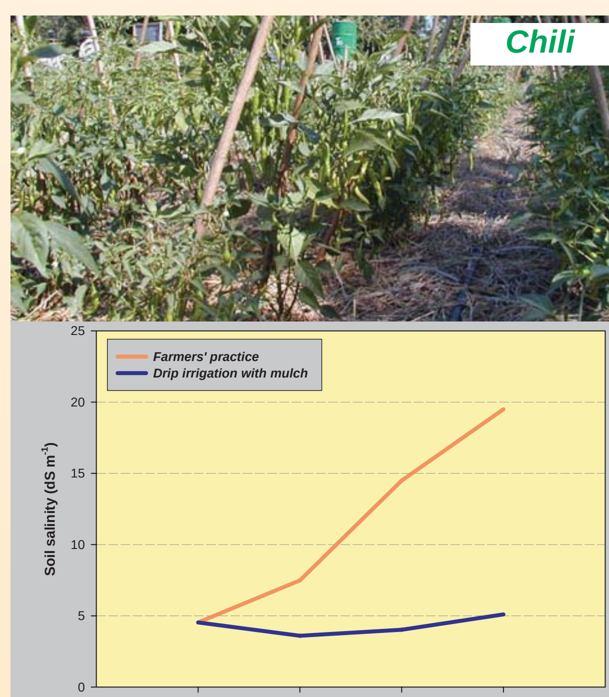


Figure 4: Farmers' practice vs drip irrigation with mulch in chili

irrigate 0.6 ha of the tested crops. The estimated benefit-cost ratio (BCR) of using such a pond was 3.74 for tomato, 3.10 for watermelon, 2.45 for cucumber and 1.57 for chili.

Drip irrigation with mulch/raised bed saved 32-41% of irrigation water over the traditional pitcher/can irrigation technique for the tested crops. The use of mulch alone in drip irrigation saved 20-25% water.

Field day for farmers

Drip irrigation in raised bed with mulch treatment produced 59 t ha^{-1} of tomato, an increase of about fourfold over the control treatment. The BCR was 4.71 using drip irrigation treatment. Tomato yield using the control treatment was 15 t ha^{-1} and the BCR was 2.79. In case of watermelon, the yield was 55 t ha^{-1} and the BCR was 4.14 under raised bed with drip irrigation. For the control plot, the corresponding values were only 12 t ha^{-1} and the BCR 1.64. Cucumber cultivation also showed positive results (42 t ha^{-1} and the BCR 3.28) under similar drip irrigation treatment. Chili cultivation generated the lowest BCR (2.00) among the crops tested.

In comparison with farmers' traditional practices, drip irrigation with mulch reduced soil salinity by 71% for tomato, 74% for chili, 77% for watermelon and 75% for cucumber during March, the driest month of the growing season (Figures 1-4).

A Field Day was held on 20 March to demonstrate the research results. About 100 farmers participated along with government and NGO officials. Farmers showed keen interest in applying the demonstrated technologies.

Proposed activities for 2007

In the upcoming dry season (December 2006 to March 2007), field demonstrations of cash crops will continue on farmers' fields. A Field Day is planned early in the year. Considering the project will be completed in June 2007, a project proposal for Phase II will be developed.

Feasibility study for biosaline agriculture in the UAE (PMS32)

Duration: 2004-06
Collaborator: Ministry of Environment and Water (MOEW)
Resources: International Atomic Energy Agency (IAEA), MOEW, Core

Significance of the project

As a follow-up of IAEA activities related to sustainable utilization of saline groundwater and wastelands for plant production, ICBA and MOEW prepared a strategic document for the UAE which was approved by IAEA. A Feasibility Study entitled *Biosaline agriculture in the UAE* was then prepared. The outcome of this report will serve as a guideline to prepare the national program for the UAE, and will identify the gaps for information currently available.

Abandoned agricultural farms can be brought back into production through biosaline agriculture

Objectives

- Compile existing farm data and filling the gaps on (a) the extent of saline water resources and salt-affected agricultural areas; (b) farm facilities, including equipment and irrigation/drainage systems; and (c) cropping patterns and marketing strategies.
- Update existing data on soil and water quality and quantity.
- Prepare guidelines for the national program document.

Achievements in 2006

ICBA and MOEW completed the report on the feasibility of biosaline agricultural production. The report also identified the gaps related to low productivity, especially those related to soil and water. It was observed that the farmers, extension staff and the ministry do have sufficient information both on quality and quantity of water to identify areas where salinity is a problem and which production systems will work. However, information related to soil properties (particularly soil salinity) is lacking. Nevertheless, all available information has been compiled and is currently under review. An additional component of socio-economic study is added to the report to assess current and future trends for proposed biosaline agriculture systems. The outcome of this report will serve as a baseline to identify the gaps and prepare a national program on biosaline agriculture for the country.

Proposed activities for 2007

The report will be completed in 2007 and the information will be shared by ministries, municipalities, universities and research and development institutes for formulating a national plan for the UAE.

Biosaline Agriculture Development Program at the NPC Site, Al-Laith, Saudi Arabia (PMS33)

Duration: 2004-08
Collaborator: National Prawn Company (NPC), Saudi Arabia
Resources: NPC

Significance of the project

Seedlings raised and acclimatized with return seawater

NPC is the largest prawn farming company in the region with an annual production of 10,000 tons. The facility is located on the Red Sea coast in Al-Laith, about 450 km from Jeddah. Seawater is pumped at a flow of 80 m^3 per second to the shrimp ponds and the return water is discharged into a drainage canal which carries it back to the sea. This water, which contains a significant load of nutrients and organic residue from the prawn farming activities, has the potential for use in agricultural production as well as coastal rehabilitation. Moreover, a nearby lagoon has potential for rehabilitation with local mangrove species (*Avicennia marina*) along the inner shores. This area, which extends to about 40 km, can be used as a hatchery for fish and shrimps.

10,000 seedlings will be propagated and transplanted annually

NPC and ICBA signed a memorandum of understanding (MoU) in 2004 for collaboration. The agreement stated that ICBA would provide germplasm for plants that could be cultivated with the return water and demonstrate the viability of growing them for both environmental and economic reasons.

Objectives

- Utilize return seawater for the production of halophytes for forage, environmental beautification, biomass energy and organic fertilizers.
- Expand mangrove plantation at the barrier island and the return water canal.
- Investigate halophytes that can be grown as ground covers for erosion control of dikes.

Achievements in 2006

During 2004 and 2005, ICBA provided about 7,500 seedlings of shrubs and trees in addition to mother stock (about 76,000 seeds) of many salt-tolerant grass species. Based on the guidelines provided by ICBA scientists, NPC prepared an area of 4 ha for plantation and infrastructure for a shadehouse and an irrigation system.

The ICBA team continued its periodic visits to the site during 2006

In 2006, ICBA scientists commissioned the irrigation system and started planting seedlings in the field, for use mainly as windbreaks. In addition, they transplanted several grass species in plots and trained NPC staff to propagate the plant species in the shadehouse. However, due to very strong sandstorms during the April-August period, further transplantations were delayed. When transplanting resumed, it was observed that *Conocarpus* and *Salvadora* spp. were sufficiently sturdy to protect other species inside the area.

Salt-tolerant grasses thriving on saline water

NPC staff germinated a large number of mangrove seeds collected from the coastal plantations. These seedlings were acclimatized under different salinity conditions and currently kept in the shallow water of the lagoon at high salinity levels.

During November, ICBA staff visited NPC to discuss strategies for protecting the area from sandstorms and also for gradually planting the area during the next twelve months. NPC also agreed to extend the project period and its collaboration with ICBA for the next 2 years. The current agreement will be renewed shortly.

Proposed activities for 2007

Three major activities will be undertaken in 2007. The first relates to mangrove plantation, the second to windbreaks in the demonstration plot and the third to the propagation of seedlings and their screening at various salinity levels.

NPC will acquire satellite images of the lagoon area to identify the gaps where mangrove species can be planted. It is envisaged that about 10,000 seedlings will be propagated and transplanted annually. The work should be completed in 5-6 years.

ICBA proposes to increase windbreak plants to protect the 4-ha demonstration area. These plantings will be undertaken from November 2006 to November 2007. ICBA scientists will visit the site in April and November to assess progress. During that period, other shrubs and grasses will be transplanted within the area.

NPC staff will continue propagating seedlings as suggested by ICBA scientists. During the year, screening facilities will also be built in a new shadehouse where seedlings of plant species provided to NPC will be tested at salinity levels of 8, 16, 24 and 40 ppt (11.5, 23, 34 and 57 dS m^{-1}).

Several tree species survived the sandstorms

Soil Survey for the Emirate of Abu Dhabi (PMS36)

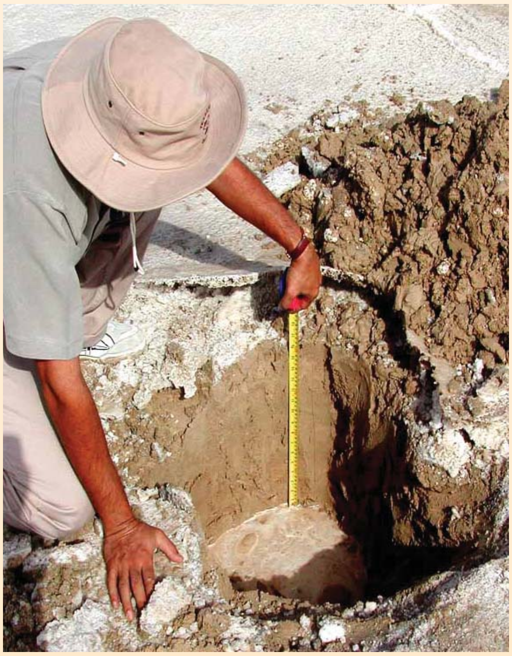
Duration: 2005-09
Collaborator: Environment Agency-Abu Dhabi (EAD)
Contractor: GRM International, Australia
Resources: EAD, Core

Significance of the project

Soil is a vital part of the environment and plays a key role in environmental interaction, linking the atmosphere, water resources and land use. Protecting the activity of the soil to support agriculture, forestry, wildlife and other uses is important in conserving the environment and promoting the national economy. Understanding the capabilities and limitations of this resource is crucial for sustainable and profitable development. In some parts of the world where fertile soils and plentiful water are taken for granted, efficient agricultural production can be conducted with little effort. Because of its geography and climate, however, the Emirate of Abu Dhabi lacks an abundance of these resources.

Managing diversity of soils ensures sustainable land use

To determine the nature of the soil resource and how it can best be utilized, Environment Agency-Abu Dhabi (EAD) and ICBA are jointly implementing the Soil Survey Project through GRM International Pty Ltd, a multinational company. The data obtained from the survey will be of immense value to potential land users who require information about soil and water resources. These data, which are obtained in an environmentally beneficial and cost-effective manner, will be used for a number of purposes, including master planning, environmental monitoring, environmental impact assessment, soil conservation, farming and land resource management.



Measuring soil levels

Objectives

- Conduct a survey of the Emirate at a 1:100,000 scale.
- Conduct a survey of 400,000 ha for agricultural expansion on a scale of 1:25,000.
- Publish soil, current land use, land degradation, soil salinity, vegetation and other thematic maps at various scales.

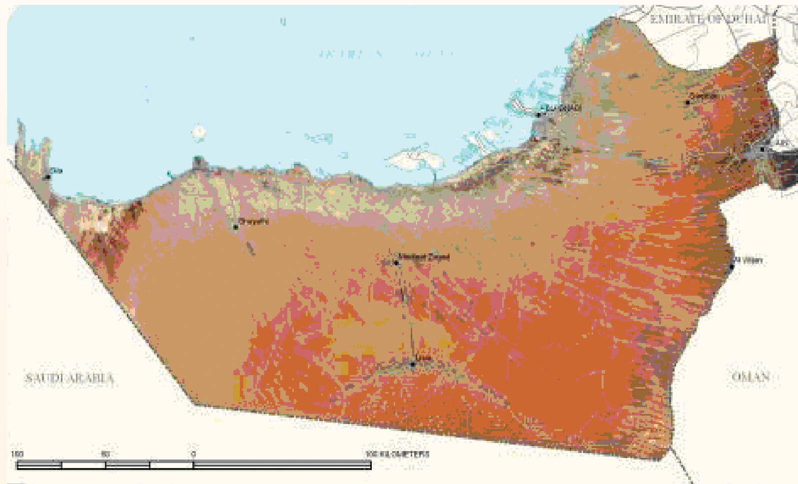
- Develop a Soil Database Management System within a Geographic Information System (GIS) environment.
- Establish a soil reference collection.
- Build capacity of UAE nationals.

ACHIEVEMENTS IN 2006

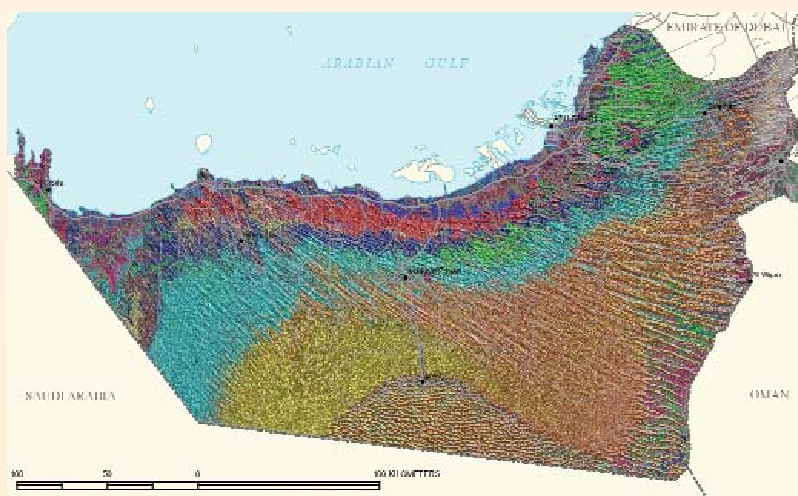
Meeting its obligations as specified in the Memorandum of Agreement, which was signed between EAD and ICBA in April 2005, ICBA prepared a Project Agreement Document. This document was signed on 25 April 2006 by EAD and the contractor, GRM International Pty Ltd, in the presence of ICBA. GRM is hosted at ICBA's expanded office in Abu Dhabi, where the necessary facilities are established to implement the project activities.

Following completion of a preliminary soil super class map at a 1:500,000 scale in August, a full-scale field survey was initiated in November. By the end of the year, a great deal had been accomplished.

- 3,781 sites investigated.
- 30 soil map units and 29 soil families recognized.
- 0.99 million ha (18% of the survey area) covered.
- Advanced soil quality criteria and thematic maps for broad land use statements had been initiated.
- Land uses in the Emirate identified.
- Central Laboratory Unit at the UAEU selected for bulk laboratory analysis.
- US Department of Agriculture and Western Australian University nominated as quality assurance laboratories.



Landsat ETM bands 3,2,1 used to create false color image. This is an approximation of what the Emirate would look like from space. (Courtesy GRM International)



Spectral classification of Landsat ETM bands 1-5 and 7 underlain by filtered SRTM digital elevations model. Using a combination of different imagery and special analysis, the variability in the soil can be emphasized. (Courtesy GRM International)

- 50 soil samples analyzed.
- The soil archive became operational and held 70 samples.
- The EAD/ ICBA/GRM team met with potential stakeholders to ensure that the Soil Information System will meet their needs.
- Vision and scope document of the Abu Dhabi Soil Information System (ADSIS) finalized.
- Geodatabase Model, Soil Information System/Soil Database Management System and Remote Sensing reports completed.

The project produces a monthly newsletter call Soil Alert

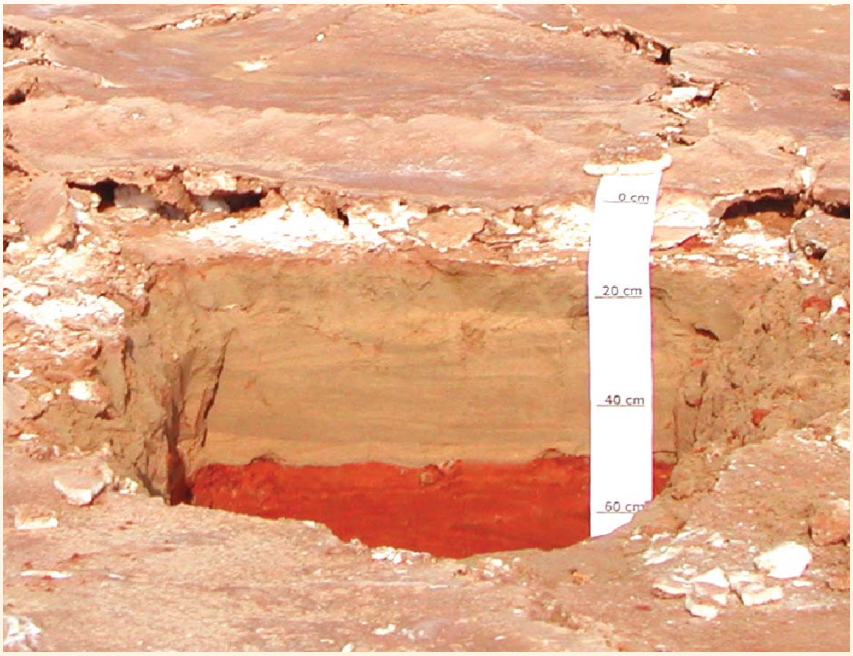
- Tentative program for capacity building of UAE nationals prepared.
- The first training course, *Soil survey concepts and framework*, held for 17 participants at ICBA headquarters 11-15 February.

Proposed activities for 2007

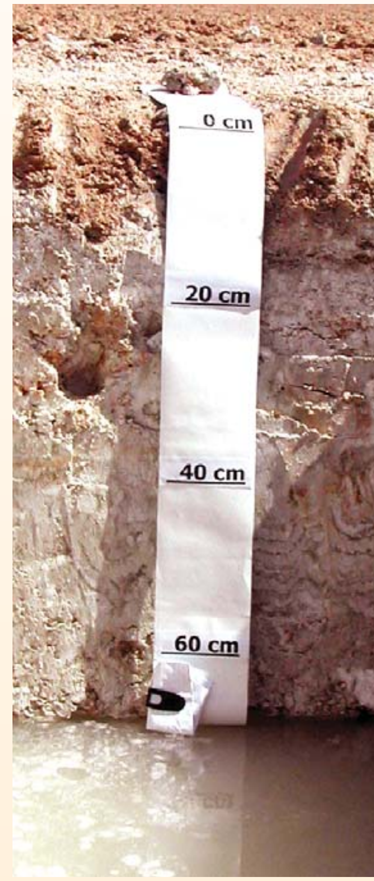
ICBA will continue to supervise and manage the project. Field work for an extensive survey at a scale of 1:100,000 will be completed and the soil database updated. EAD/ICBA staff will continue quality assessment exercises on various technical tasks. The deep drilling, infiltration and penetration resistance activities and associated reports will be completed.

An area covering 1 million ha with potential for irrigated agriculture will be identified. A field survey of 400,000 ha of this area will commence at

The EAD-ICBA-GRM team



The unique soils of Abu Dhabi have never previously been surveyed



a scale of 1:25,000. Soil, thematic, vegetation, land degradation, salinity and current land use maps will be prepared at appropriate scales (eg, 1:500,000; 1:250,000; 1:100,000). Three quarterly progress reports and one interim report will be prepared. UAE nationals will receive on-the-job training during the second training workshop on *Laboratory techniques in soils* at ICBA.

Soil analytical resources upgraded

In addition to the achievements listed above, ICBA has made significant strides in upgrading its capacity to analyze soils. Technological advances at ICBA headquarters will facilitate its work on soil, agricultural and environmental studies. ICBA's laboratories provide immediate analytical services, thus making the Center independent of external labs.

The soil laboratory is capable of handling large numbers of soil and water samples. It is equipped to analyze soil salinity; carbonate equivalents and gypsum; solution chemistry (Na, K, Ca, Mg, CO_3, HCO_3, Cl, SO_4); nutritional aspects (N, P, K, Fe, Cu, Mn, Zn, Mo, Si, Ti, B and Pb); and physical aspects (particle size distribution). During 2006, lab facilities were improved by adding new equipment such as a tension infiltrometer, a calcimeter, a flame photometer, a mechanical sieve shaker, a centrifuge machine, a muffle furnace, EC and pH meters and ovens.

Field salinity can be monitored through an EM38 and a state-of-the-art Real Time Dynamic Automated Salinity Monitoring System under gield conditions. A time domain reflectometer, a neutron probe, a double ring infiltrometer, a Guelph permeameter and tensiometers are used for field testing.

Field and Forage Crops

Optimizing management practices for maximum production of two salt-tolerant grasses (PMS03)

Duration: 2002-06
Collaborator: UAEU
Resources: Core

Highlights

- *In its fourth season, dry matter yield of* Distichlis *ranged from 10.0 to 16.2 t ha^{-1} per harvest. Two harvests were completed in 2006.* Sporobolus *dry yield varied between 8.7 to 16.5 t ha^{-1} per harvest. Mean annual dry matter production of* Distichlis *and* Sporobolus *reached nearly 26.07 t ha^{-1} and 25.8 t ha^{-1}, respectively.*
- *Maximum dry matter production of both species was highest at the high fertilizer rates (NPK equivalent to 60 units of N and 30 of P and K).* Distichlis *yield reached 24.8 t ha^{-1} and* Sporobolus *28.3 t ha^{-1}.*
- Distichlis *produced maximum dry matter at high fertility and irrigation levels.* Sporobolus *produced maximum dry matter at high levels of fertility but medium levels of irrigation.*
- *Mineral content (expressed as ash %) stayed consistently within acceptable ranges despite the high salinity of irrigation water. In both species, it ranged from 9 to 12%. Crude protein content increased significantly with increased salinity and fertility levels in both species.*
- *Feeding trials on sheep and goats using different ratios of the two grasses against Rhodes grass showed that animals fed on 70%* Sporobolus *or* Distichlis *performed much better than animals fed on conventional forages or other mixtures of the two groups.*

Significance of the project

Information on the long-term field studies on sustainable and economically feasible forage production systems using non-conventional salt-tolerant grasses and highly saline water are very limited globally, and virtually non-existent in the UAE and the Middle Eastern region.

Harvesting Distichlis spicata

Two highly salt-tolerant grass species, *Sporobolus virginicus* and *Distichlis spicata*, were selected for studies of such forage production systems. These species were selected based on previous evaluation of their salinity tolerance, nutritional value, and suitability for mechanical harvesting and handling for large-scale production. Each species was planted in a large field at the ICBA farm on 0.6 ha using split-plot technique with randomized complete blocks and three replications.

Objectives

- Determine yield potential of the two grasses when grown under high salinity levels, and the level at which the productivity remains economical.
- Determine the optimal irrigation level for maximum production of the two grasses, and the levels that minimize salt accumulation in the soil.
- Determine appropriate fertilizer regime for maximum production.
- Assess the nutritional value of the two species in response to the different salinity, irrigation and fertilizer levels.

Achievements in 2006

The harvesting program followed a pattern similar to that of 2005 and was adjusted to reflect actual field growth at certain times of the year. Two harvests were completed in 2006. Dry matter yield of both *Sporobolus* and *Distichlis* in each cut was in the range of 8-17 t ha^{-1}.

Laboratory analyses were carried out for soil samples to monitor physio-chemical properties of the soil. In addition, plant samples from the 12th cut (of a total of 14 during 2006) were also analyzed in collaboration with UAEU and Abu Dhabi Agricultural Laboratory to determine the forage quality and nutritional values.

On all figures in this project:

IR = Irrigation treatment
- IR1: 1.0 x ET_0
- IR2: 1.5 x ET_0
- IR3: 2.0 x ET_0

ST= Salinity treatment
- S1: 10 dS m^{-1}
- S1: 20 dS m^{-1}
- S1: 30 dS m^{-1}

ET= Evapo-transpiration

FT= Fertilizer treatment (NPK + urea to make the following):
- F1: 0 NPK
- F2: NPK equivalent of 20:10:10
- F3: NPK equivalent of 40:20:20
- F4: NPK equivalent of 60:30:30

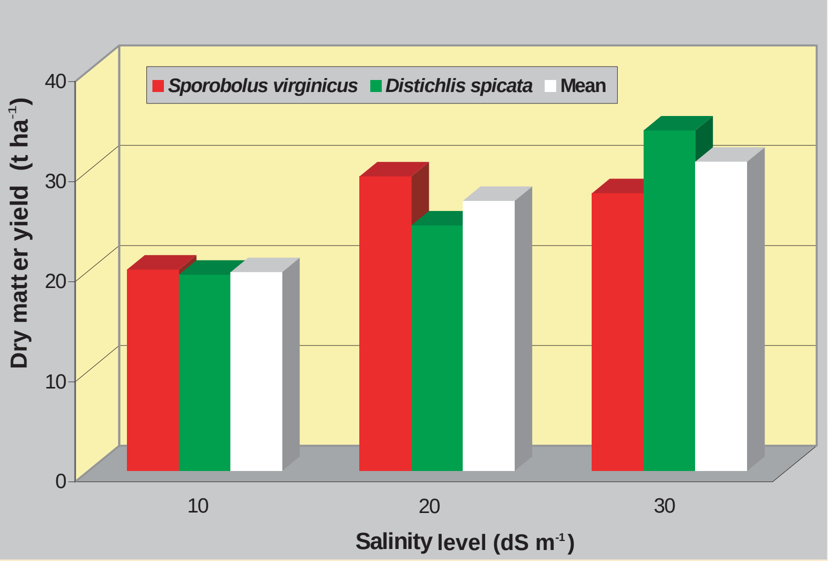


Figure 5: Total field dry matter production of *Sporobolus* and *Distichlis* at 3 salinity levels over two harvests

Based on the data collected so far, it is concluded that maximum dry matter yield is achieved at higher levels of fertilizer and irrigation in *Distichlis* and by high levels of fertilizer and medium levels of irrigation in *Sporobolus*.

Results indicate that both *Sporobolus* and *Distichlis* can be extremely productive under saline irrigation and that the quality of the forage is almost equivalent to that of green barley when managed appropriately.

Major findings of the study were widely presented and publicized at local, regional and international levels through media, special articles, symposia and workshops. *Sporobolus*, *Distichlis* and *Atriplex* shrubs were also transferred to several national agricultural research systems (NARS) and farmers in the region.

Results

Dry matter production

Highlights of dry matter production of both species in relation to various salinity, irrigation and fertilizer levels are presented in Figures 5-11. Based on two cuts in 2006, dry matter production was similar to that of 2005.

Distichlis yield increased with the increase in salinity level up to the highest average

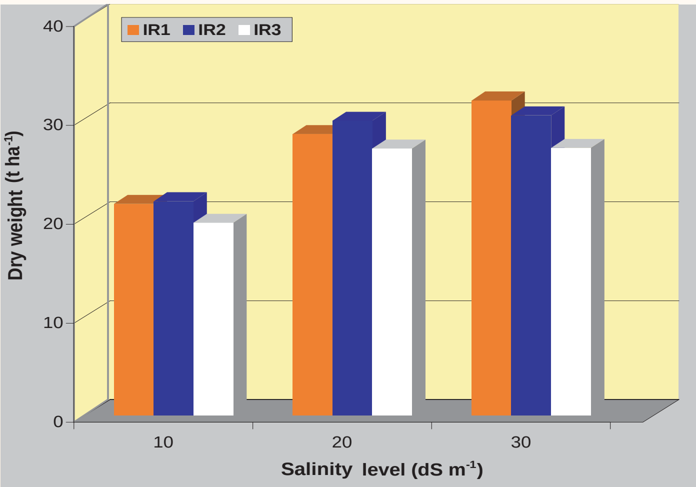


Figure 6: Effect of salinity and irrigation levels on the dry matter production of *Sporobolus*

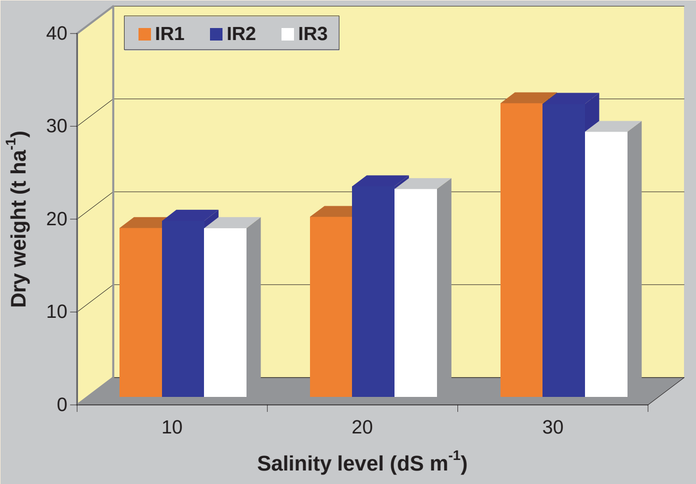


Figure 7: Effect of salinity and irrigation levels on the dry matter production of *Distichlis*

Distichlis *can be irrigated with the salinity equivalent of seawater* salinity of irrigation water (25-30 dS m^{-1}), reaching more than 34 t ha^{-1}.

Sporobolus yield was highest at the medium salinity level (20 dS m^{-1}), reaching 29.5 t ha^{-1} (Figure 5).

Summer growth (September harvest) was generally higher than other growths in both species. *Sporobolus* yield generally increased with increase in irrigation quantity at low and medium salinity levels, whereas at high salinity levels yield declined with the high irrigation level (2 ET_0) (Figure 6).

In *Distichlis*, yield increased with increased irrigation levels at all salinity levels (Figure 7).

The relation between fertilizer level and yield at different combinations of salinity and irrigation levels (Figures 8-11) clearly showed that *Distichlis* yield increased up to medium fertility levels and remained stable afterwards under all levels of salinity and irrigation. In *Sporobolus*, higher yields were achieved at high fertility levels, particularly under the lower irrigation levels. Similar trends were observed in previous seasons.

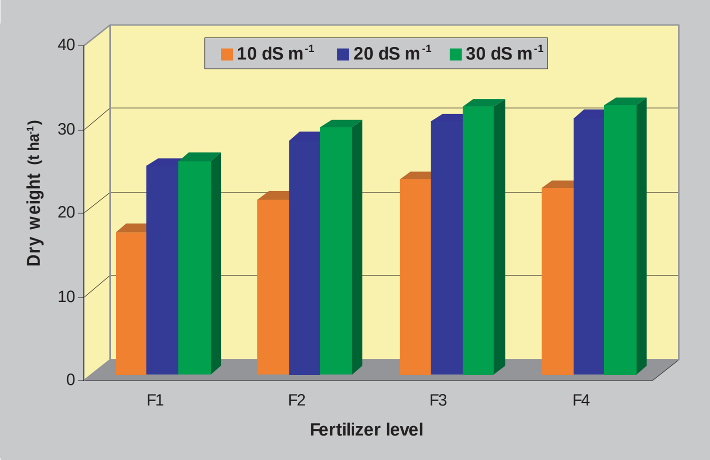


Figure 8: Effect of salinity and fertlizer on dry matter production of *Sporobolus*

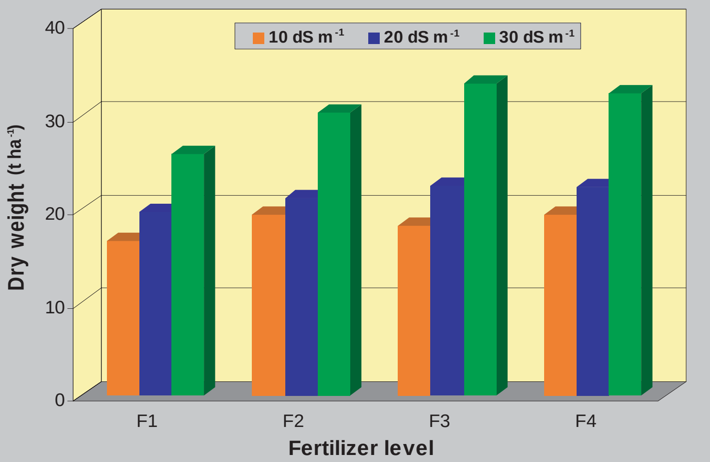


Figure 9: Effect of salinity and fertlizer on dry matter production of *Distichlis*

Goat feeding trials at UAEU

Chemical analysis and nutritional value

Consistently over several analyses performed during the last three seasons, both *Sporobolus* and *Distichlis* showed very acceptable ranges of ash content, even at very high salinity levels (Figures 12 and 13). Such a trait made the two species, unlike many other halophytes, suitable for animal feed even at high consumption rates. Protein content was moderate and comparable to conventional forage grasses like barley. Higher protein percentages (7-8 %) were reached at combinations of high fertility and salinity levels (Figures 14 and 15).

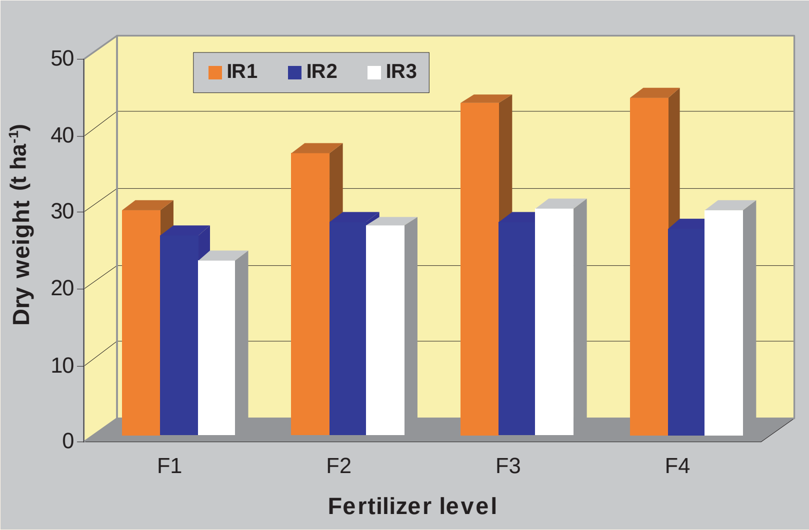


Figure 10: Effect of fertlizer and irrigation levels on dry matter production of *Sporobolus*

Feeding trials on sheep and goats

Harvested *Sporobolus* and *Distichlis* plants have been used simultaneously and continuously in animal feeding trials at UAEU. Several feeding trials on indigenous and exotic sheep and goats were performed.

Feeding trials consisted of five treatments.

1. 0% salt-tolerant grasses (*Sporobolus* or *Distichlis*) and 100% conventional forage grass *Chloris gayana* (Rhodes grass).
2. 30% salt-tolerant grasses + 70% Rhodes grass.
3. 50% salt-tolerant grasses + 50% Rhodes grass.
4. 70% salt-tolerant grasses + 30% Rhodes grass.
5. 100% salt-tolerant grasses.

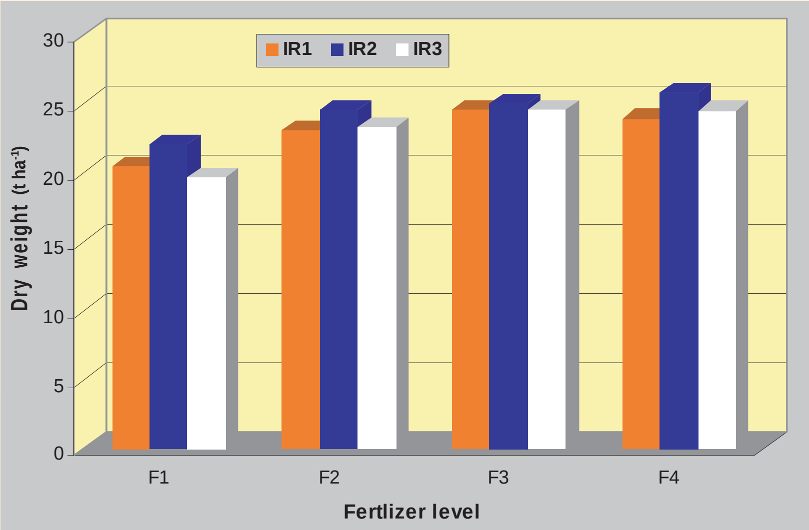


Figure 11. Effect of fertlizer and irrigation levels on dry matter production of *Distichlis*

The following experiments were completed.

- Growth performance of local sheep fed *Sporobolus.*
- Growth performance and body composition of fattening local goats fed *Distichlis.*
- Effect of long-term feeding of *Sporobolus* on growth performance of Awassi sheep (exotic breed).
- Growth performance and body composition of fattening local sheep fed *Sporobolus.*
- Effects of feeding *Sporobolus* on growth and reproduction of Awassi sheep (18-month trial).

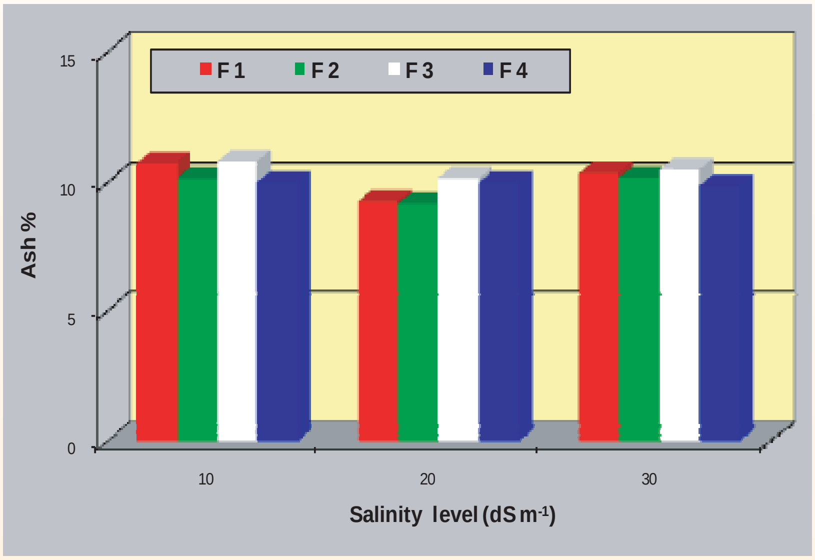


Figure 12: EEffect of salinity and fertility levels on ash content of *Sporobolus*

Highlights of feeding trials

- Animal performance was closely monitored, including feed intake, water consumption, feed conversion ratio, growth, reproduction, slaughtering characteristics and some indicative physiological and biochemical parameters.
- No health problems were observed in any treatment group throughout the study.
- Animals fed 70% *Sporobolus* or *Distichlis* performed much better than animals in the other groups (Figure 16).
- Average daily gain did not differ significantly (P>0.05) between the two groups at any stage.
- No significant difference (P>0.05) was observed between birth weight of dams and those of their offspring in both treatment groups.

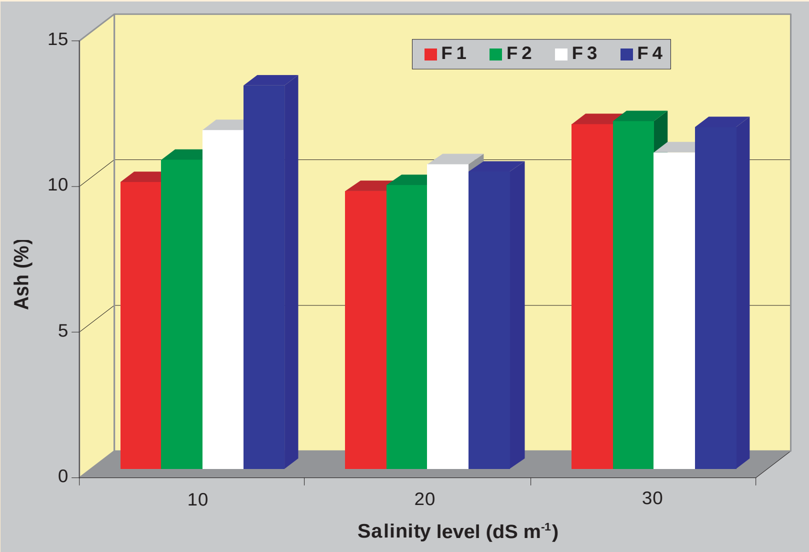


Figure 13: Effect of salinity and fertility levels on ash content of *Distichlis*

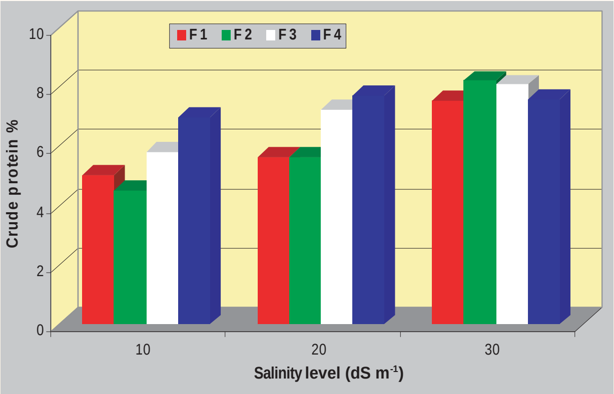


Figure 14: Effect of fertility levels on crude protein (CP) of *Sporobolus*

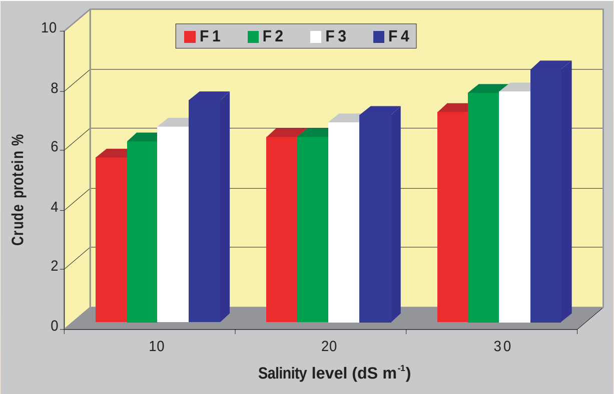


Figure 15: Effect of fertility levels on crude protein (CP) of *Distichlis*

- Animals fed the salt-tolerant forages consumed 20% more forage than the control group.
- Body composition and meat-fat-bone ratio were better (or similar) in animals fed 70% salt-tolerant forages than in animals fed 100% conventional forages (Figures 17 and 18).
- Feeding sheep on *Sporobolus* forage did not impair fertility or normal reproductive processes (circulating estradiol and progesterone hormones, conception rate and normal live birth of lambs).

Based on the results obtained after more than 14 harvests, the production packages of the two species under high saline conditions are now well defined. The package so far includes:

- Mass propagation of the two grasses.
- Field establishment.
- Suitable irrigation system.
- Irrigation and soil management.
- Cutting program.
- Fertilizer levels.
- Harvest and baling.
- Feeding ratios and impact on animals.

Economic evaluation of the package is under way at both the ICBA farm and in farmers' fields in Oman and the UAE.

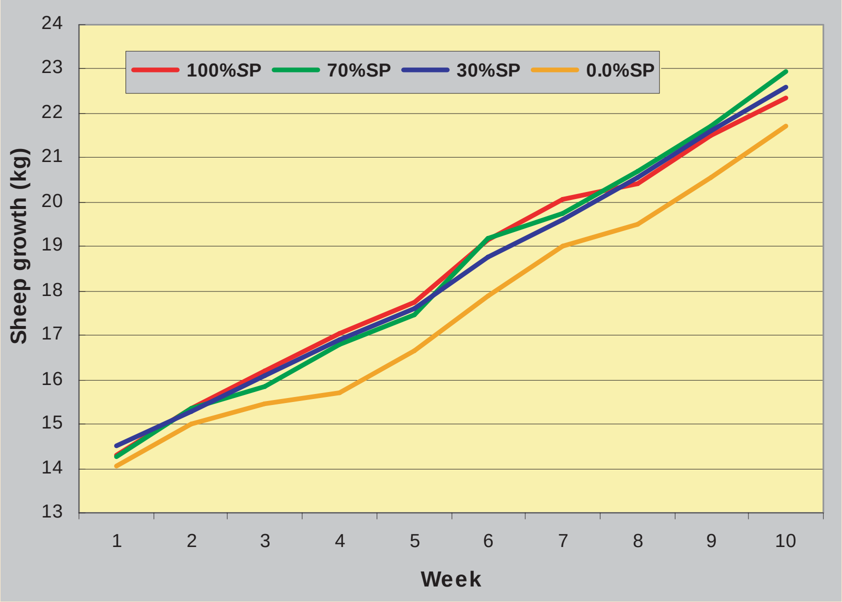


Figure 16: Comparison of sheep growth under different feeding trials with *Sporobolus* (SP) of local race from UAE

Both Sporobolus and Distichlis can be extremely productive under saline irrigation

PROPOSED ACTIVITIES FOR 2007

It is expected that after four full seasons, the cumulative effect of applying various treatments will lead to clear and solid conclusions on the effect of salinity, fertilizer and irrigation on plant production. The overall performance of two species under various salinity levels under optimal management practices will lead to maximum and sustainable yields. At project completion, improved management strategies to further increase yield will be identified, and the two grasses will be transferred to a large number of selected farmers' fields in the WANA region.

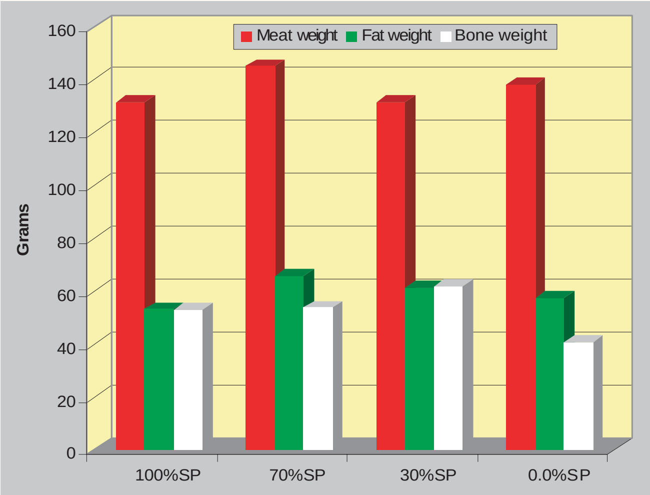


Figure 17: Compositions of the 9th, 10th and 11th ribs

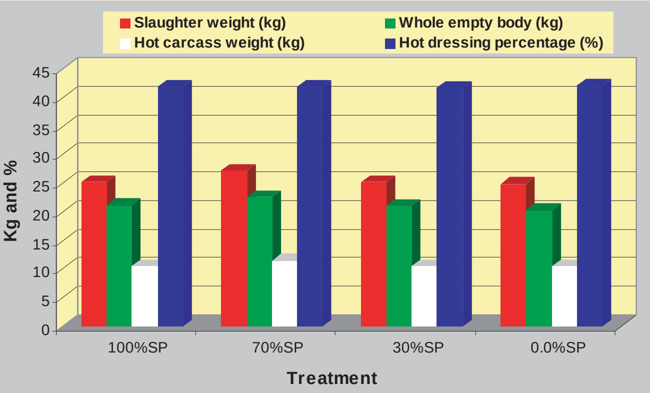


Figure 18: Means for body compositions

High growth of Sporobolus *at the high salinity level*

Optimizing management practices for maximum production of three *Atriplex* species under high salinity levels (PMS04)

Duration: 2002-06
Collaborator: United Arab Emirates University (UAEU)
Resources: Core

Highlights

- *As in previous seasons,* Atriplex lentiformis *produced the highest green matter in comparison with* A. nummularia *and* A. halimus*.*
- *Yield increased linearly with increase in number of plants per unit area (planting density). Total harvestable biomass was higher at the medium salinity level. At 20 dS m^{-1}, the fresh yield of* A. lentiformis *reached nearly 25.05 t ha^{-1},* A. nummularia *16.9 t ha^{-1} and* A. halimus *14.6 t ha^{-1}.*
- *Biomass production had a negative relationship with irrigation levels. Maximum yield of 23 t ha^{-1} was obtained with minimum irrigation application.* A. nummularia *produced maximum yield at medium irrigation level.*
- *Ash content was very high in* A. halimus *and* A. nummularia *(42.9%) over three salinity levels. Maximum ash content was measured at the medium salinity level.* A. lentiformis *produced the highest ash content with the combination of medium salinity and irrigation of both factors.*
- *Crude protein content of both* A. halimus *and* A. nummularia *was 10.2% – higher than* A. lentiformis*. The maximum protein content was produced at low salinity levels.*
- *As expected, animals fed on pure* Atriplex *performed poorly and had the lowest growth rates. Animals fed the conventional Rhodes grass had the highest growth rate. Surprisingly, however, the 50:50 mixes of* Atriplex *and* Sporobolus *led to growth comparable to that of Rhodes grass.*

Significance of the project

Atriplex is well known for its salt tolerance and value as a high-protein animal feed. However, animals do not thrive if fed solely on *Atriplex* because it contains high concentrations of mineral salts. A mixture of salt-tolerant grass and shrubs can provide a balanced diet.

This project is also focused on the assessment of potential production, feasibility and long-term sustainability of forage production systems based on salt-tolerant forage shrubs.

Objectives

- Determine yield potential when grown under high salinity.
- Determine the level at which the productivity remains economical.
- Determine optimum irrigation level for maximum production and minimum salt accumulation in the soil.
- Determine the optimum plant density for maximum production under all salinity levels.
- Determine the appropriate fertilizer regime for maximum production.
- Assess nutritional value in response to different salinity, irrigation and fertilizer levels.

Atriplex *tolerates high salinity*

Achievements in 2006

Progress was judged on the basis of plant growth and soil salinity. All treatments were applied according to the previous schedule and method. Soil and plant samples were collected for laboratory analysis. Plant samples were analyzed for chemical composition and nutritional values. Feeding trials were also completed in 2006. To meet the demands for continued supply of *Atriplex* for the feeding trials, cutting program was adjusted to accommodate this need. Twice a week a number of plants were cut and delivered to UAEU in Al Ain for sheep and goat feeding. By the end of the experiment period, total plant biomass harvested each week was totaled to obtain total annual biomass production.

Results

Growth and biomass production

Effects of salinity, irrigation and density levels on the growth and production of the three *Atriplex* species are summarized in Figures 19-21. As in previous seasons, *A. lentiformis* had the highest average yield among the

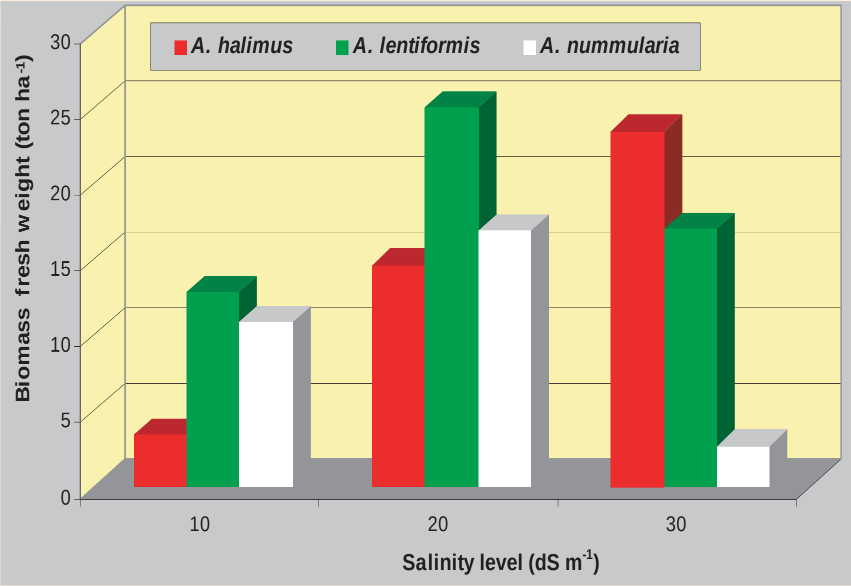


Figure 19: Biomass production of 3 *Atriplex* spp. at 3 salinity levels

three species overall the treatments applied. *A. halimus* yield had the highest yield level at the high salinity level, while the other two species yielded highest at the medium salinity level (20 dS m^{-1}) (Figure 19).

Similarly, high plant density (5,000 plants per ha) led to significantly higher biomass production in all species. *A. halimus* had the highest yield increase from low to high density (nearly triple increase in yield), while the other species ranged between 20% and 50% increase (Figure 20).

Increase in irrigation level to double the ET_0 led to reduction in yield in all species (Figure 21). Irrigation equivalent to reference evapo-transpiration (ET_0) and a leaching proportion (1.5 ET_0) was also the level that achieved the higher yield in previous seasons.

Forage quality

Mineral content, expressed as ash percentage, was extremely high. It reached more than 40% under certain combinations of salinity and fertility levels (Figure 22). Ash percentage remained high under all irrigation levels (Figure 23). Protein content was less than the percentages recorded in previous seasons. The effect

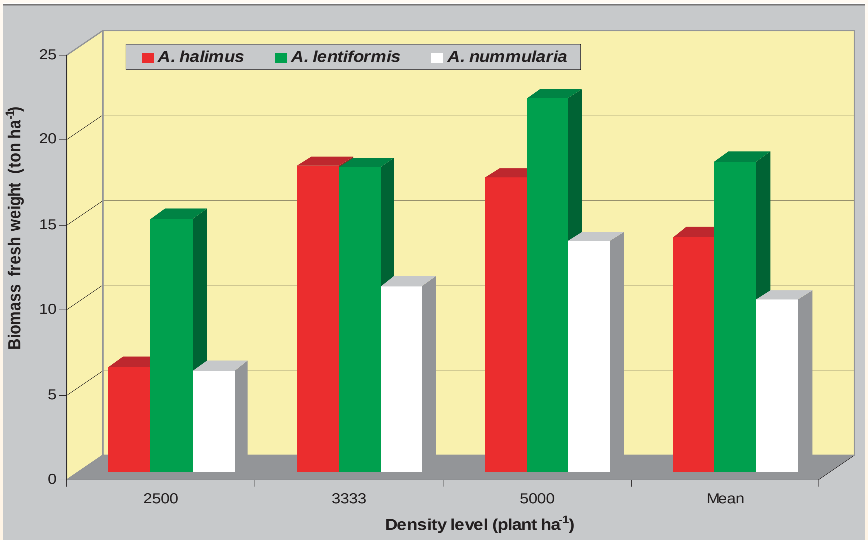


Figure 20: Biomass production of *Atriplex* spp. at 3 planting densities

In this project:

IR = Irrigation treatment
IR1: 1.0 x ET_0
IR2: 1.5 x ET_0
IR3: 2.0 x ET_0

ET= Evapo-transpiration

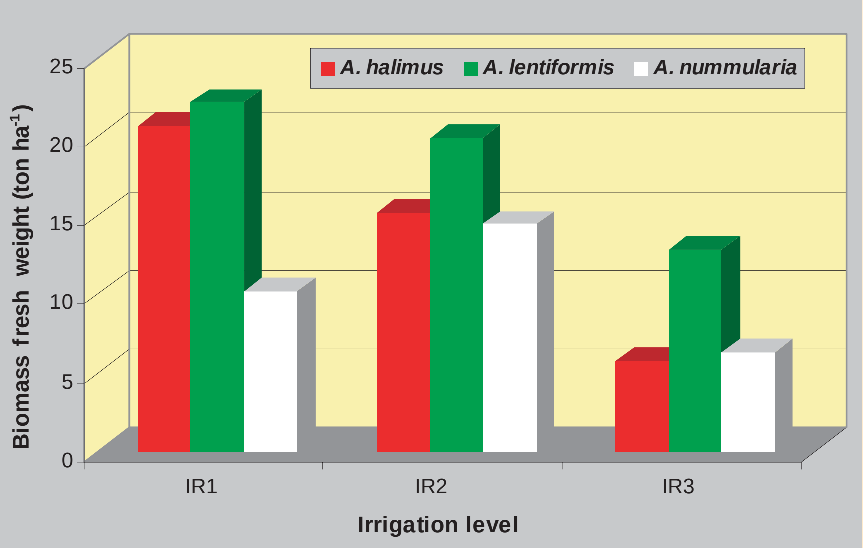


Figure 21: Biomass production of *Atriplex* spp. at 3 irrigation levels

of the season on protein content is under evaluation to determine what is responsible for such variation. Protein percentages were in the range of 10-13% (Figure 24).

Feeding trials

In 2006, *Atriplex* green matter was used in feeding trials on local goats and sheep. Different combinations of *Atriplex*, *Sporobolus* and Rhodes grass were used. Results in both sheep and goats were similar. As expected, animals fed on pure *Atriplex* performed poorly and had the lowest growth rates. Animals fed on the conventional Rhodes grass had the highest growth rates, but surprisingly, the 50:50 mixes of *Atriplex* and *Sporobolus* led to growth comparable to the Rhodes grass, followed by the pure *Sporobolus* treatment (Table 2). This was very encouraging and proves that such a mixture of salt-tolerant plants can be used as an alternative to conventional forages.

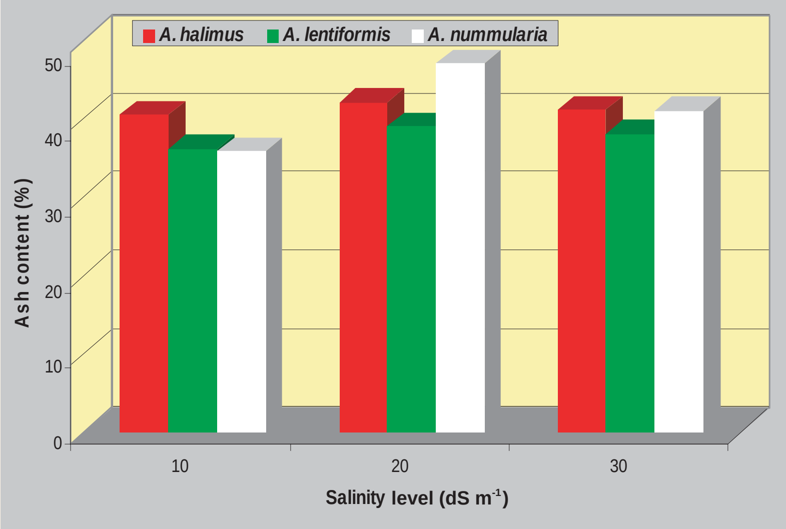


Figure 22: Ash content of *Atriplex* spp. over 3 salinity levels

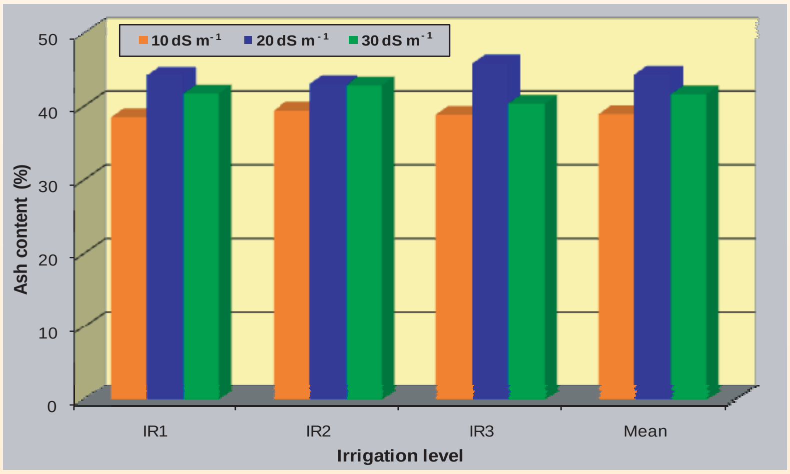


Figure 23: Ash content of *Atriplex* spp. over 3 salinity and irrigation levels

Table 2: Growth rates of indigenous goats fed different levels of *Atriplex* plants and *Sporobolus* grass hay

Parameter	Treatment			
	50:50 *Atriplex*:*Sporobolus*	100% *Atriplex*	100% *Sporobolus*	100% Rhodes
Initial body weight (kg)	10.30 ± 0.40	9.10 ± 0.87	10.40 ± 0.76	9.40 ± 0.62
Final body weight (kg)	16.70 ± 0.73a	11.80 ± 0.51b	15.80 ± 0.86a	16.20 ± 0.87a
Body weight gain (kg)	6.40 ± 0.53a	2.70 ± 0.066b	5.40 ± 0.43a	6.80 ± 0.56a
Average daily gain (g)	42.70 ± 3.50a	18.00 ± 4.40b	36.00 ± 2.86a	45.33 ± 3.74a
Feed conversion ratio	12.37 ± 0.27	20.01 ± 1.07	9.29 ± 0.23	6.80 ± 0.14

Values in rows with different letters are significantly different ($P<0.05$).

Proposed activities for 2007

Observations will be continued during 2007 to monitor and evaluate the performance of the three species under various management practices. Further analysis on forage quality and variations under different management practices and over seasons will be conducted. Assessment of optimal management practices will be determined at the end of the experiment. More plants are being transferred to farmers and NARS in the region for on-farm evaluation in salt-affected areas.

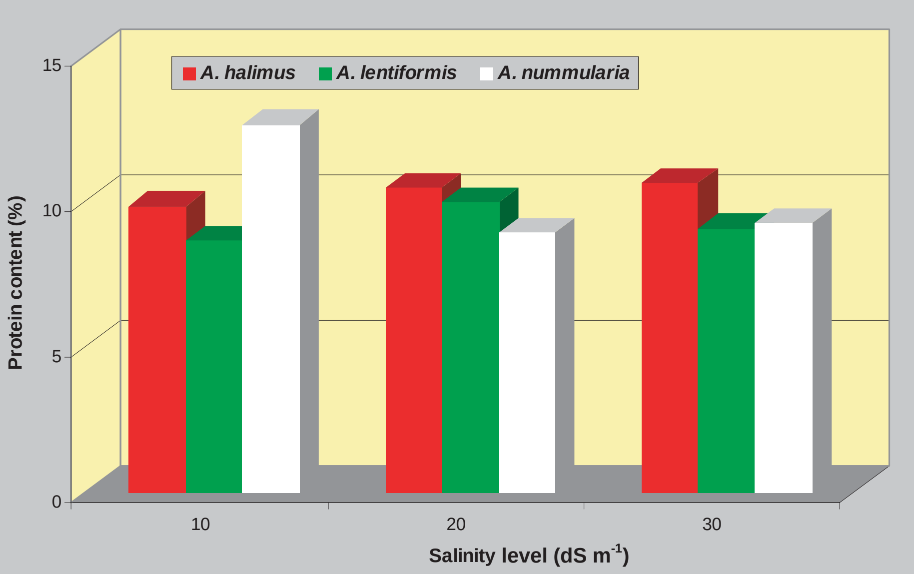


Figure 24: Protein content of *Atriplex* spp. over 3 salinity levels

A mixture of salt-tolerant plants can be used as an alternative to conventional forages

Tolerant of both drought and salinity, Atriplex *is an ideal forage crop for the WANA region*

Application of biosaline agriculture in a demonstration farm in the Northern Emirates of the UAE (PMS05)

Duration: 2003-06
Collaborator: MOEW
Resources: Core

Significance of the project

Although irrigated agriculture in the UAE has increased dramatically over the last 30 years, few farmers are trained in its special skills and techniques. This project will demonstrate biosaline agricultural techniques to farmers to show how sustainable and profitable plant production is possible on farms affected by moderate to high levels of salinity. The demonstration farm will be a model for salt-affected farms in the region.

Objectives

- Apply integrated farm management methods suitable for salt-affected farms in the Northern Emirates.
- Demonstrate biosaline agricultural principles to produce both conventional and non-conventional forage crops.
- Study and monitor the physical, chemical and productive aspects of the demonstration farm, including soil, water and forage production over a 4-year period.
- Involve local farmers and technicians in the evaluation of the project and organize field days.

Achievements in 2006

The demonstration farm for biosaline agriculture was established in R'as al-Khaimah in 2004 in collaboration with MOEW. The farm selected had been abandoned due to high salinity damage. Salinity of irrigation water was 20 dS m^{-1} in 2005 and exceeded 25 dS m^{-1} in 2006. Due to its high salinity level, the farm was completely devoted to highly salt-tolerant plants and halophytes in 2006.

The area allocated for conventional crops like barley, millet and sorghum was replanted with halophytes. Expansion in planting of salt-tolerant grasses and shrubs such as *Sporobolus*, *Distichlis* and *Atriplex* is under way.

Emirati farmers met with MOEW and ICBA scientists in R'as al-Khaimah during a field day to discuss the collaborative research

Cenchrus ciliaris (buffelgrass) and fodder beet were among the few non-halophytic species able to sustain acceptable yield levels at the high salinity level in the farm. Growth data from barley, fodder beet and other halophytes were collected.

Farmer input is extremely valuable in assessing plant varieties and production practices

Results

***Cenchrus ciliaris*.** Thirty-eight accessions/varieties of indigenous and exotic forage grasses were successfully established under high salinity levels. Irrigation water salinity reached up to EC 20-22 dS m^{-1}. An African *Cenchrus ciliaris* variety showed excellent growth, followed by Australian accessions. Local *Cenchrus ciliaris* and *Panicum turgidum* grasses showed clear variation in growth in response to water salinity. Most promising genotypes were propagated and distributed to 10 farmers. Additional production and distribution is under way.

Halophytic grasses. *Sporobolus virginicus*, *Distichlis spicata*, *Paspalum* and Kallar grass, all provided by ICBA, showed excellent growth under different salinity treatments. The most successful grasses grown under sprinkler irrigation were expanded in area in 2006. Distribution to interested farmers is under way.

Shrubs and trees. Three shrubs (*Atriplex lentiformis*, *A. nummularia* and *A. halimus*) and one tree species (*Acacia ampliceps*) showed excellent growth under salinity treatment. The planted area also expanded in 2006 to cover 1000 m^2 for each species. Production is under way to meet the demand of local farmers.

Barley. The 24 accessions provided by ICBA were replanted for a second season. Dry matter yield varied considerably among accessions. Highest total dry matter was 3.5-3.7 t ha^{-1} and the lowest was 2.0-2.5 t ha^{-1}. Seed yield reached 1.8 t ha^{-1} in the best performing genotype. The top five accessions were multiplied and distributed to farmers for on-farm evaluation in 2007.

Promising genotypes were propagated and distributed to farmers

Fodder beet. Seven varieties were evaluated in 2006. Tuber yield ranged from 10 to 33 t ha^{-1} despite the high salinity level. Varieties Turbo, Adagio and Abando showed the highest yield.

Brassica. Four forage brassica/rape varieties were evaluated. Dry yield in the top forage type, Interval, reached 10.5 t ha^{-1}, while in the seed type (Hyola) yield ranged from 2.5 to 4 t ha^{-1}.

Proposed activities for 2007

Planting of highly salt-tolerant species will continue during 2007. Accessions that prove productive will be expanded. Soil salinity will be monitored closely. Management practices will be refined to maintain soil salinity at acceptable levels. Field days for farmers and technical staff will be organized to introduce suitable production packages. Other farms with lower salinity levels will be selected to introduce salt-tolerant conventional crop production systems.

Development of salinity-tolerant sorghum and pearl millet varieties for saline lands (PMS15)

Duration: 2003-06
Collaborator: ICRISAT and NARS of India, Oman, UAE and Yemen
Resources: OFID, Core

Highlights

- *ICBA developed an improved primary production package suitable for pearl millet and sorghum production under saline conditions by adjusting the standard package used under local climatic conditions.*
- *In 2006, multi-cut and single-cut input variables were added to the package.*
- *The standard package was applied to the nurseries to achieve optimal production levels and select best-performing genotypes.*
- *The 30 genotypes of each crop showed a wide range of genetic variation for yield under salinity. The top 10 productive genotypes within each crop were identified for further seed multiplication in an expanded on-farm evaluation.*

Significance of the project

Soil and irrigation water salinity limits crop production, especially in arid and semi-arid regions. It is estimated that more than 50% of the irrigated lands in these regions are affected to some degree by salinization and that millions of hectares of agricultural land have been abandoned because of salinity. Moreover, large areas are potentially vulnerable and could easily be damaged by salinization through irrigation. Global efforts to alleviate increasing salinization are ongoing and sustainable integrated methods are being evaluated to improve crop production. However, although several engineering and agronomic options have been used to manage salt-affected lands, they are not always practical in all the areas. The development of salt-tolerant crop varieties is a cost-effective option for the management of salt-affected lands.

The present project, the second phase of an earlier project (PMS02, 2002-03), is aimed at the improvement of agricultural productivity in salt-affected arid and semi-arid environments of the Near East and Asia through the development of salt-tolerant pearl millet and sorghum genotypes with high grain and fodder yields.

Multi-cut and single-cut pearl millet in ICBA field trials

Objectives

- Select pearl millet and sorghum genotypes with improved salinity tolerance suitable for either forage or dual-purpose forage and grain production.
- Identify molecular markers for quantitative trait loci (QTLs) that affect salt tolerance.
- Evaluate nutritional values of selected genotypes under various saline conditions.
- Optimize productivity of pearl millet and sorghum in salt-affected environments in the Near East.
- Transfer technologies and crop production packages to national programs and farmers.

Achievements in 2006

In 2006, 30 genotypes each of pearl millet and sorghum were evaluated under field conditions at three salinity levels (EC 5, 10 and 15 dS m^{-1}) at ICBA. These genotypes included forage, seed and dual-purpose types. Genotypes were grown as a single-cut crop. However, from 30 single-cut genotypes, 9 genotypes of pearl millet and 8 genotypes of sorghum were also grown as a multi-cut crop. Pearl millet genotypes were cut four times and sorghum three times. Soil samples were taken at the end of the growing season for laboratory analysis.

Evaluation of the selected nurseries of pearl millet and sorghum were also carried out at several NARS in the West Asia North Africa (WANA) region.

Results

1. Evaluation at NARS stations and farmers' fields in WANA

Nurseries of salt-tolerant pearl millet and sorghum were established during 2005/06 in Oman (two sites), India (three sites), Iran (two sites), and Egypt (one site) as well as at ICBA and ICRISAT.

In Oman, dry matter production of top-yielding sorghum genotypes reached more than 14 t ha^{-1}, and green fodder production in a single cut reached more than 77 t ha^{-1}. Pearl millet dry matter reached 13 t ha^{-1}, and green fodder production more than 85 t ha^{-1}. In Yemen, 25 accessions each of sorghum and pearl millet were evaluated under saline field conditions (groundwater salinity ranged from 3 to 11 dS m^{-1}). Mean dry matter yield in top-performing sorghum genotypes reached 30 t ha^{-1} and in pearl millet 23 t ha^{-1}. Sorghum genotypes produced more seeds than pearl millet.

In Jordan, the same nurseries were evaluated at a NARS demonstration site in Al Khaldiah. In single-cut treatments, fresh biomass yield reached 100 t ha^{-1} in pearl millet (genotype Dauro Genopool) and dry matter up to 29.3 t ha^{-1}. In multi cut, the landrace, IP 19586, produced the highest total fresh yield (61.1 t ha^{-1}). Among sorghum genotypes, Super Dan and ICSR 196 produced the highest fresh biomass (69.2 and 65.4 t ha^{-1}, respectively), while the genotype ICMW 155 Brist produced the highest dry yield (8.16 t ha^{-1}). The variety Izraa 7 produced the highest grain yield (5.7 t ha^{-1}).

In Syria, the dry yield of pearl millet under field conditions decreased from 14.8 to 7.16 t ha^{-1} when water salinity was increased. Super Feed showed the best performance. The germination decreased with increase in water salinity. IP 6105 and IP 6107 were superior to the other two varieties tested.

In Pakistan, 45 sorghum and 28 pearl millet varieties/entries were evaluated at low, medium and high salinity levels. Several sorghum genotypes produced significantly higher green fodder than check varieties at low and medium salinity levels (up to 65 t ha^{-1}) and in pearl millet up to 45 t ha^{-1}.

In Palestine, the fresh matter yield of pearl millet genotypes tested at salinity levels up to 22 dS m^{-1} varied between 4.5 t ha^{-1} and 50 t ha^{-1}.

2. Evaluation at ICBA

Pearl millet field evaluation

Two field experiments were conducted in 2006. Thirty genotypes were grown as a single-cut crop and 9 genotypes were grown as a multi-cut crop. The results of both trials are presented separately here.

Single-cut crop

Analysis of variance confirmed the highly significant differences among genotypes and salinity levels, whereas interaction between salinity and genotypes was insignificant. The

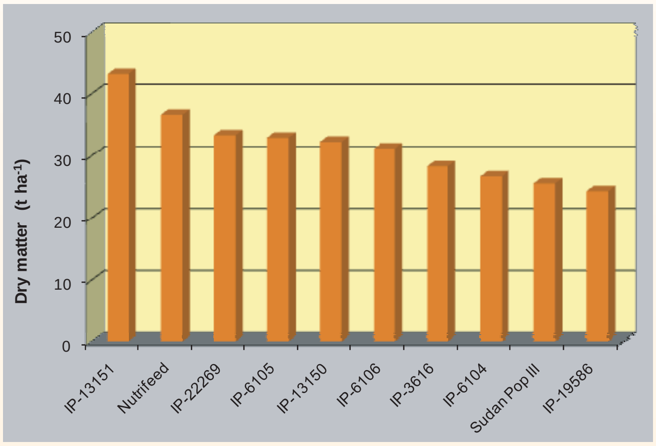


Figure 25: Dry matter yield of single-cut pearl millet genotypes at 5 dS m^{-1}

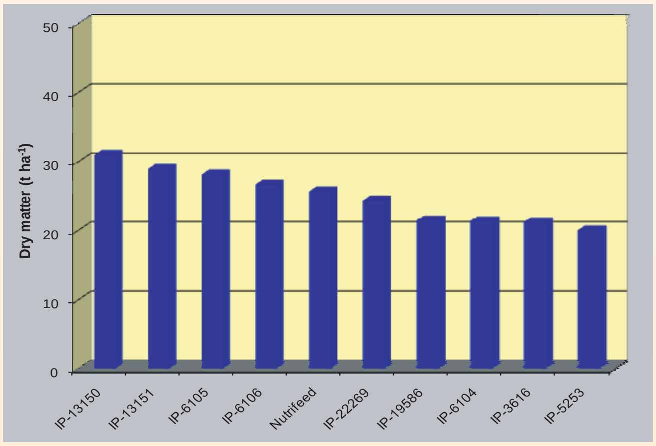


Figure 26: Dry matter yield of single-cut pearl millet genotypes at 10 dS m^{-1}

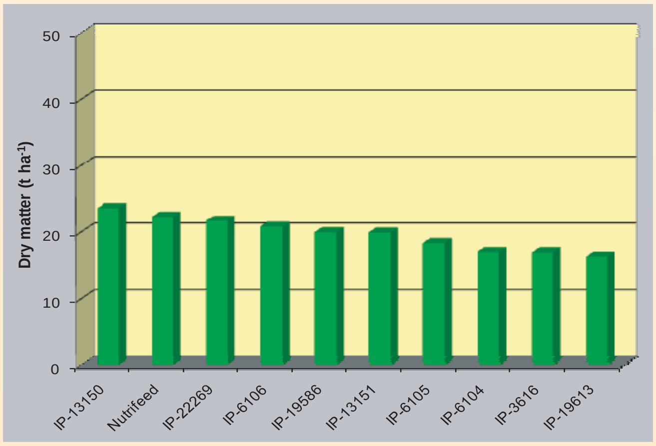


Figure 27: Dry matter yield of single-cut pearl millet genotypes at 15 dS m^{-1}

genotype IP 13151 produced the highest dry matter (31 t ha-1) over all salinity levels. Yield at low salinity ranged from 10 to 43 t ha-1 with an average of 22 t ha-1; at medium salinity from 7 to 31 with an average of 17 t ha-1; and at high salinity from 4 to 24 t ha-1 with an average of 13 t ha-1. The dry matter production of top 10 genotypes at each salinity level and over three salinities are shown in Figures 25-28.

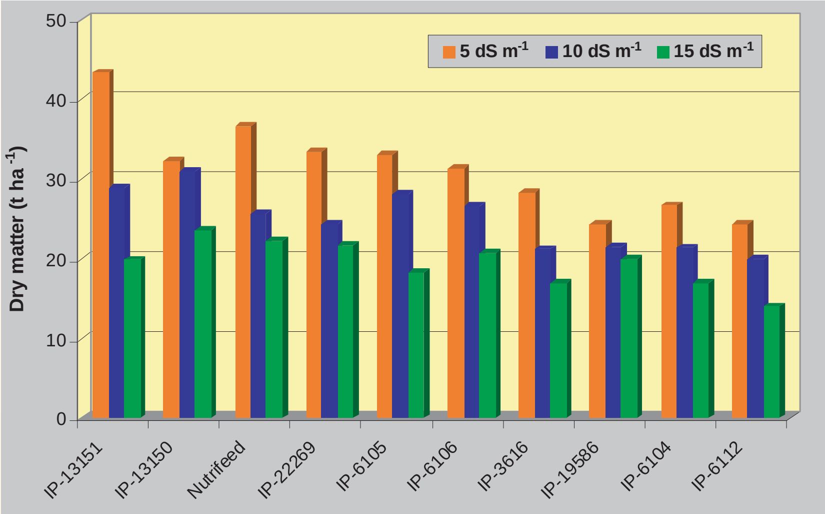


Figure 28: Dry matter production of top 10 single-cut pearl millet genotypes over 3 salinity levels

Multi-cut crop

Nine genotypes/commercial varieties were tested for their salinity tolerance potential and the ability to reproduce over more than one cut. Statistical analysis confirmed the highly significant differences among genotypes and salinity levels and non-significant interaction between salinity and genotypes. The genotype IP 6106 produced the highest mean dry matter (32 t ha-1) over all salinity levels. Total yield at low salinity over four harvests ranged from 30 to 35.5 t ha-1; at medium salinity from 26 to 34 t ha-1; and at high salinity from 16.8 to 29.6 t ha-1. The total yields under multi-cut are significantly higher than yield in a single-cut treatment under the same level of salinity. The results of dry matter production of the genotypes for all the cuts over all salinity levels are shown in Figure 29.

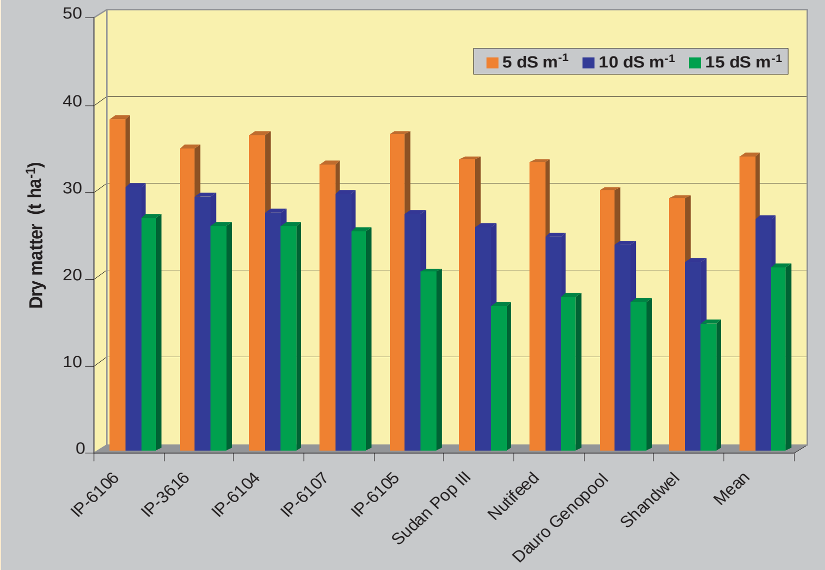


Figure 29: Dry matter production of multi-cut pearl millet genotypes over 3 salinity levels

Sorghum field evaluation

Two separate experiments were conducted for field evaluation of sorghum genotypes in 2006. Thirty genotypes were grown as single-cut and 8 genotypes as a multi-cut crop. The results of both studies are presented herein.

Single-cut crop

Analysis of variance confirmed the highly significant differences among genotypes and salinity levels, whereas interaction between salinity and genotypes was insignificant. The genotype Sugar Graze produced the highest dry matter (32 t ha-1) of all salinity levels tested. Yield at 5 dS m-1 ranged from 13 to 37 t ha-1; at 10 dS m-1 from 10 to 31 t ha-1; and at 15 dS m-1 from 8 to 27 t ha-1. The dry matter production of top 10 genotypes at each salinity level tested is shown in Figures 30-32.

Multi-cut crop

Eight sorghum genotypes/commercial varieties were evaluated for salinity tolerance potential and the ability to produce fodder over more than one cut. Statistical analysis confirmed the highly significant differences among genotypes and salinity levels and cuts. Interaction between salinity and genotypes and cuts was insignificant. Pioneer 858 produced the highest mean dry matter (8 t ha-1) over all the cuts over all salinity levels tested. The results of dry matter production of the top 10 genotypes over all cuts at each salinity level are shown in Figure 33.

Nutritional value of selected genotypes

The project's activities stipulate that once best-performing genotypes are identified under field conditions, nutritional values, optimum agronomic practices and technological packages will be determined. However, during the first phase of the project, due to time and resource constraints, it was only possible to initiate such activities and produce preliminary information to guide field activities in the second phase. Through a Master's of Science thesis conducted at Sultan Qaboos University in Oman, we were able to generate valuable information related to pearl millet forage quality. Tables 3-6 highlight the results of analysis performed on a selected number of genotypes over two cropping seasons.

The analysis tables showed that the ranges of the parameters studied are within

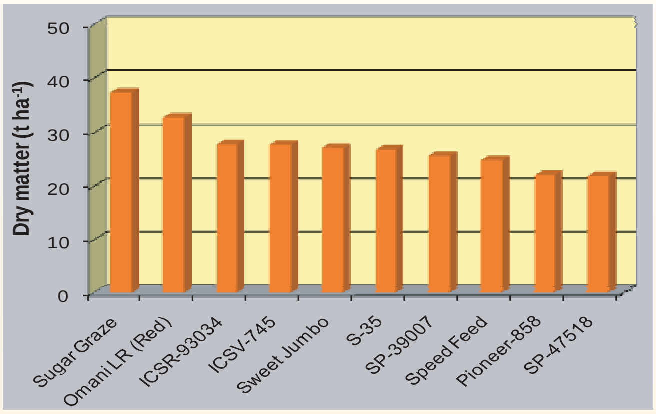


Figure 30: Dry matter production of top 10 single-cut sorghum genotypes at 5 dS m-1

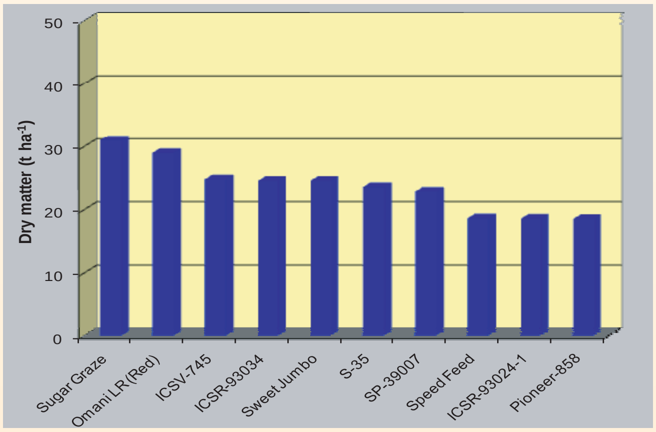


Figure 31: Dry matter production of top 10 single-cut sorghum genotypes at 10 dS m-1

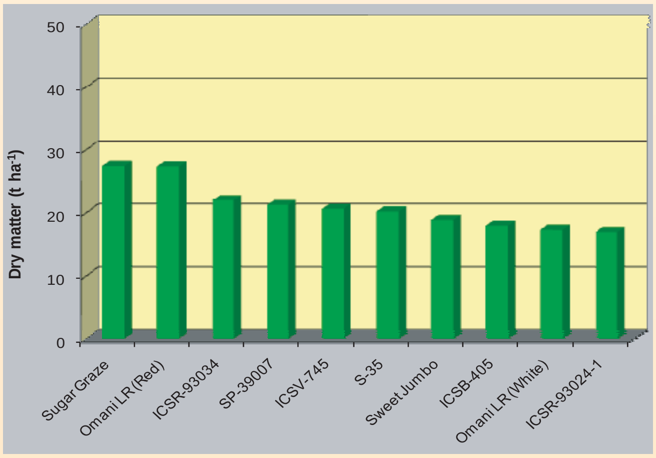


Figure 32: Dry matter production of top 10 single-cut sorghum genotypes at 15 dS m-1

acceptable limits. Na% was low, even when grown under saline field conditions. Also, it is generally concluded from a wide range of salinities research that increased K^+ to Na^+ ratios (and Ca^{2+}/Na^+) is an indication of adaptation of plants to osmotic and ionic stresses. The high K^+/Na^+ ratio was also reflected in pearl millet genotypes studied and selected for high yield (Tables 3 and 4). Crude proteint (CP) and ash percentage are two main indicators of forage quality. High protein percentage is an important forage trait; pearl millet genotypes showed high rates in comparison with many known grass forages like barley. Similarly, when mineral content (expressed as ash%) increased the forage value, digestibility

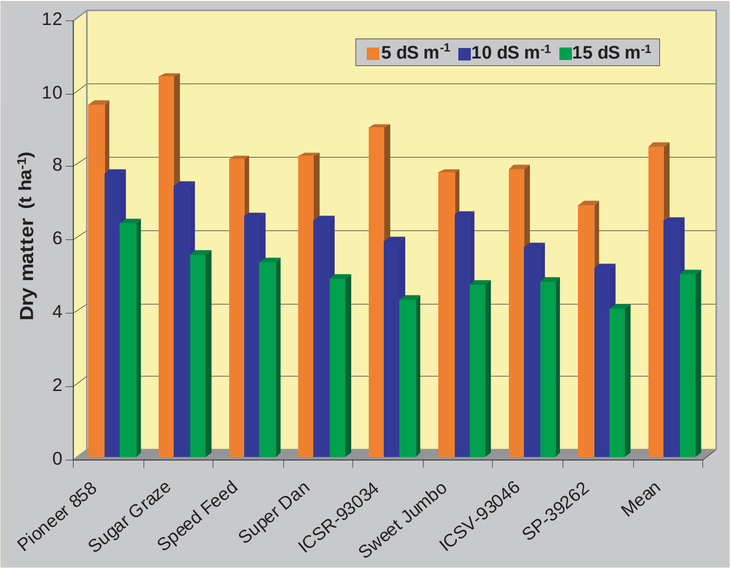


Figure 33: Mean biomass production in each cut of multi-cut sorghum genotypes at 3 salinity levels

Table 3: Means of percent ionic concentrations of 10 selected pearl millet genotypes (2004)

Entry	P	K	Ca	Mg (%)	Na	Cl	K/Na
IP 19586	0.20	1.79	1.20	1.68	0.35	2.88	5.11
IP 3616	0.31	1.79	1.04	1.27	0.32	2.44	5.59
ICMV 155 Brist	0.24	1.82	1.32	1.99	0.38	3.10	4.79
IP 6109	0.21	1.31	1.44	1.65	0.27	2.66	4.85
ICMV 155 Original	0.18	1.78	1.48	1.44	0.36	2.22	4.94
IP 6112	0.25	1.83	1.52	1.70	0.36	2.44	5.08
Sudan Pop III	0.28	2.04	1.16	1.80	0.41	2.44	4.98
IP 22269	0.20	1.80	1.52	1.49	0.39	2.22	4.62
IP 19612	0.26	2.02	1.40	1.66	0.51	2.88	3.96
IP 6106	0.24	1.78	1.56	1.68	0.46	4.21	3.87

Table 4: Means of percent ionic concentrations of 10 selected pearl millet genotypes (2005)

Entry	P	K	Ca	Mg (%)	Na	Cl	K/Na
IP 19586	0.10	1.53	0.96	0.86	0.98	2.66	1.53
IP 3616	0.09	2.08	1.20	1.06	0.39	3.11	5.30
ICMV 155 Brist	0.11	2.51	2.00	1.30	0.41	5.33	6.12
IP 6109	0.18	2.33	1.12	1.73	0.52	3.55	4.48
ICMV 155 Original	0.06	2.35	1.84	1.06	0.48	3.99	4.90
IP 6112	0.12	1.88	1.36	1.97	0.47	5.33	4.00
Sudan Pop III	0.16	2.52	1.84	1.20	0.61	3.55	4.10
IP 22269	0.08	1.95	1.60	1.44	0.26	2.66	7.50
IP 19612	0.03	1.84	1.20	2.26	0.66	5.77	2.80
IP 6106	0.03	1.72	2.00	2.16	1.07	6.21	1.60

and forage intake decline. Despite increased salinity levels, pearl millet genotypes maintained generally acceptable ranges similar to non-saline conditions (Table 5). Fiber content, as reflected in neutral detergent fiber (NDF) and acid detergent fiber (ADF), was also estimated and found to be generally low and within the favorable ranges (Table 6).

Based on the chemical analysis performed, genotypes with desirable yield potential and chemical composition (like high CP, low ash and acceptable ranges of other minerals) were identified. Examples are IP 19586, IP 31616 and Sudan Pop III. However, this work need to be conducted on more samples from different salinity levels to reach a solid conclusion and determine trends between yield potential under salinity and nutritional parameters.

Table 5: Means of the ash and crude protein percentages of 10 selected pearl millet genotypes, 2004 and 2005

Entry	2004		2005	
	Crude protein (%)	Ash (%)	Crude protein (%)	Ash (%)
IP 19586	13.33	12.68	12.81	8.00
IP 3616	15.31	9.11	21.25	11.54
ICMV155 Brist	13.05	14.09	12.38	16.22
IP 6109	12.25	12.07	11.44	13.51
ICMV 155 Origina	13.39	15.49	13.00	11.11
IP 6112	12.08	10.82	14.75	18.75
Sudan Pop III	14.13	14.09	13.63	12.90
IP 22269	14.70	11.93	13.50	10.00
IP 19612	14.74	13.75	15.69	12.90
IP 6106	12.14	12.77	5.88	26.67

Table 6: Means of NDF and ADF percentages of 10 pearl millet genotypes (summer 2005)

Entry	NDF (%)	ADF (%)
IP 19586	59.73	31.60
IP 3616	52.52	28.84
ICMV155Brist	55.17	32.68
IP 6109	51.33	31.57
ICMV 155 Original	52.77	31.81
IP 6112	61.97	33.89
Sudan Pop III	58.27	34.75
IP 22269	55.07	32.82
IP 19612	58.13	33.93
IP 6106	53.83	29.77

Phase I Final Report

ICBA and ICRISAT jointly submitted the final report of Phase I of the project (2003-06) to OFID. A proposal for the second phase of the project was also submitted along with this report. Major achievements and impacts of the phase I of the project are summarized as below.

Summary of project achievements and impact

Both pearl millet and sorghum are two main fodder crops that can play a significant role to fill the gaps in the farm productivity and crop-livestock systems of the WANA region. In many salt-affected areas with reduced potential for the production of high-value cash crops, the most viable option is to shift crop production to a forage-livestock production system that can maintain farm productivity and improve income through the integration of forage production with livestock system. Demands for forage production are very high in water-limited environments and it is projected to increase sharply in future due to increased demands for meet and other livestock products.

This three-year project was initiated by both ICBA and ICRISAT in 2003. The objective was to screen and select salt-tolerant pearl millet and sorghum genotypes from among the large germplasm collection at ICRISAT and to develop an optimal production package for these crops and transfer it to farmers in the targeted regions in WANA and Asia.

Initially, more than 800 genotypes of both species were screened at selected salinity levels at ICBA and ICRISAT stations up to 15 dS m^{-1} (11,000 ppm). These genotypes comprised of four main groups (B lines, elite genotypes and varieties, landraces and mapping populations of both species). Through intensive, controlled and field screening and evaluation, top-performing genotypes within each group were identified. At ICBA, mean dry matter yield range of B Lines varied between 10 and 72g per plant; of elite genotypes between 11 and 56g per plant; of landraces between 7 and 116g per plant; and of mapping populations between 19 to 90g per plant.

The range of dry matter production of sorghum genotypes screened in 2003 and 2005 varied between 1 to 114g per plant and 3 to 70g per plant, respectively. The field dry matter production of pearl millet genotypes reached 15 t ha^{-1}. Dry matter production of sorghum genotypes reached 12 t ha^{-1}. In pearl millet, Crude Protein content (CP) ranged from 5 to 15%, Neutral Detergent Fiber (NDF) from 50 to 60%, Acid Detergent Fiber (ADF) from 30 to 40% and Ash from 10 to 17%. All the parameters indicated the good nutritional value of the crop even at the high salinity levels evaluated in this work.

Based on their performance in the screening trials, high-yielding, salt-tolerant genotypes were selected and nurseries were assembled for further field evaluation at ICBA, ICRISAT and NARS. The selected genotypes were distributed to NARS for on-farm trials. In 2004-05, ICBA supplied seeds to Oman and Yemen for this purpose. In 2006, more locations were selected in other countries (India, Iran, Jordan, Pakistan, Palestine, Syria, Tunisia and the UAE) and seeds were supplied by ICBA.

On-farm trials conducted in Oman and Yemen demonstrated promising results for pearl millet and sorghum production under local farming conditions. Several genotypes of pearl millet and sorghum showed high biomass and seed production at more than 8 dS m^{-1} soil salinity level.

In 2005, under Oman's high soil and water salinity, green biomass production at heading stage in top-yielding sorghum lines was about 36 t ha^{-1}, and dry matter at maturity stage exceeded 11 t ha^{-1}, despite disease problems. In the 10 top-yielding pearl millet genotypes, green fodder production at heading stage reached 52 t ha^{-1} and averaged

44.6 t ha^{-1}. In addition, protein percentage ranged from 12% to 15% in the top-yielding pearl millets. At the same time, ash and sodium content were within the normal limit.

Pearl millet and sorghum can play a significant role in filling gaps in farm productivity and crop-livestock systems

In 2006, promising genotypes of both sorghum and pearl millet were selected for further evaluation under high planting density (32 plants per m^2) in Oman. Two farms, in Rumais and Suwaiq area were selected. Mean green matter productivity of 11 top yielding pearl millet genotypes at Rumais farm was 173.7 t ha^{-1}. By contrast, at Suwaiq farm, mean green matter yield of five pearl millet was lower (81.7 t ha^{-1}) compared to Rumais farm. Sorghum trial was abandoned at Rumais farm site due to stem borer attack. However at Suwaiq farm mean green matter yield of five sorghum genotypes was to 54.9 t ha^{-1}.

Most of the sorghum genotypes maintained promising ranges of seed and biomass production under local climatic conditions of Yemen. Mean sun dry biomass of sorghum and pearl millet was 18.5 t ha^{-1} and 16.4 t ha^{-1}, respectively and mean 1000 seed weight (seed index) for sorghum and pearl millet was 29.17g and 14.2g, respectively.

At ICBA, nurseries of both pearl millet and sorghum were evaluated between 2003 and 2006 under field conditions to develop production and management packages and an additional treatment, cutting regime (both single- and multi-cut) was tested. Nine pearl millet and eight sorghum genotypes were grown as multi-cut crops. Dry matter yield of pearl millet ranged between 7 to 31 and 22 to 32 t ha^{-1} for single-cut and multi-cut crops, respectively. Dry matter yield of sorghum genotypes varied between 11 to 32 and 16 to 24 t ha^{-1} for single-cut and multi-cut crops respectively.

At ICRISAT, 200 mM NaCl treatment was found to be the optimal salinity level for pot culture screening. Both sorghum and pearl millet growth were affected by soil salinity at all stages from germination (more so in pearl millet) to grain production (more so in sorghum). Correlation between dry matter yield under salinity and salinity tolerance index (STI) was highly significant and positive both in sorghum (r^2 = 0.57) and pearl millet (r^2 = 0.92). Several parental lines and populations with high grain yield ratio were identified in sorghum, but there was poor correlation (r = 0.33) between grain yield ratio and stover yield ratio. In pearl millet, several parental lines and populations with both high grain and stover yield ratios were identified as there was highly significant and positive correlation between the two (r = 0.89).

Interestingly, some of the improved populations and parental lines of hybrids, and open-pollinated (and released) varieties were also found to have produced high yield under saline field conditions. Two pairs of inbred lines in pearl millet and eight pairs of inbred lines in sorghum were identified to develop mapping population to identify QTLs for salinity tolerance.

ICRISAT results confirmed that shoot biomass, stover yield and grain yield measured under non-saline conditions could be effectively used to select for these traits under saline conditions in pearl millet. Several sorghum lines with high levels of salinity tolerance for grain yield and stover yield were identified.

These studies and field evaluations have provided the foundation for larger on-farm trials, seed increase, release and adoption of identified high-yielding and salinity-tolerant sorghum and pearl millet; and also for enhancing the efficiency of genetic improvement for salinity tolerance, following conventional as well as biotechnological approaches involving marker-assisted selection.

Pearl millet (above) and sorghum (below) are the fifth and sixth most important cereal crops worldwide. Both have enormous potential in saline environments

Farmer's field trials in various NARS stations produced encouraging results. Many farmers showed interest in on-farm trials and both ICBA and ICRISAT provided seeds to them. Presently, demand for on-farm evaluation has increased, and more farmers are expected to participate in 2007. It will lead to develop a comprehensive, standardized production technology for each crop under particular conditions of each country.

On-farm trials so far have led to develop a technology package for the production of pearl millet and sorghum under saline environments (initially including appropriate genotypes, field preparation, and density and seeding rate, irrigation management, fertilization, plant protection and cutting regimes). However, the trials conducted so far are not sufficient to reach to solid conclusions and more locations within and among the are needed to refine this packages.

Proposed activities for 2007

The second phase will focus on:

- Identification of the final short list of the most productive genotypes of pearl millet and sorghum (5 genotypes of each) under salinity for large-scale field evaluation at ICBA, ICRISAT, NARS stations and farmers' fields.
- Completion of the development of optimal production packages of the two crops under saline conditions.
- Transfer of technology packages to NARS and farmers in the target countries.
- Wide adoption of the packages by farmers and large-scale, on-farm application.
- Determination of nutritional values of salt-tolerant genotypes and the trends in changes in nutritional value with salinity levels.
- In country, on-farm seed production.
- Capacity building of NARS and farmers in production and management of the two crops and in seed production and forage utilization.

The development of final technologies for both crops still needs more evaluations at more sites.

Development of sustainable salt-tolerant forages for sheep and goat production (PMS16)

Duration: 2003-07
Collaborator: United Arab Emirates University (UAEU)
Resources: Core

Significance of the project

The introduction of salt-tolerant plants as a source of forage will lead to a substantial reduction in production costs

This project aims at improving the sustainability of sheep and goat production systems by increasing the availability of forage resources through the introduction of salt-tolerant forages. It consists of two components. The first component focuses on optimizing management practices for large production of two salt-tolerant grasses (*Sporobolus virginicus* and *Distichlis spicata*) and three *Atriplex* shrub species (*Atriplex halimus*, *A. nummularia* and *A. lentiformis*). The second component focuses on the performance of indigenous goats (Emirati and Jabli) and sheep (Mahali and Hebsi), fed salt tolerant forages as the only source of fodder. Productive and reproductive performance, as well as feed intake will be considered. Also, adaptive and genetic potential of the species and breeds studied will be evaluated.

It is expected that the results of this project will lead to significant reduction of feeding costs in both sheep and goats production systems. Also, the results will help in determining the productive and adaptive capabilities of indigenous breeds, which can contribute to sustainable agriculture in low-input production systems.

Potential for practical applications

First component

1. Development of alternative sustainable forage production systems that utilize marginal environmental resources such as saline water, salt affected soils and underutilized sub-coastal lands.
2. Increases forage and fodder resources available for sheep and goat feeding.
3. Saving fresh water resources currently used in forage production.
4. Improve environmental conditions in unproductive areas.
5. The research results will lead to the development of production packages for optimum forage production under saline conditions that are easily transferable and applicable by the local agricultural community.

Second component

1. Development of such systems will lead to a substantial reduction of production costs, through the introduction of salt-tolerant plants as a source of forage instead of using freshwater-irrigated grass (ie, Rhodes grass hay).

2. In addition, using indigenous animals, adapted to the local environment will help in conservation these breeds and accordingly lead to optimum utilization of the available resources (land, water, animals).

Objectives

The overall objective of this research project is to develop salt-tolerant forages and sheep and goat production systems that are environmentally sustainable in the Gulf Coast region. Specific objectives of the project:

- Develop sustainable salt-tolerant forage production systems that are less demanding on resources and that utilize marginal lands and saline water resources.
- Develop sustainable sheep and goat production systems based on the use of salt-tolerant forages

Several experiments are planned within this project. Objectives of each component of the project are listed below.

First component

Experiments I and II: Optimizing productivity of two salt-tolerant forage grasses, *Sporobolus virginicus* and *Distichlis spicata*, and three salt-tolerant forage shrubs, *Atriplex halimus*, *A. lentiformis* and *A. nummularia* under high salinity levels.

First component objectives

- Determine the yield potential of the grasses and shrubs when grown under high salinity levels, and the level at which the productivity remains economical.
- Determine the optimum irrigation levels for maximum production of the grasses and shrubs, and the level that minimizes salt accumulation in the soil.

Feeding sheep and goats requires sustanable production of forages under saline conditions

- Determine the appropriate fertilization regime for maximum production.
- Assess the nutritional value of the grasses and shrubs in response to the different salinity, irrigation and fertilizer levels.

Second component

Experiment I: Productive and reproductive performance of two breeds of sheep fed different levels of *Sporobolus* grass hay (irrigated with highly saline water)

Objective of Experiment I: Evaluate the effects of feeding diet containing different levels of *Sporobolus* grass hay on the performance of two different breeds of sheep (one indigenous, one exotic).

Experiment II: Weight gain, carcass characteristics and feed intake of ram lambs, fed different levels of *Sporobolus* grass hay (irrigated with highly saline water)

Objective of Experiment II: Evaluate the effects of feeding diet containing different levels of *Sporobolus* grass hay on growth performance of lambs from three different breeds of sheep (two indigenous, one exotic).

Experiment III: Weight gain and carcass characteristics of goat kids fed different levels of *Distichlis* grass hay (irrigated with high saline water)

Objective of Experiment III: Evaluate the effects of feeding diet containing different levels of *Distichlis* grass on the performance of goat kids from two breeds of goat (one indigenous, one exotic).

Experiment IV: Performance of indigenous sheep fed *Atriplex* grass hay (irrigated with highly saline water)

Objective of Experiment IV: Evaluate the effects of feeding diet containing different levels of *Atriplex* plants on productive and reproductive performance; and feed intake of the local sheep.

Achievements in 2006

Projects PMS03 and PMS04 (pp 28-40) summarize the results and achievements of this project.

Publications related to the project

Al-Shorepy SA, **Alhadrami GA**, **Ayoub MA** and **Dakheel AJ**. 2004. Growth performance and body composition of indigenous goats fed *Distichlis* grass. Proceedings of the 5th Annual Research Conference, UAE University, Al Ain, UAE.

Al-Shorepy SA, **Alhadrami GA** and **Dakheel AJ**. 2005. Effect of feeding *Sporobolus* grass hay on growth performance and slaughtering characteristics of fattening indigenous lambs. Proceedings of the 6th Annual Research Conference, UAE University, Al Ain, UAE.

Al-Shorepy SA, **Alhadrami GA** and **Dakheel AJ**. 2006. Effect of feeding saltbush (*Atriplex* spp.) and *Sporobolus* grass hay on growth of indigenous goats. Proceedings of the 7th Annual Research Conference, UAE University, Al Ain, UAE.

Al-Shorepy SA, **Alhadrami GA** and **Dakheel AJ**. 2006. Indigenous goats and salt-tolerant forages: towards sustainable meat production in the United Arab Emirates. 12th Asian Australian Animal Science Congress, South Korea.

Ayoub MA, **Al-Shorepy SA**, **Alhadrami GA** and **Dakheel AJ**. 2004, Estradiol and progesterone hormonal profiles in pregnant sheep fed *Sporobolus* grass hay grown in saline desert lands and irrigated with high salt content water. *In* Proceedings of the 5th Annual Research Conference, UAE University, Al Ain, UAE.

Dakheel AJ, **Alhadrami GA** and **Al-Shoreby SA**. 2006. The economic and environmental potential of two non-conventional salt-tolerant grasses: *Sporobolus virginicus* and *Distichlis spicata*. *In* the International Conference on Biosaline Agriculture and High Salinity Tolerance, Tunis, 3-8 Nov 2006.

Dakheel AJ, Alhadrami GA, Al-Shoreby SA and **AbuRumman G**. 2006. Optimizing management practices for maximum production of two salt-tolerant grasses: *Sporobolus virginicus* and *Distichlis spicata. In* Proceedings of the 7h Annual Research Conference, UAE University, Al Ain, UAE.

Evaluation of salinity tolerance and yield in barley varieties and accessions (PMS17)

Duration: 2003-07
Collaborator: International Center for Agricultural Research in the Dry Areas (ICARDA)
Resources: ICARDA, Core

Highlights

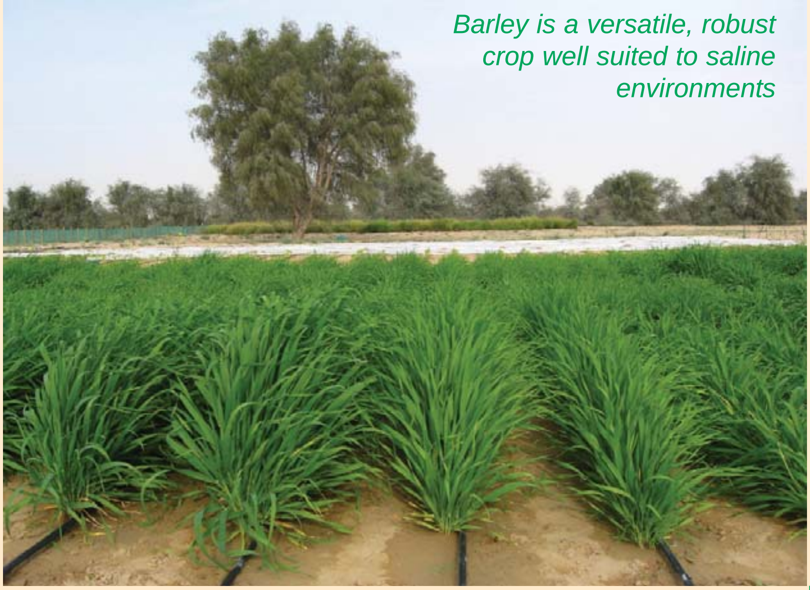
Three experiments were conducted during 2006 in which 700 genotypes were screened for salinity tolerance, including:

- *25 genotypes previously selected from Omani landraces and ICARDA materials*
- *75 genotypes including 64 varieties from WANA region*
- *600 barley genotypes representing five nurseries from the ICARDA breeding program*

The genotypes showed a wide range of genetic variability in terms of biomass production. Among the 75 accessions in Experiment II, dry matter production varied between 212 and 33 g/plant. Accessions in different nurseries showed wide genetic variability within and between nurseries.

Significance of the project

Barley (*Hordeum vulgare*) is the fourth most important cereal crop in the world. The salt tolerance of barley is among the highest of all food crops. Previous studies indicate that some genetic lines of barley have even higher tolerances. These genetic lines/cultivars need to be identified in the environments where they are grown. Barley is a source of food for humans, raw material for beverages and high quality feed for animals in dryland agro-ecosystems.


Barley is a versatile, robust crop well suited to saline environments

Because high salinity is a constraint in dryland environments, improvement in the productivity of barley in such areas is the major focus of this research. In collaboration with ICARDA, ICBA obtained a large number of barley genotypes and accessions from various origins for evaluation and screening under pot and field conditions.

Objectives

- Evaluate salinity tolerance among selected groups of barley genotypes and landraces from various sources.
- Select salt-tolerant genotypes for large-scale field evaluation in the UAE and other countries of the WANA region.
- Provide sufficient seed of improved genotypes to the regional and national programs for field evaluation.
- Provide information to the collaborating institutes concerning salinity tolerance among their barley accessions for use in future breeding programs.

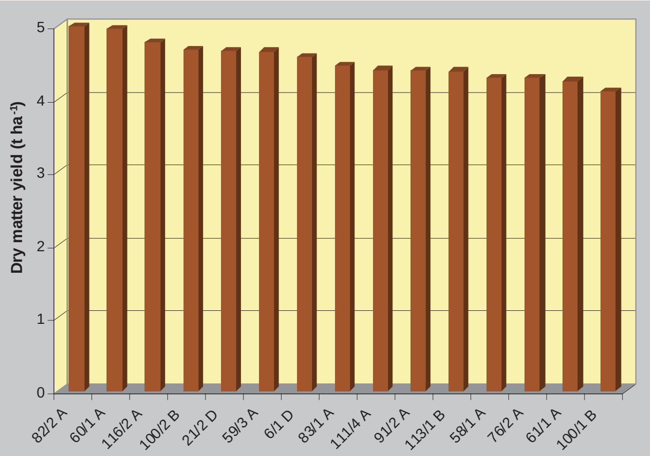


Figure 34: Dry matter production of top 10 barley genotypes tested under field conditions over all salinity levels (Experiment I) at ICBA

Achievements in 2006

Three experiments were conducted in 2006. In Experiment I, 25 genotypes were evaluated under field conditions at three salinity levels (EC 5, 10 and 15 dS m^{-1}). Experiment II was comprised of 75 accessions (64 from ICARDA) with 11 ICBA varieties as checks). The accessions were screened in pot culture under semi-controlled conditions at four salinity levels (EC 5, 10, 15, and 20 dS m^{-1}). In Experiment III, five barley nurseries obtained from ICARDA's barley breeding program were screened in pots under semi-controlled conditions at EC (10 dS m^{-1}).

Results

Experiment I

The seeds of the 25 genotypes that included elite germplasm from ICARDA's barley breeding program and local Omani landraces were collected from previous barley crops at maturity. The experiment was sown in the 2005/06 season under field conditions at three salinity levels: EC 5, 10, and 15 dS m^{-1}. The average dry matter production was 4.13 t ha^{-1} over all salinity levels used. Yield declined with increase in the salinity levels. Mean dry matter production of top genotypes over all salinity levels ranged from 4 to 5 t ha^{-1} (Figure 34). It is evident from the response that the top-performing genotypes maintained high biomass

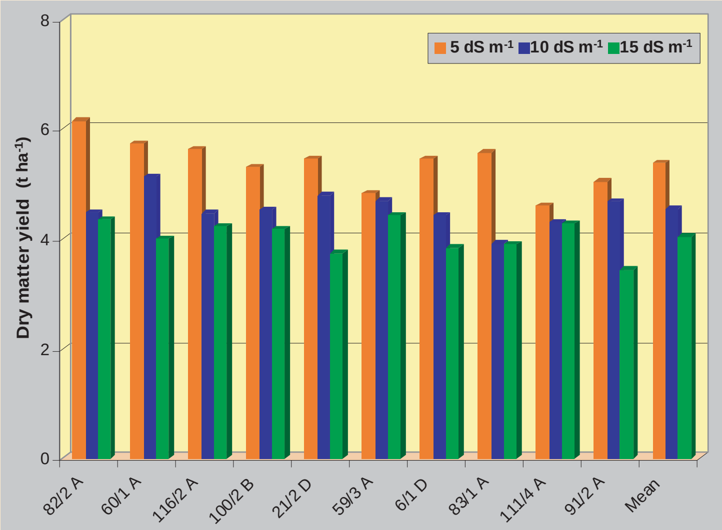


Figure 35: Biomass production of top 10 barley accessions at three salinity levels (2005/06)

even at 15 dS m^{-1} (Figure 35). Dry weight ranged from 3.8 to 4.3 t ha^{-1}.

The experiment was terminated at harvest. The promising genotypes will be selected for large-scale evaluation at both ICBA and NARS stations, and they will also be used as check genotypes in future barley trials.

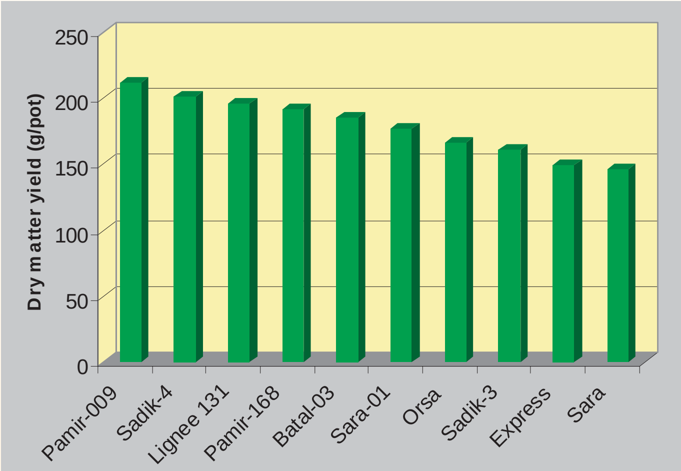


Figure 36: Mean dry matter production of top 10 genotypes of barley nursery (WANA varieties) screened at 4 salinity levels at ICBA

Experiment II

The experiment consisted of 75 barley genotypes, including 64 varieties common to the WANA region. The genotypes were provided by ICARDA's barley breeding program. One Tunisian variety and 10 genotypes used as checks were selected from ICBA's barley screening program. The genotypes were sown in pots at ICBA using four salinity levels: EC 5, 10, 15 and 20 dS m^{-1}. All plants were harvested and data recorded for biomass and seed yield for all genotypes. The average yield was 99.23g per pot. There was a clear trend of yield decline with increasing salinity. The average yield for all entries recorded at the lowest salinity level was 120g per pot. Yield declined to 71g per pot at the highest salinity level. Mean dry matter yield in top-performing varieties ranged from 147 to 214g per pot (Figure 36). The top five varieties showed acceptable yields up to 15 dS m^{-1} (Figure 37).

Experiment III

Five barley nurseries were supplied by ICARDA for salinity evaluation at ICBA.

1. International Barley Observation Nursery CAC (IBON-CAC).
2. International Barley Crossing Block Winter Types (IBCB-W).
3. International Barley Crossing Block Spring Types (IBCB-S).
4. International Barley Observation Nursery (low rainfall areas) Mild Winter (IBON-LRA-M).
5. International Barley Observation Nursery (moderate rainfall areas) (IBON-MRA).

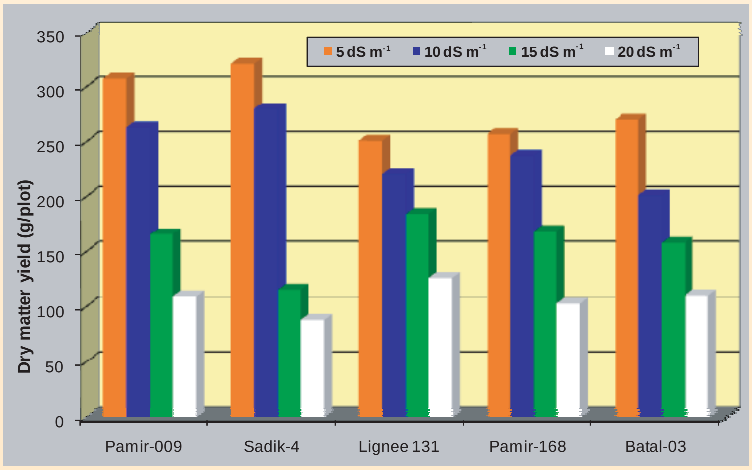


Figure 37: Dry matter production of top 5 varieties of barley (Experiment II) screened at 4 salinity levels at ICBA

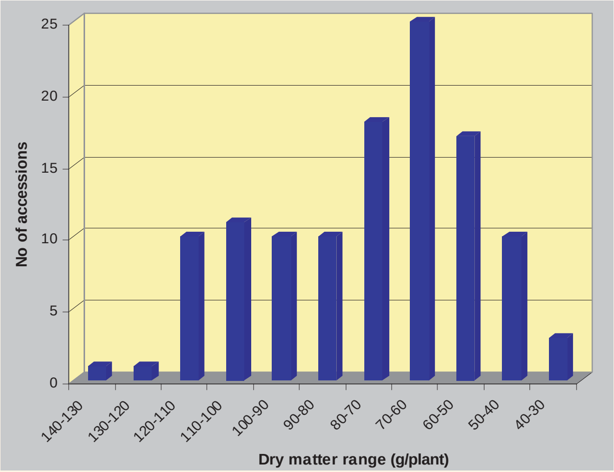


Figure 38: Range of dry matter production of barley nursery IBON-CAC screened under 10 dS m^{-1} salinity level at ICBA

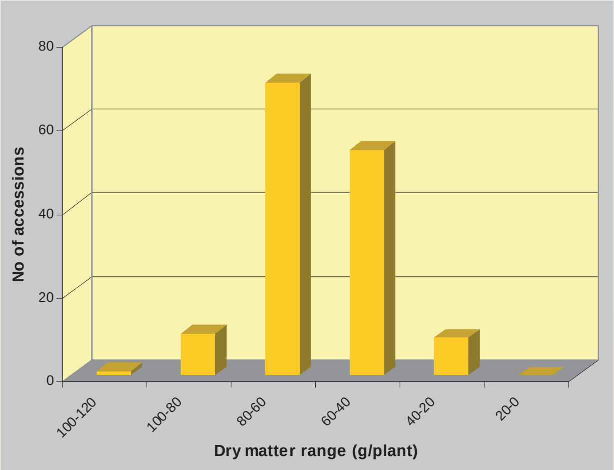


Figure 39: Range of dry matter production of barley nursery IBCB-W screened under 10 dS m^{-1} salinity level

The total number of accessions for nurseries 1, 2, 3, 4 and 5 were 116, 139, 120, 110 and 135, respectively. The genotypes were sown in pots for preliminary screening at single salinity (10 dS m^{-1}). Data were collected for biomass and seed yield for each genotype for all nurseries.

Generally, the genotypes tested in both Experiments II and III showed significant differences in terms of biomass production. The wide variability among genotypes in the yield parameters provides the basis for the selection of suitable genotypes. Results for all nurseries are presented in Figures 38-42. All nurseries showed large variation in dry matter yield and seed production. Based on these results, the top 25% of the genotypes in each nursery were selected for further evaluation under various salinity levels.

The salt tolerance of barley is among the highest of all food crops

Barley trials at ICBA showing variations in response to salinity among varieties

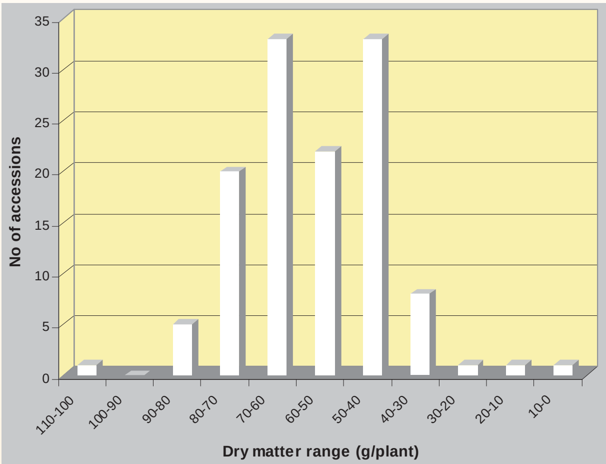


Figure 40: Range of dry matter production of barley nursery IBCB-S screened under 10 dS m^{-1} salinity level at ICBA

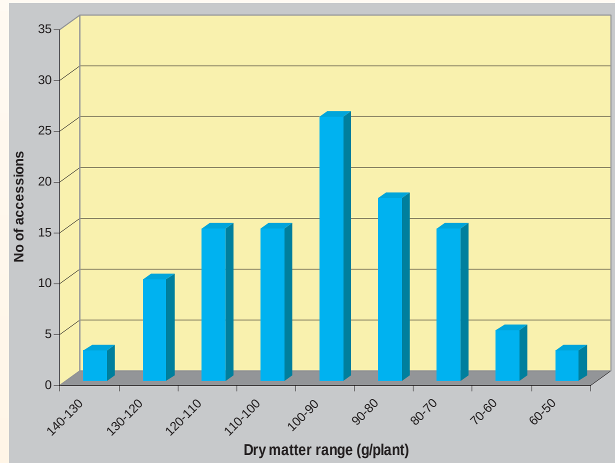


Figure 41: Range of dry matter production of barley nursery IBON-LRA-M screened under 10 dS m^{-1} salinity level at ICBA

Proposed activities for 2007

Seeds from all three experiments will be collected and prepared for use in next year's planting. Experiment I will be continued for the next screening cycle as before. However, from Experiments II and III, best-performing genotypes will be selected based on biomass production and seed yield. Seeds of the best genotypes will be sown under field conditions at three salinity levels. Moreover, seeds will be produced in sufficient quantity for distribution among partner countries in the WANA region for evaluation and trials. Plant tissue samples will also be analyzed to determine the forage quality parameters.

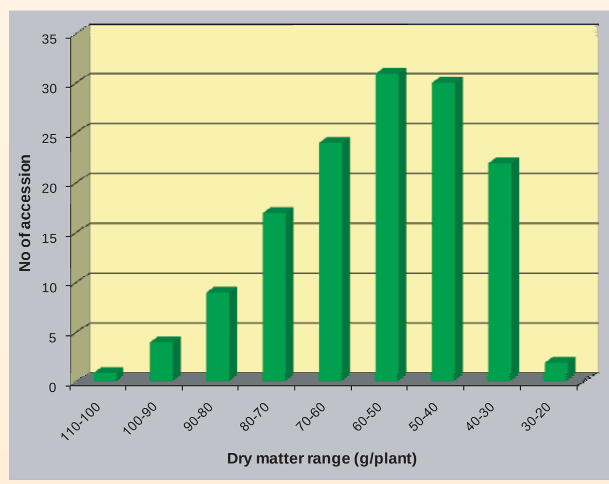


Figure 42: Range of dry matter production range of barley nursery IBON-MRA screened under 10 dS m^{-1} salinity level at ICBA

Barley trials in controlled pot screening

Evaluation of salinity tolerance and fodder yield of fodder beet and fodder rape/brassica varieties (PMS18)

Duration: 2003-07
Resources: Core

Highlights

- ***Seven commercial fodder beet and 4 brassica/rape varieties were evaluated for yield potential under salinity. ICBA's work provides backup field information on salinity tolerance and yield to NARS.***
- ***The top yielding variety, Abondo, produced highest dry matter among all varieties. Below-ground yield of fodder beet (7.81 t ha^{-1}) was higher than above-ground yield. Mean yield of brassica/rape varieties tested over all the salinity levels was 4.72 t ha^{-1}. Hobson produced the highest yield (7.63 t ha^{-1}). Mean above-ground yield of brassica/rape varieties was 3.86 t ha^{-1}, far higher than below-ground yield of 0.86 t ha^{-1}.***
- ***Salinity had a marked effect on both above- and below-ground biomass production of both fodder beet and brassica/rape. Although biomass yield declined with increased salinity, the study identified varieties capable of maintaining acceptable yield levels up to 15 dS m^{-1}.***

Significance of the project

Salinity occurs naturally in arid and semi-arid regions. Problems caused by soil salinity are compounded when a high water table impedes root development and concentrates salts in the already limited root zone. Biosaline agriculture technology, an alternative approach for effective utilization of salt-affected soils, involves the cultivation of salt-tolerant species/cultivars with genetic traits. It includes screening and selection of highly salt-tolerant plant species/varieties from both landraces and elite germplasm and introducing selected plants into saline areas.

Fodder beet and brassica species are widely grown as winter forage crops. They have several advantages, including fast growth, easy seed production, growth at low temperature and considerable frost tolerance. They are recommended as alternatives for winter fodder crops. Brassicas are high in dry matter digestibility at 85-95% (as compared to alfalfa at 70%). They also contain significant amounts of certain minerals and are high in protein.

Fodder beet trials at ICBA

Objectives

- Evaluate salinity tolerance among selected varieties of fodder beet and brassica/rape.
- Procure and supply sufficient amounts of seed of these varieties to the region's national programs for multi-location field evaluation.
- Provide information to collaborating institutes about salinity tolerance of fodder beet and brassica/rape varieties.

Achievements in 2006

Seeds of seven fodder beet and four brassica varieties were imported from different international commercial seed producers. Seeds were grown under field conditions to evaluate for salinity tolerance. Standard agronomic practices were followed throughout production. Three levels of irrigation water salinity (5, 10 and 15 dS m^{-1}) were supplied through drip irrigation.

Results

Response of fodder beet varieties to salinity

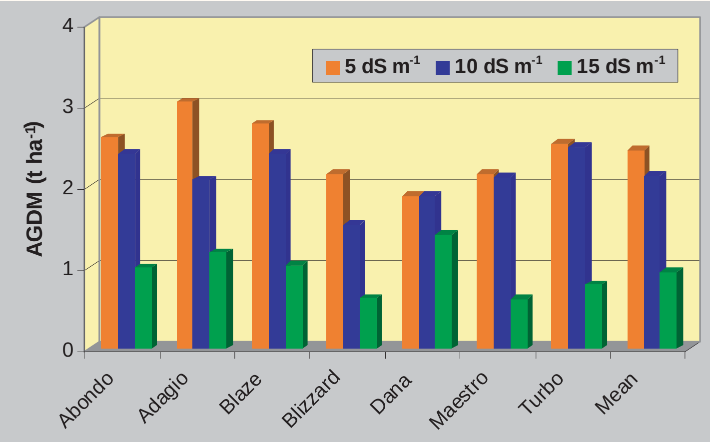


Figure 43: Above-ground dry matter (AGDM) production of fodder beet varieties under 3 salinity levels at ICBA

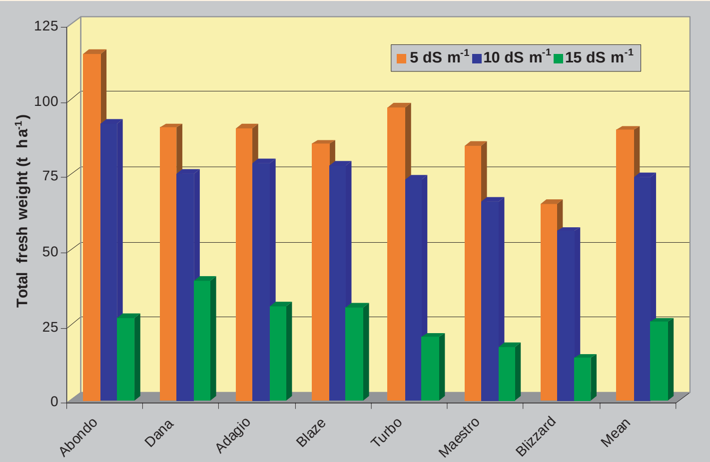


Figure 44: Fresh matter production of fodder beet varieties at 3 salinity levels at ICBA

Data were collected for important plant characteristics and statistically analyzed. Above-ground dry matter production ranged from a maximum 3 t ha^{-1} at low salinity in variety Adagio to 1.4 t ha^{-1} at high salinity (15 dS m^{-1}) (Figure 43). Variety Dana had the best yield at high salinity. Medium salinity level (10 dS m^{-1}) had minimum impact on yield reduction, while high salinity reduced yield by more than 50% in most varieties.

In addition to their high salinity tolerance, fodder beet and brassica have high nutritional value relative to other forages

Total fresh weight of above-ground parts and tubers varied from 65-115 t ha^{-1} at low salinity to 14-40 t ha^{-1} at high salinity (Figure 44). Similarly, tuber dry weight declined sharply at high salinity to less than one third of the low salinity production level (Figure 45). Varieties Dana, Adagio and Blaze had the best yield at high salinity, while Abando had the highest yield at low salinity as well as the overall mean over all salinity levels (Figure 46). Although variation in reaction to salinity was evident in most varieties, this study identified specific varieties capable of maintaining acceptable yields even at

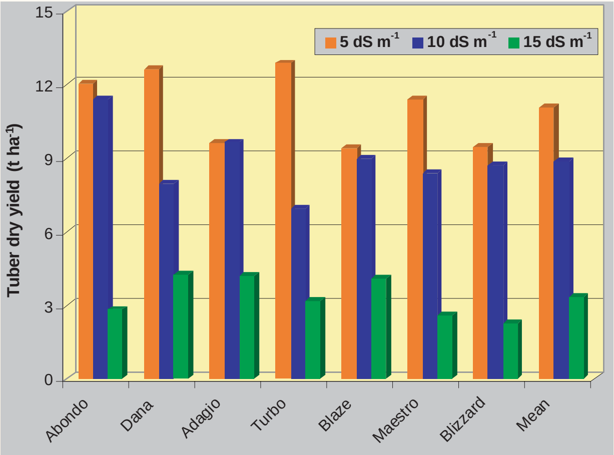


Figure 45: Tuber dry yield of fodder beet varieties at 3 salinity levels at ICBA

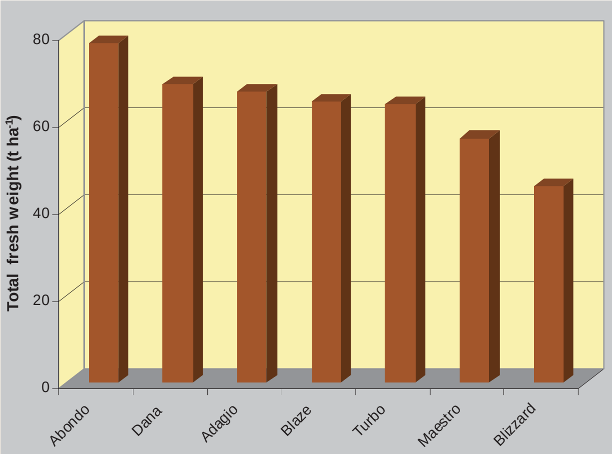


Figure 46: Total fresh yield of fodder beet varieties at 3 salinity levels at ICBA

high salinity levels. Comparable yields were obtained in other locations with higher yield levels per hectare due to increased planting density.

Response of brassica/rape varieties to salinity

The four varieties evaluated contain both forage and dual-purpose types. Forage types Hobson and Interval performed very well under both saline and non-saline conditions with dry yield level ranging from 3 to 13 t ha^{-1} under low and high salinity (Figure 47). Multi cut was not applied at this stage, but further field evaluation will focus on this aspect.

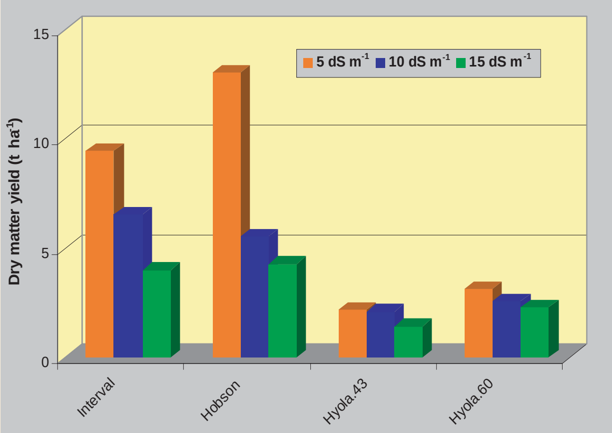


Figure 47: Dry matter yield of brassica/rape varieties under 3 salinity levels at ICBA

Proposed activities for 2007

Seeds of more varieties of fodder beet and brassica/rape have been imported from Denmark, Australia and China. These varieties will be evaluated further in the field both at ICBA and at partner research stations in other countries. Trials in multi-location fields will eventually lead to concrete conclusions regarding the salinity tolerance potential of fodder beet and brassica/rape varieties. Recommendations could then be made concerning the use of selected varieties under specific sets of environmental conditions.

Brassica trials at ICBA

Screening for salinity tolerance among large collections of buffelgrass (*Cenchrus ciliaris*) (PMS19)

Duration: 2003-07
Resources: Core

Highlights

Forty* Cenchrus ciliaris *accessions were grown under field conditions for screening at three salinity levels. These were selected from previous screening of a larger collection of 160 accessions. Two harvests were completed in 2006. Accessions showed wide genetic variability. Yield response demonstrated the potential to select genotypes with economical yields up to 20 dS m^{-1}.

Significance of the project

Continuous inclusion of new species for use as fodder is extremely important for expanding the existing plant pallet and enhancing the sustainable utilization of agro-ecosystems. It is especially important for arid and semi-arid regions where harsh environmental conditions limit the production of many crop species. Salinity is one of the major abiotic stresses in these areas. The evaluation and screening of new germplasm is therefore essential to select salt-tolerant crop species and varieties that can be grown successfully in arid lands.

Several genotypes showed high potential for biomass production under a wide range of salinity levels.

Objectives

- Assess *Cenchrus* accessions, including local landraces.
- Evaluate the selected accessions for forage yield and quality under field conditions.
- Multiply and distribute seed to the NARS of the WANA region.
- Optimize production and management technology for *Cenchrus* production in the UAE and similar areas.
- Collect baseline data and transfer the technology to partner countries.

Achievements in 2006

Buffelgrass trials at ICBA

Forty accessions selected from 160 tested during the previous season were grown at ICBA under field conditions at three salinity levels: EC 7, 14, and 20 dS m^{-1}. Two harvests were completed in 2006. Soil samples were obtained in order to monitor salinity levels in the root zone and to investigate the effect of irrigation water salinity on the chemical and physical properties of the soil. The average dry matter yield over all the salinity levels was 11.7 t ha-1. The yield declined with increased in salinity levels, and higher yield was obtained in the first cut (12.7 t ha-1) compared with the yield in the second cut (10.7 t ha-1).

Results

Dry matter yield in the 40 genotypes varied considerably under all salinity levels. At 7 dS m-1, yield ranged from 5 to 35 t ha-1, at 14 dS m-1 from 3 to 19 t ha-1 and at 20 dS m-1 from 2 to 13 t ha-1. The 10 best-yielding accessions over all salinity levels are shown in Figure 48. Several genotypes showed high potential for biomass production under a wide range of salinity levels. Total annual yield and potential number of harvests will be assessed in 2007. The best-performing accessions under the three salinity levels are shown in Figure 49. As expected, some of the genotypes that performed well under low levels of salinity did not do well under high levels (eg, accession Grif 1639). Although PI 225012, PI 409174, PI 365650 and PI 161633 all showed lower yield at low salinity than Grif 1639, they showed more yield stability and higher relative yields at high salinity levels. Cumulative effects of salinity will be more evident in subsequent harvests.

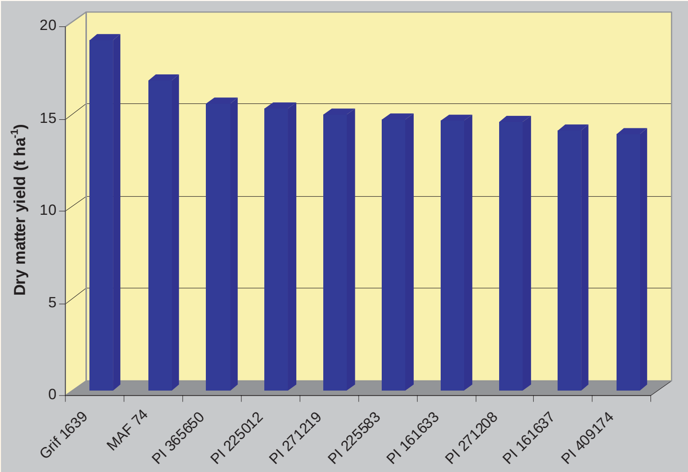


Figure 48: Mean dry matter production of high-yielding *Cenchrus ciliaris* accessions over 3 salinity levels

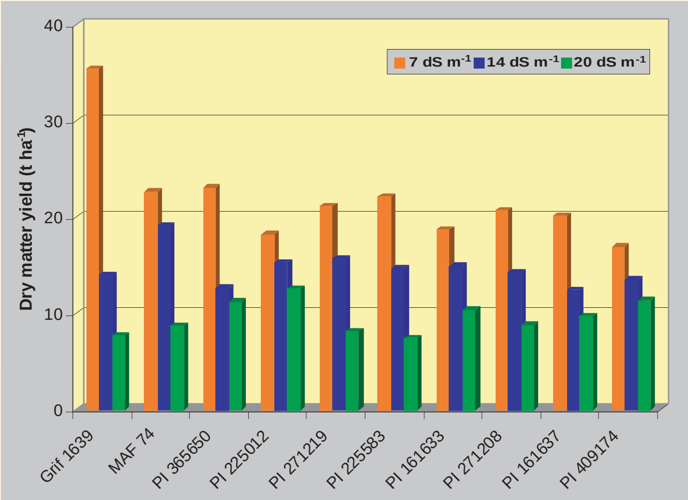


Figure 49: Dry matter production of top 10 *Cenchrus ciliaris* accessions at 3 salinity levels

Proposed activities for 2007

The experiment will be monitored throughout the duration of the project. Data on field management and agronomic practices for *Cenchrus* forage production will be collected. The cutting schedule will be optimized and adjusted to allow for making conclusions and recommendations at the end of the project. Data from other countries will also be collected and compared to reach more concrete conclusions. Plant samples will be subjected to laboratory analysis to determine biochemical characteristics and quality parameters of *Cenchrus* fodder.

Buffelgrass: a versatile crop

Saving fresh water resources with salt-tolerant forage production in marginal areas of the WANA region – an opportunity to raise the incomes of the rural poor (PMS27)

Duration: 2004-08
Collaborators: Jordan, Oman, Pakistan, Palestine, Syria, Tunisia and the UAE
Resources: IFAD, AFESD, OFID, the NARS of the seven countries, Core

Highlights

The project will prepare underdeveloped and developing countries to build animal production systems that improve livelihoods and contribute to four Millennium Development Goals (MDGs)

Significance of the project

This project was approved and financially supported in late 2004 by IFAD for a grant of USD 1.35 million and co-financed by AFESD, which provided a grant of USD 1 million for all components of the project except those relating to Pakistan. The UAE component is not supported by the IFAD grant.

OFID supported the component relating to sorghum and pearl millet in UAE and Oman (PMS15), the component that leveraged the full project, and the aspects of capacity building related to forage production with saline water.

Objectives

The goal of the project is improved livelihoods and higher incomes for resource-poor rural men and women in degraded and marginal lands in the WANA region.

This project will prepare underdeveloped and developing countries to build animal production systems that improve livelihoods and contribute to four Millennium Development Goals (MDGs):

MDG 1: Eradicating extreme poverty and hunger

MDG 3: Promoting gender equality and empowering women

MDG 7: Ensuring environmental sustainability

MDG 8: Developing a global partnership for development

This overall goal will be met by focusing on three objectives.

- Increase feed availability for livestock through sustainable use of underutilized saline water resources.
- Integrate the use of saline water into an overall strategy of sustainable semi-arid and arid farm system management.
- Capacity development of NARS.

Achievements in 2006

Project management

The first meeting of the project Steering and Technical Committees was convened in Dubai in 2005. Work plans and budgets for each participating country were developed and approved by the two committees. Technical cooperation agreement and project agreements were also signed with each of the seven countries partners in the project.

All countries made satisfactory progress in implementing the main objectives of the first year

In February 2006, the second Steering and Technical Committee meeting was also held in Dubai. This meeting had two main outputs.

1. The progress made by each country in implementing the work plans and objectives of the first year was evaluated and the obstacles encountered were assessed. Generally, all countries made satisfactory progress in implementing the main objectives of the first year. Details of work achieved by each country are given in the review report. The main activities during the first year were:
    - Establishment of a full demonstration site at each NARS to introduce salt-tolerant forages and management practices to the targeted region.
    - Introduction of salt-tolerant forages and management packages to one or more selected farmers in the region.
    - Collection of data and monitoring the fields.
2. Develop work plans and budgets for the second year.

Project implementation

The full project became operational in all seven countries following meetings of the two committees. Funds were released to each national program by ICBA in accordance with the Cooperation Agreements to execute the work plans. Difficulties were encountered in money transfer to Palestine and Syria due to restrictions imposed outside of the control of ICBA and the receiving country. In Syria, funds must be transferred

Technical and Steering Committees meeting at ICBA, February 2006 through a money transfer bureau instead of a bank because of recent government-imposed restrictions.

Implementation plans for 2006 for the seven countries and ICBA were finalized during the Technical and Steering Committee meetings in Dubai in February 2006. The implementation plan included details of activities to be undertaken by each country during 2006 and early 2007.

The detailed activities in year two according to outputs are presented in the project's annual report. The main points are summarized below.

Output 1. *Productive salt-tolerant forage grasses, legumes and shrubs identified and distributed to national programs in the Near East and North Africa for irrigated cultivation under saline conditions*

- ICBA and NARS staff worked together to identify suitable salt-tolerant grasses, legumes and shrubs for the demonstration sites.
- A final list for each country was included in the implementation plan.
- In addition to locally available materials at the NARS, ICBA supplied each country with nearly 140 accessions of 11 forage species.
- Several additional fodder beet, brassica and rape were provided through ICBA from producers to NARS directly. More varieties were procured.
- Screening facilities for field salinity evaluation were completed in 2006.
- Salinity tolerance of selected species was evaluated.
- New species were introduced at the demonstration plots and in farmers' fields.
- Promising salt-tolerant forage species were selected at the national level for wider distribution and large-scale evaluation in subsequent years.

Crop growth and irrigation system provided through the project in a farmer's field in Oman, June 2006

Output 2: *Soil salinity management packages incorporating irrigation systems and low-cost drainage options for sustainable biosaline forage production*

- Few countries compiled and summarized information on quantity and quality of groundwater resources in the target areas and more widely in the country.
- In each country 3-5 farms participated in the project activities. They were supported with irrigation systems and other requirements.
- All countries collected soil, water, climatic and crop production data on all demonstration sites for use in crop modeling, as outlined in the guidelines provided during the first year.

Output 3: *Optimized systems for economic and environmentally sustainable production of forages using saline water resources developed and transferred to national programs*

- Farmers' field plots of selected forage crops (alfalfa, barley, pearl millet and sorghum) were established.
- Summer and winter crops were demonstrated in selected farmers' fields.
- Three countries collected baseline socio-economic data for impact assessment. Initial analysis was performed as agreed and outlined in the output of the expert group meeting held in 2005.

Growth of different salt-tolerant species at Al-Khaldia station, Jordan

Output 4: *Capacity development of research and development staff of countries of the Near East and North Africa in all aspects of biosaline agriculture*

A. Workshops

1. Traveling workshop

A 10-day traveling workshop was held in Syria 9-15 September that brought together 25 technical staff from the seven partner countries (Jordan 4, Oman 2, Pakistan 2, Palestine 3, Tunisia 3, Syria 8 and UAE 3). All participants were involved in field implementation.

The workshop focused on field activities and exchange of knowledge. The opening session included lectures concerning the strategies and general achievements of both ICBA and the General Commission of Scientific Agricultural Research (GCSAR); forage project objectives and main activities during 2006; and GCSAR achievements in forage project implementation. Participants from the seven NARS presented progress reports from their respective countries.

During the following five days, the participants visited diverse agro-ecosystems, large-scale irrigation and drainage systems, farmers' fields and NARS implementation sites. On the way to the eastern part of Syria, participants visited forage shrub production sites, water harvest projects, Palmyra Oasis, Al Talilah large-scale wildlife and plant communities protected areas (22,000 ha) and other desert forage protected areas.

Participants visited the forage project implementation sites near Deir-Eezzor, participated in a field day with farmers and technical staff, visited farmers' fields and plant production systems based on the use of saline ground water, and modern reclamation projects and use of agricultural drainage water in irrigation. Following the two days in the East, the workshop moved to the northern Syria towards Aleppo. On the way, participants visited different plant production systems and salt-affected farms. A lengthy visit to the Euphrates dam, storage lake and irrigation projects took place. In the afternoon large-scale irrigation and drainage projects were also visited. On the last day, participants visited crop and fruit tree production systems based on the use of groundwater with different salinity levels. The group also visited GCSAR research stations on the road and observed various irrigation and groundwater management techniques.

The project aims at developing sustainable forage crops for feeding animals in the WANA region

At the conclusion of the traveling workshop all participants, scientists and officials recognized the importance of such capacity building workshops for the WANA region, and all of them recommended that more workshops be held in future.

ICBA staff participated in field days in Jordan, Oman, Pakistan, Syria and UAE

2. Training workshop on *Use of saline water resources in agricultural production*

This training workshop was held jointly in collaboration between ICBA, the Arab Organization for Agricultural Development (AOAD) and the UAE's MOEW 19-25 November in the UAE. Fourteen participants from the seven country participants in the forage project, as well as 19 participants from other Arab countries, participated.

The objectives of the training were to review basic principles and guidelines related to the use of saline water resources in agricultural production and to relate experiences of Arab countries and regional institutes in biosaline agriculture.

B. Individual training

Five technical staff from the project team in Jordan, Oman and Syria (as well as ICBA) participated in a training course on *Pearl millet breeding and production* organized by ICRISAT (Hyderabad, India) during May 2006.

C. In-country training

Six of the seven participating countries (Jordan, Oman, Pakistan, Palestine, Tunisia and UAE) organized one training course for the project team and collaborators. Syria organized two courses.

D. Field days

All the seven countries organized at least one field day for farmers in the area around the NARS demonstration site.

E. Follow-up field visits

ICBA scientists and technicians visited the participating countries for follow-up and meetings with local project teams to explain the objectives of the project in depth. Implementation plans and expected achievements from the country's project team

Officials and farmers participating in the Field days in Pakistan and Jordan, 2006 during 2005/06 were thoroughly discussed. Also, ICBA staff participated in field days in Jordan, Oman, Pakistan, Syria and UAE. All seven countries were visited in response to special requests. ICBA staff also provided technical backstopping and consultations on specific issues when so requested by NARS.

These visits proved very effective in motivating local project teams to explain the work in detail and to advise on appropriate procedures for establishing the demonstration sites and the planting and management of the forage plant species/accessions. Such visits are needed on a regular basis to fill gaps in implementation and management of the project. Field days were also very productive in presenting the objectives and benefits of farmers' participation.

F. Seed procurement and distribution to NARS

ICBA staff strove to provide NARS with seed supply to conduct planned field activities. Each country was supplied with 132 accessions of 11 species. Several countries received additional quantities of certain species as available. Also, ICBA procured fodder beet, forage brassica and rape, sending them directly through commercial companies in Australia and Europe. Additional quantities were procured and prepared for dispatch upon preparation of required documents. ICBA also reached agreement with ICRISAT to produce pearl millet and sorghum seed in quantities sufficient to meet demand for summer 2007 planting. Negotiations with commercial companies in India are under way to procure seeds of commercially available pearl millet and sorghum hybrids to be used by farmers and NARS. Detailed information on the seeds is presented in Table 7.

Field visits by ICBA staff to NARS (Tunisia, Syria and Pakistan, 2006)

Table 7: Basic set of seeds supplied to NARS in 2006

S No	Acc No	Accession/crop	S No	Acc No	Accession/crop	S No	Acc No	Accession/crop
Bufflegrass			**Alfalfa**			74	19	Speed Feed
1	1	PI 153671	39	1	Omani	75	20	Sugar Graze
2	2	PI 161633	40	2	Eureka	76	21	Super Dan
3	3	PI 161637	41	3	Sceptra	77	22	Sweet Jumbo
4	4	PII 185564	42	4	Iraqi	78	23	Pioneer 858
5	5	PI 225012	43	5	American	79	24	Omani landrace (white)
6	6	PI 225583	44	6	Pakistanian	80	25	Omani landrace (red)
7	7	PI 271206	**Fodder beet**			**Pearl millet**		
8	8	PI 271208	45	1	Blaze	81	1	IP3616
9	9	PI 271209	46	2	Bblizzard	82	2	IP6094
10	10	PI 271214	47	3	Maestro	83	3	IP6098
11	11	PI 271219	48	4	Adagio	84	4	IP6101
12	12	PI 279596	49	5	Turbo	85	5	IP6104
13	13	PI 294595	50	6	Abondo	86	6	IP6105
14	14	PI 295659	51	7	Dana	87	7	IP6106
15	15	PI 365650	**Brassica**			88	8	IP6107
16	16	PI 365651	52	1	Interal	89	9	IP6109
17	17	PI 365720	53	2	Hobson	90	10	IP6110
18	18	PI 385321	54	3	Hyola 43	91	11	IP6111
19	19	PI 409174	55	4	Hyola 60	92	12	IP6112
20	20	PI 409216	**Sorghum**			93	13	IP19586
21	21	PI 409267	56	1	ICSB203	94	14	IP19612
22	22	PI 409429	57	2	ICSB405	95	15	IP22269
23	23	PI 409556	58	3	ICSB483	96	16	Dauro Genepool
24	24	PI 409669	59	4	ICSB707	97	17	Eraj Pop
25	25	PI 409689	60	5	ICSB196	98	18	GB8735
26	26	PI 409704	61	6	ICSB93024-1	99	19	Guerinian-4
27	27	PI 414447	62	7	ICSV745	100	20	HHVDBC Tall
28	28	PI 414452	63	8	ICSV112	101	21	ICMS 7704
29	29	PI 414499	64	9	ICSV93046	102	22	ICMV 155 Brist
30	30	PI 414513	65	10	SP47513	103	23	ICMV 155e,e1
31	31	PI 442096	66	11	SP47529	104	24	ICMV 155 Original
32	32	PI 443507	67	12	ICSR172	105	25	ICMV87901 Brist
33	33	PI 516516	68	13	SP40516	106	26	ICMV 92901
34	34	Grif 1619	69	14	ICSB682	107	27	Leonis genepool
35	35	Grif 1639	70	15	ICSB702	108	28	SRBC
36	36	MAF 74	71	16	SP39007	109	29	Sudan Pop III
37	37	MAK 7	72	17	SP39105	110	30	Nutrifeed
38	38	MAK 9	73	18	ICSV93048			

Table 7 *(cont'd)* **: Basic set of seeds supplied to NARS in 2006**

S No	Acc No	Accession/crop	S No	Acc No	Accession/crop	S No	Acc No	Accession/crop
Barley			121	11	91/2 A	132	22	ICARDA 8
111	1	58/1 A	122	12	111/4 A	133	23	ICARDA 20
112	2	59/3 A	123	13	116/2 A	134	24	AD 187
113	3	60/1 A	124	14	50/3 B	135	25	186 AD
114	4	61/1 A	125	15	51/1 B	***Atriplex***		
115	5	63/2 A	126	16	100/1 B	136	1	*amnicola*
116	6	76/2 A	127	17	100/2 B	137	2	*nummularia*
117	7	82/2 A	128	18	113/1 B	138	3	*undulata*
118	8	83/1 A	129	19	6/1 D	***Acacia***		
119	9	86/2 A	130	20	21/2 D	139	1	*ampliceps*
120	10	91/1 A	131	21	57/2 D			

PROPOSED ACTIVITIES FOR 2007

A mid-term review workshop was scheduled for March. The workshop will be held in Amman, Jordan, prior to the Technical and Steering Committee meetings. A new Work and Implementation Plan will be developed during the third coordination meeting for the remaining two years of the project. Training and capacity building will also be discussed and planned for the next two years.

Traveling workshop (above) and field day (below) in Syria, September 2006

Development of technologies to harness the productivity potential of salt-affected areas of the Indo-Gangetic, Mekong and Nile River Basins (PMS34)

Duration: 2004-07
Collaborators: International Rice Research Institute (IRRI); BARI; Rice Research and Training Center, Egypt; Rice Research Institute of Iran
Resources: CGIAR Challenge Program on Food and Water (through IRRI)

Significance of the project

ICBA contributed to the development of a project proposal submitted by IRRI to the CGIAR Challenge Program on Food and Water, which is coordinated by IWMI. The project was approved for funding and ICBA participated in an inception workshop held in the Philippines in March 2004 during which detailed work plans were developed. A letter of agreement with IRRI was signed in September 2004 to cover ICBA's inputs. Project activities were initiated in late 2004.

Objectives

- Identify salt-tolerant cultivars of crops that fit into rice-based cropping systems for salt-affected areas of Bangladesh, Egypt and Iran.
- Provide promising crops and varieties with salt tolerance to be validated in target areas.

Achievements in 2006

Seven fodder beet (*Beta vulgaris*) and 4 rape/canola (*Brassica napus*) cultivars were evaluated for salinity tolerance under field conditions at ICBA and several other locations in WANA. Three salinity levels (5, 10 and 15 dS m^{-1}) were used. Several beet varieties maintained high growth and yield up to 15 dS m^{-1}. Total fresh tuber weight ranged from 45 to 89 t ha^{-1} at low salinity and 9-27 t ha^{-1} at the high salinity level. With leaves, fresh weight ranged from 65 to 117 t ha^{-1} at low salinity and 13 to 40 t ha^{-1} at 15 dS m^{-1}. At low salinity, the best performing varieties

Brassica trials at ICBA

were Abondo, Dana and Turbo; while at high salinity, Dana, Blaze and Adagio were the best (see PMS18 on pp 62-64 for more information).

The growth patterns of rape/canola were erratic and the crops showed less tolerance for salinity than fodder beet. In general, fodder rape grew better than canola. Interval and Hobson were the best-performing fodder rape varieties.

Selected varieties or lines will be distributed for field testing in Egypt and Iran in early 2007

PROPOSED ACTIVITIES FOR 2007

- ICBA acquired 17 varieties of fodder beet and 14 brassica/rape varieties for evaluation at ICBA and other participating countries.
- Field evaluation of salinity tolerance and yield potential of fodder beet and fodder brassica species, as potential off-season crops for the Nile Delta of Egypt and the Caspian Sea coast of Iran, will be conducted during 2007 on a large scale at ICBA and in Egypt.
- Selected varieties or lines will be distributed for field testing in Egypt and Iran in early 2007.

Fodder beet trials at ICBA

Halophyte production

Water use and salt balance of halophytic species (PMS12)

Duration: Ongoing
Resources: Core

Significance of the project

Salt and water movements are dynamic processes, based on soil properties and climatic conditions. Furthermore, growth of different types of plant species also influences the movement of salts and water at different stages of growth and periods. Studying these processes under controlled conditions could lead to better irrigation and soil management practices. Lysimeter studies provide an opportunity to observe the salt-water balance and responses of plants to changes in soil profile. They also provide answers to irrigation volume and scheduling as well as the leaching fraction, which is needed to flush the salts from the rhizosphere. Another problem encountered is the proper disposal of drainage water with its high concentration of salts (and often such chemicals as pesticide residues and nitrates). It has become increasingly apparent that drainage water (waste water) is a very important resource that can and should be used in agriculture.

Studying the processes of salt and water movement under controlled conditions leads to better irrigation and soil management practices

Lysimeter studies undertaken at ICBA provide a model to study the various physical and chemical aspects of using drainage water in agriculture. Since it carries numerous minerals and salts, drainage water must complement the salt tolerance of the plants used. In both the USA and Australia, a serial biological concentration (SBC) approach has been successfully adapted where drainage water is used to grow different salt-tolerant plant species in successions.

Objectives

- Develop productivity management of promising halophytic species for forage. Test plant genotypes exhibiting salt tolerance in lysimeters for productivity management.
- Study the effects of water quality/quantity, harvest period and frequency, and nutritional aspects for optimizing productivity.
- Simulate studies related to re-use of drainage water for efficient water utilization, minimum drainage disposal, and maximizing productivity for increasing the salt tolerance of plants.

Lysimeter studies over time have given ICBA scientists significant data about salinity tolerance in a range of plants

	Set 1	Set 2	Set 3	Set 4	Set 5	
	10.44	10.66	10.98	10.03	10.94	← EC_{iw}
Grasses	*L. fusca*	*S. arabicus*	*S. virginicus*	*P. vaginatum*	*D. spicata*	
	16.10	16.25	16.01	15.78	15.98	← EC_{dw}
Trees	*C. lancifolius*	*T. stricta*	*S. persica*	*A. ampliceps*	*C. lancifolius*	
	23.79	22.91	22.91	22.66	23.14	← EC_{dw}
Halophytes	*A. canescens*	*A. lentiformis*	*A. nummularia*	*A. halimus*	*A. undulata*	
Drainage water	32.36	32.62	31.61	32.66	32.01	

Figure 50: Layout of trial for serial use of drainage water. Data in top row indicate the salinity (in dS m^{-1}) of irrigation water (EC_{iw}). The data in the other rows show salinity of drainage water (EC_{dw}). The bottom line shows the salinity of the brine (drainage) water.

Achievements in 2006

Five sets of different plant species (grasses, shrubs and trees) were grown with increasing salinity of drainage water (Figure 50). Growth and productivity of the test species were assessed in reference of volume and salinity of irrigation water. The plants were harvested in 2006.

Growth of tree species was evaluated by measuring plant height at different periods of the year (Figure 51). Among the species tested, *Tamarix stricta* showed maximum increase in plant height (2.52 m), followed by *Acacia ampliceps* (1.87 m). *T. stricta* exhibited an increase of 67% during the year, whereas *A. ampliceps* showed an increase of 49%.

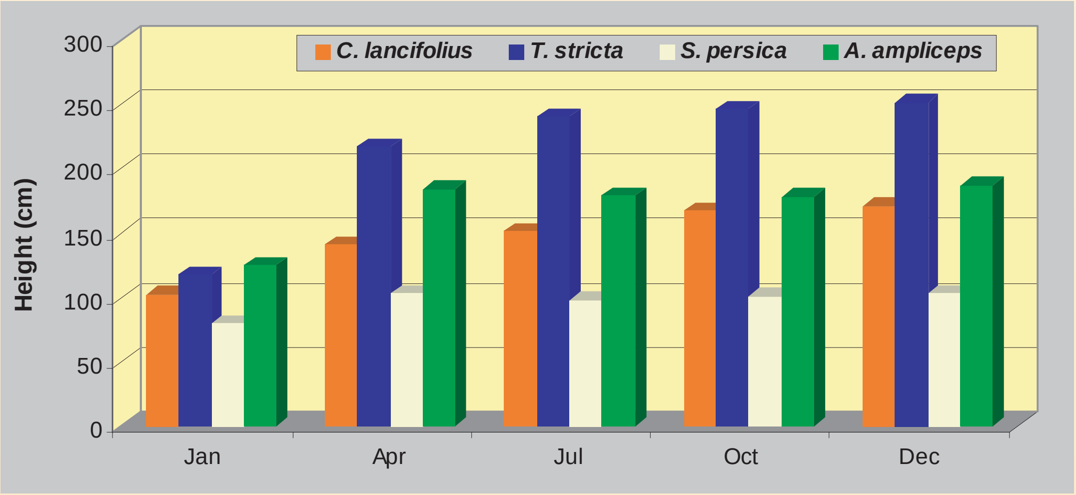


Figure 51: Plant height of various tree species irrigated with drainage water (15.78-16.25 dS m^{-1})

Table 8: Growth and biomass productivity of grass, tree and halophytic species (Figures in first rows for each set indicate the level of salinity of the water in which the groups of plants were grown)

Parameters	Units	Plant species			Drained water
		Leptochola fusca	*Conocarpus lancifolius*	*Atriplex canescens*	
Salinity of water	dS m^{-1}	10.44	16.10	23.79	32.36
Shoot length	cm	39.40	176.40	36.80	-
Shoot fresh biomass	gm m^{-2}	1883.74	1207.38	116.55	-
Shoot dry biomass	gm m^{-2}	1251.18	718.46	54.40	-
Root length	cm	45.00	161.00	113.60	-
Root fresh biomass	gm m^{-2}	2341.01	1334.42	62.43	-
Root dry biomass	gm m^{-2}	1806.45	742.25	29.55	-
		Sporobolus arabicus	*Tamarix stricta*	*Atriplex lentiformis*	
Salinity of water	dS m^{-1}	10.66	16.25	22.91	32.62
Shoot length	cm	41.60	130.50	97.40	-
Shoot fresh biomass	gm m^{-2}	580.97	2055.44	337.20	-
Shoot dry biomass	gm m^{-2}	347.76	1459.99	164.92	-
Root length	cm	52.60	90.80	150.00	-
Root fresh biomass	gm m^{-2}	775.48	1134.16	211.33	-
Root dry biomass	gm m^{-2}	457.29	687.96	85.82	-
		Sporobolus virginicus	*Salvadora persica*	*Atriplex nummularia*	
Salinity of water	dS m^{-1}	10.98	16.01	22.91	31.61
Shoot length	cm	11.00	90.80	129.00	-
Shoot fresh biomass	gm m^{-2}	763.15	453.86	498.91	-
Shoot dry biomass	gm m^{-2}	347.76	1459.99	164.92	-
Root length	cm	50.33	72.00	110.20	-
Root fresh biomass	gm m^{-2}	596.29	371.26	201.85	-
Root dry biomass	gm m^{-2}	338.90	190.84	98.58	-
		Paspalum vaginatum	*Acacia ampliceps*	*Atriplex halimus*	
Salinity of water	dS m^{-1}	10.03	15.78	22.66	32.66
Shoot length	cm	5.40	226.80	91.80	-
Shoot fresh biomass	gm m^{-2}	1266.03	1587.18	248.93	-
Shoot dry biomass	gm m^{-2}	719.42	992.40	101.26	-
Root length	cm	55.80	151.20	95.80	-
Root fresh biomass	gm m^{-2}	955.44	1130.48	108.62	-
Root dry biomass	gm m^{-2}	598.88	607.84	45.61	-
		Distichlis spicata	*Conocarpus lancifolius*	*Atriplex undulata*	
Salinity of water	dS m^{-1}	10.94	15.98	23.14	32.01
Shoot length	cm	11.33	160.00	106.60	-
Shoot fresh biomass	gm m^{-2}	999.49	894.89	236.77	-
Shoot dry biomass	gm m^{-2}	659.83	642.23	115.52	-
Root length	cm	87.00	115.60	77.40	-
Root fresh biomass	gm m^{-2}	1505.78	985.43	61.39	-
Root dry biomass	gm m^{-2}	988.86	663.26	27.74	-

Growth and biomass of all species harvested is provided in Table 8. Among grasses, shoot length was maximum for *Sporobolus arabicus* and *Leptochola fusca*, with higher shoot biomass in *L. fusca* and *P. vaginatum*. Root length and weight were higher for *L. fusca* and *D. spicata* than other species. Among tree species, *Acacia ampliceps* and *Conocarpus lancifolius* exhibited greater shoot length, with higher biomass for *Tamarix stricta*. Root biomass was similar for *C. lancifolius*, *T. stricta* and *A. ampliceps*. Among halophytes, *Atriplex nummularia* and *A. lentiformis* (woody halophytes) showed higher productivity. In general, grasses and trees showed higher biomass than halophytes because the latter species were grown at lower salinity levels.

Attempts were also made to quantify the volume of water consumed and/or drained at each level of plant groups. Average daily volume of drainage water for the year showed that grass species consumed about 50% of water through evapo-transpiration, whereas, tree species used 25-39% and halophytic shrubs 8-12%, depending on the species tested (Figure 52).

Data for all species grouped as grasses, trees and shrubs averaged for the whole year showed that total water consumption through biological use contributed to about 85%, with 15% drained down, if three crops are used. This reduction in volume of water increased the salinity of drainage water three times the level of the

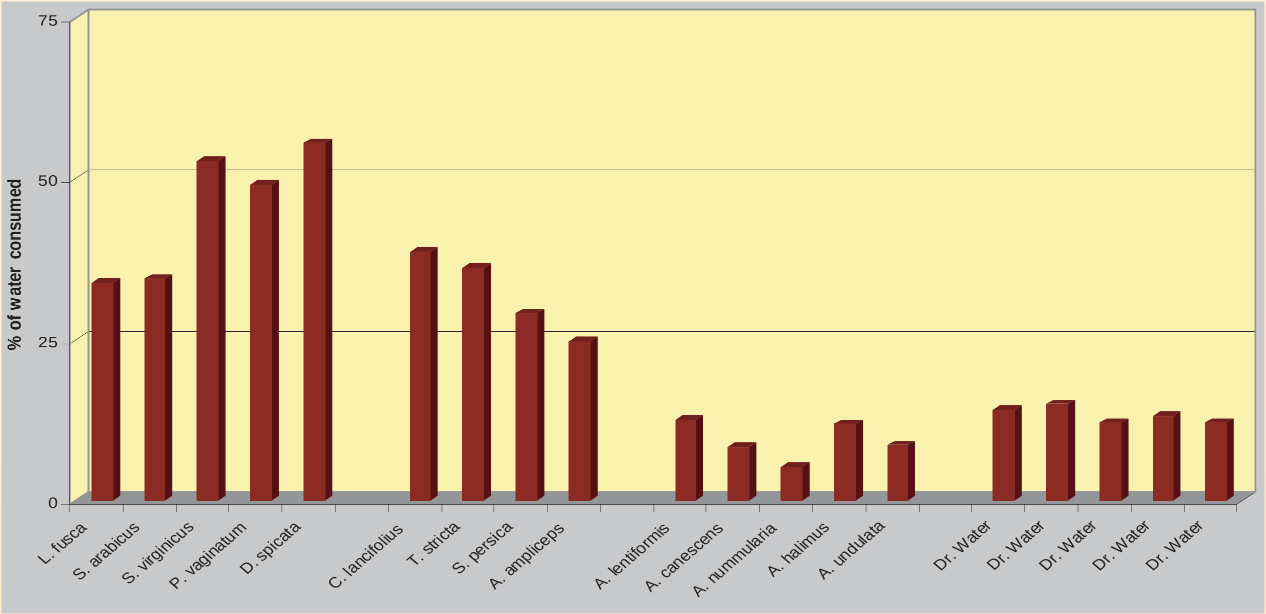


Figure 52: Amount of water consumed through evapo-transpiration and other losses by different groups of plant species (Volume of water drained in the end after three crops constituted about 12-15% for the different groups of plants tested)

irrigation water used for the first crop (grasses in this case), as shown in Figure 50. Salinity of the drainage water measured throughout the year for all the five sets of plants ranged between 31.59 and 32.37 dS m^{-1}.

Soil salinity was measured at two soil depths during final harvest. EC remained the same at both soils depths (0-30 and 30-60 cm) (Figure 53). Soil salinity was lower in lysimeters with grasses and higher when *Atriplex* species were grown.

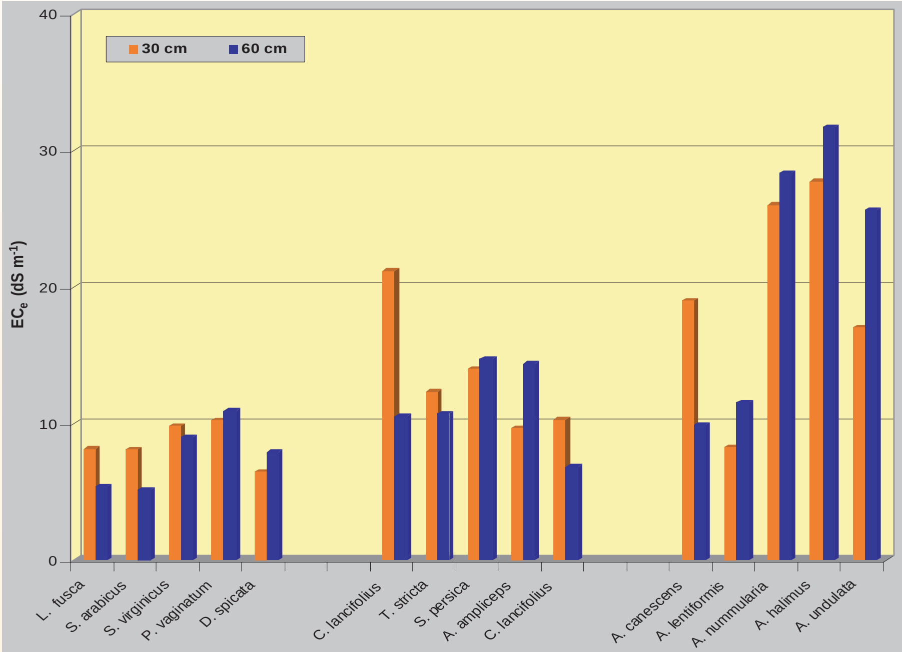


Figure 53: Soil salinities (EC_e) as affected by growth of different species irrigated with drained water at 0-30 and 30-60 cm soil depths

Proposed activites for 2007

In 2007, emphasis will be given to nutrient management in drainage water under saline conditions. Data will be collected on the chemical content of drainage effluents and their interaction with salts in the different plant species. This information is important in order to protect the environment from toxic effluents introduced into the soil through drainage water. Attempts will also be made to study biological methods for cleaning the drainage waste water to render it safe for use and re-use.

Grasses and trees levels of the lysimeter

Use of low quality water for productive use of desert and salt-affected areas in Pakistan (PMS21)

DURATION: 2003-06
COLLABORATOR: Pakistan Agricultural Research Council (PARC)
RESOURCES: PARC, Core

SIGNIFICANCE OF THE PROJECT

Pakistan is facing the effects of global changes. During the last 3 years there has been a 40% shortfall in water supply through the Indus Basin irrigation system. Moreover, the country's population has increased fivefold over the last 50 years, with a consequent fall in the per capita availability of water. This situation necessitates the use of marginal quality water for agriculture.

Of the total cultivated land in Pakistan, 6.8 million ha is salt-affected. These lands have poor economic and social implications, especially for resource-poor farmers. Such areas constitute about 47% of Sindh province and more than 15% of Punjab province. If these areas could be brought under cultivation of fruit trees and crops using saline groundwater for irrigation, crop production would be significantly boosted and the financial resources of the community enhanced.

47% of Sindh province and 15% of Punjab province are salt-affected

ICBA initiated outreach collaborative projects with developing countries among members of the Organization of Islamic Conference (OIC). The major thrust of such collaborative research is to strengthen the work undertaken by partner countries and to provide expertise from ICBA scientists and others. This project was initiated in collaboration with PARC in January 2003 for a period of 3 years. However, in early 2006, PARC sent an official request to ICBA for an extension of 1 year to complete pending work. Because no additional funding was requested, the request was approved by ICBA management.

OBJECTIVES

- Select and adapt appropriate species for silvo-horticultural systems.
- Evaluate irrigation techniques for efficient utilization of low-quality water.
- Monitor soil salinity under different management strategies.
- Develop management strategies for marginal lands and water.

ICBA has been able to help Pakistani farmers find ways to utilize their salt-affected soils

Achievements in 2006

ICBA and PARC initiated trials at three representative salt-affected areas to test management strategies for fruit, green manure and forage species for silvo-horticultural systems using poor quality water and salt-affected soils. The significant outcome of the project included the rehabilitation of wastelands that had been abandoned by the local community 45 years ago. The current project work in Bhalwal, which initially targeted an area of 3 ha, has been extended to 13 ha by the local farming community.

As a result of the work done on biological reclamation, kallar grass (*Leptochloa fusca*) and *Cynodon dactylon* have been grown with other silvicultural crops such as guava and zizyphus. These trials were conducted with different types of irrigation systems and water application rates (evaporation rates). Many fruit species did not survive establishment during the first year, with plant mortality of these species around 90%. The species were transplanted again later. *L. fusca* and *C. dactylon*, were harvested during 2006 and the results are being compiled.

Land abandoned for decades has been brought back in to cultivation

Propagation and development of *Distichlis spicata* var. Yensen-4a (NyPa forage) under arid environment (PMS29)

Duration: 2004-07
Collaborator: NyPa International
Resources: NyPa, Core

Background

Underground water in coastal areas is very saline due to seawater intrusion. As a result, both landscaping and agricultural activities are severely affected. With the exception of mangrove cultivation, very few opportunities exist for terrestrial plants to be grown under such high salinity. The situation also leads to different types of land degradation and exposes the areas to natural disasters.

Using seawater for irrigation, NyPa Forage provides an excellent opportunity for converting barren coastal areas into forage production areas

Halophytes are naturally found in such areas. However, without economic utilization of these halophytes, they are not commercially viable. Halophytes that can flourish under seawater irrigation have huge potential in many coastal regions. NyPa grass (*Distichlis spicata* var.Yensen 4a) developed by NyPa International is one such halophyte. It can be grown with seawater and has a good forage/fodder value. The variety is currently marketed internationally as NyPa Forage.

ICBA and NyPa signed an MoU to test the germplasm for its growth and forage potential in the coastal conditions - both arid and humid - of the Middle East. Using seawater for irrigation, NyPa Forage has proved to be successful and feasible, providing an excellent opportunity for converting barren coastal areas into forage production areas.

Objectives

- Demonstrate growing NyPa forage under local conditions using highly saline water.
- Expand NyPa forage material in agreement with NyPa International and NyPa Arabia.


NyPa Forage in the field

Achievements in 2006

A pilot-scale trial was initiated at ICBA from 2004 with three salinity treatments (15, 25 and 40 dS m^{-1}) and three irrigation treatments (ET_0x1, ET_0x1.25 and ET_0x1.5). Three harvests were taken after every four months. Shoot

Table 9: Biomass productivity of NyPa Forage at different growth periods and at different salinity and irrigation treatments

Growth period	Salinity levels (dS m^{-1})	Irrigation treatment (ET_0x)	Fresh weight (t ha^{-1})	Air-dried weight (t ha^{-1})	Ash-free dry weight (t ha^{-1})
Harvest 1 (April)	15	1.00	7.76	6.35	4.74
		1.25	10.99	9.17	5.24
		1.50	15.92	14.27	8.35
	25	1.00	13.24	11.75	7.97
		1.25	14.52	12.60	7.23
		1.50	16.29	14.67	10.06
	40	1.00	7.63	6.43	4.34
		1.25	7.60	6.44	4.55
		1.50	9.01	7.72	4.60
Harvest 2 (July)	15	1.00	4.16	3.65	2.99
		1.25	8.85	7.83	6.13
		1.50	15.94	13.42	9.91
	25	1.00	7.39	5.91	3.96
		1.25	6.97	5.65	4.00
		1.50	11.54	8.96	6.20
	40	1.00	5.63	4.75	3.18
		1.25	7.33	5.64	3.57
		1.50	14.03	11.38	7.74
Harvest 3 (December)	15	1.00	4.06	3.51	2.92
		1.25	7.09	6.10	4.87
		1.50	12.75	10.47	7.89
	25	1.00	6.87	5.44	3.79
		1.25	6.49	5.19	3.81
		1.50	10.73	8.25	5.88
	40	1.00	5.44	4.54	3.04
		1.25	7.07	5.47	3.47
		1.50	13.55	11.01	7.56

biomass was measured 15 cm below ground surface showed a significant increase in biomass during the first harvest, for both salinity and irrigation treatments (Table 9). Maximum biomass was observed at 25 dS m^{-1} salinity level. Air-dried shoot biomass measured at this salinity level (averaged for all irrigation treatments) was 30.35 t ha^{-1} (Figure 54). Plants irrigated at 1.5 ET_0 showed maximum biomass of 35.20 t ha^{-1} (averaged for the three salinity treatments).

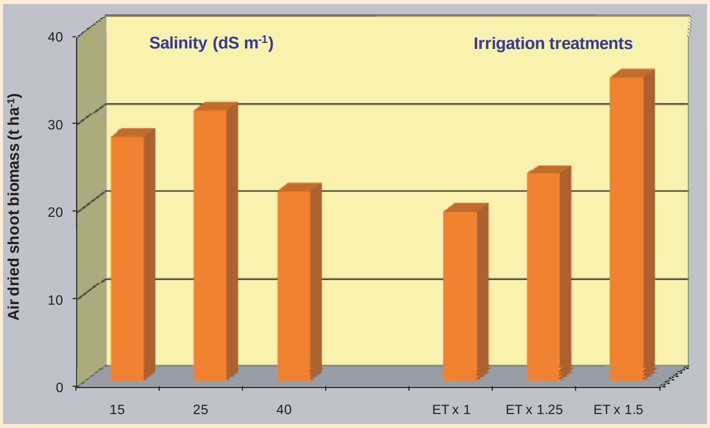


Figure 54: Air-dried shoot biomass averaged for various salinity and irrigation treatments.

Statistical analysis of the data showed significant differences for both salinity and irrigation treatments when plants were harvested during April, with non-significant differences for salinity treatments for the other two harvest periods. Irrigation treatments between ET_0x1.0 and higher ET_0 values showed significant differences at all harvest periods (Table 10).

Table 10: Analysis of variance and least significant difference ($LSD_{0.05}$) for various irrigation and salinity treatments of NyPa Forage harvested at different growth periods

Harvest	Parameter	F value			
		Salinity treatment (ST)	Irrigation treatment (IT)	ST x IT	$LSD_{0.05}$
April	Fresh biomass	17.40 ***	6.47 **	2.03 ns	2.35
	Dry biomass	16.27 ***	6.65 **	2.00 ns	2.26
	Ash-free dry biomass	14.69 ***	5.19 *	1.17 ns	1.53
July	Fresh biomass	0.48 ns	32.31 ***	2.32 ns	2.20
	Dry biomass	1.69 ns	34.00 ***	3.05 ns	1.72
	Ash-free dry biomass	4.16 *	25.32 ***	2.76 ns	1.37
December	Fresh biomass	0.38 ns	31.49 ***	1.47 ns	1.93
	Dry biomass	0.52 ns	33.35 ***	1.98 ns	1.47
	Ash-free dry biomass	0.96 ns	27.73 ***	1.65 ns	1.15

*** P<0.001; ** P<0.01; * P<0.05; ns = non-significant

Air-dried biomass production was also compared for the last three years' growth period (Figure 55). It was observed that at the high irrigation treatment (ET_0x1.5), biomass increased steadily at both 15 and 25 dS m^{-1} salinity treatments, with maximum of 37-38 t ha^{-1} in 2006.
At EC 40 dS m^{-1}, no significant differences were observed in biomass recorded for the three years at ET_0 of 1.00 and 1.25.

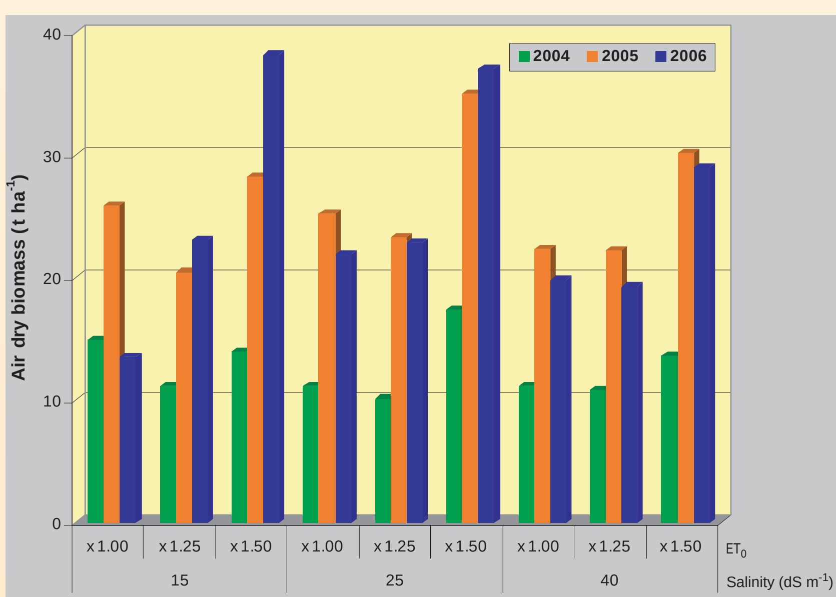


Figure 55: Air dried biomass production of NyPa grass for three years of growth period (In 2004, two harvests were done. Subsequently, the data present the totals of all three harvests)

In another trial, the feasibility of using sodium sulfate as amendment was studied. This trial was undertaken at 25 dS m^{-1} salinity treatment, applied with irrigation level ET_0x1.5. Application of sodium sulfate increased the dry biomass to 32.58-33.44 t ha^{-1} when irrigated with 25 dS m^{-1} irrigation water. Different concentrations (2, 6 and 12 mM) of sodium sulfate treatments (as fertilizers) did not show any significant effect on shoot dry biomass (Figure 56).

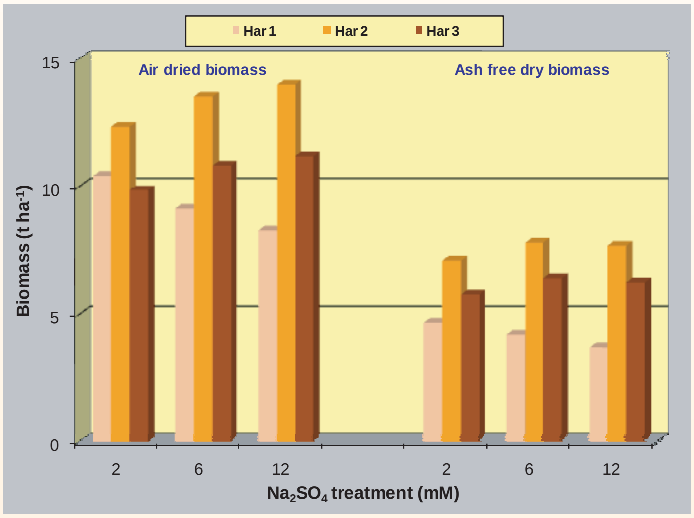


Figure 56: Effect of sodium sulfate treatments on air dry and ash free biomass

Comparisons of data for three years showed that air dried biomass in 2006 was equal to that of 2004, but lower than that of 2005 (Figure 57).

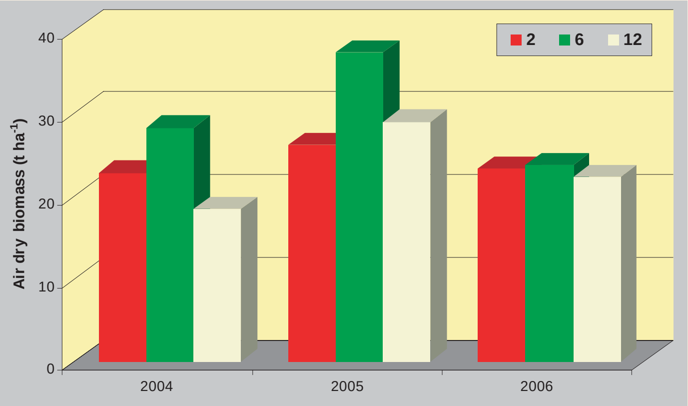


Figure 57: Effects of various sodium sulfate treatments (2, 6 and 12 mM) on air-dried biomass of NyPa Forage

Chlorophyll absorbance measured by spad meter did not show any significant differences to salinity treatments, water application rates and sodium sulfate treatments. Without addition of other N:P:K fertilizers, the grass retained its green color and chlorophyll content, indicating higher biomass productivity and re-growth after harvest. Slight variations were observed only during different months of the year.

Average soil salinity in plots irrigated with water of 40 dS m^{-1} varied between 21.36 and 22.65 dS m^{-1} for different irrigation rate treatments. This shows that with proper management, soil salinity can be kept at equilibrium ($\leq$) to that of irrigation water and increase the productivity of this grass. Plots that were grown with 25 dS m^{-1} salinity of irrigation water with sodium sulfate treatments showed slightly higher soil salinity values.

Proposed activities for 2007

In 2005, plants were harvested at 25 cm height, whereas in 2006, they were harvested at 15 cm to see the effect of deep harvesting on the re-growth and productivity. Since the plants did not show any negative effects, from 2007 plants will be harvested more frequently. Plant samples will also be analyzed at different growth periods for N and other organic compounds to analyze forage quality.

Response of two prominent grasses – indigenous dhai (*Lasiurus scindicus*) and an introduced African landrace of *Cenchrus ciliaris* – to water salinity (PMS30)

Duration: 2005-07
Collaborator: MOEW
Resources: MOEW, Core

Significance of the project

In recent years, ICBA has introduced salt-tolerant germplasm from different agro-climatic zones of the world into the region. The success of any new species, however, is based both on its adaptability and its salt tolerance. It is well known that an indigenous species can be domesticated more quickly than an exotic species. MOEW has undertaken trials on indigenous cultivar *Lasiurus scindicus* and an introduced African variety of *Cenchrus ciliaris* in the past. Collaborative work between MOEW and ICBA aims to assess the responses of these two grass species at different levels of saline irrigation water and water stress.

Lasiurus scindicus *(above) and African landrace of* Cenchrus ciliaris *(below)*

Objectives

- Study the responses of the test grass species at different levels of saline irrigation water.
- Evaluate the growth, dry matter yield and nutritive value of these species.

Achievements in 2006

Both grasses exhibited slow establishment rates when propagated vegetatively. Because the seeds produced by these grasses have low viability, it is much easier to establish them vegetatively. Repeated attempts were made to bring new cuttings/seedlings from Dibba Research Station, raise them in shade house and transplant them to the field. Once the plants established themselves, salinity treatments of 10, 20 and 30 dS m^{-1} were initiated.

The grasses were harvested five times for better establishment. Two of these harvests (in October and December) were undertaken after salinity treatments. Biomass productivity of these two harvests is presented in Figure 58. Average dry biomass for the two harvests after salinity treatments for *L. scindicus* at 15 dS m^{-1} was 9.01 t ha^{-1}, whereas that for *C. ciliaris* was 12.94 t ha^{-1}. If six harvests are undertaken each year, average biomass would be approximately 45-50 t dry matter/ha for both species. These findings indicate good potential of these indigenous species for re-introduction into forage production systems.

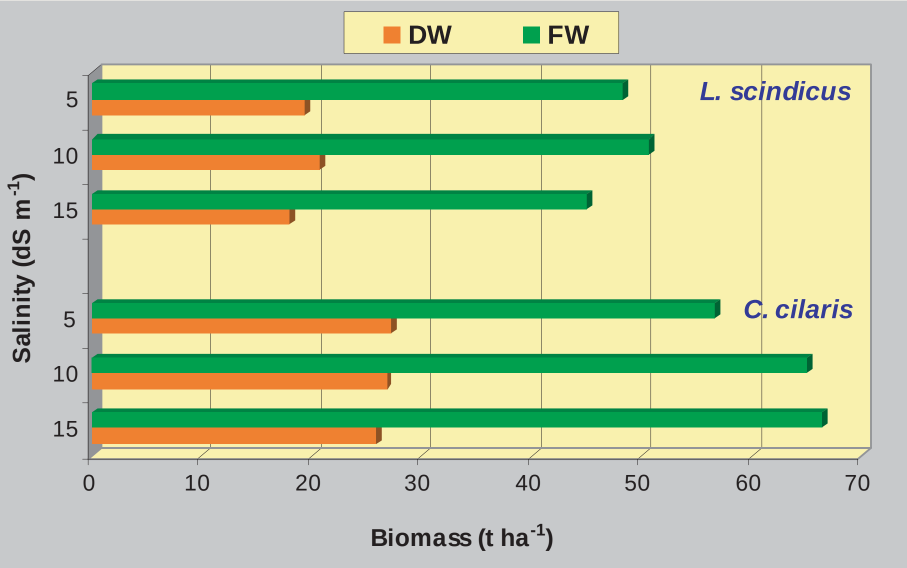


Figure 58: Biomass productivity (fresh and dry weight) of indigenous cultivar *Lasiurus scindicus* and an introduced African variety of *Cenchrus ciliaris* (Values present the total of two of the five harvests)

Because the seeds produced by these grasses have low viability, it is much easier to establish them vegetatively

Proposed activities for 2007

Growth and productivity of the test species will be evaluated under different harvest regimes. The nutritional value of these grasses will also be studied at different growth periods.

Agroforestry trial using *Acacia ampliceps*, *Sporobolus arabicus* and *Paspalum vaginatum* at different salinity levels (PMS31)

DURATION: 2004-07
RESOURCES: Core

SIGNIFICANCE OF THE PROJECT

Increased production per unit area and nutrient management are very important factors in increasing food productivity. In order to be competitive, an agricultural system has to be cost-effective and should result in better products. The byproducts of many agricultural crops have exhibited commercial importance that supplements the value of the primary products of the crops. Moreover, in less productive areas and wastelands, mineral deficiency, especially nitrogen, is a major limitation. The addition of expensive fertilizers in such wastelands makes the whole system unprofitable for farmers.

An agroforestry system includes production of tree species along with other plants so that the species benefit each other through better nutrient and water management

Multicropping systems include both crop rotations and cultivation of different crops simultaneously in a unit area. An agroforestry system is a multicropping system that includes production of tree species along with crops and/or other plants in a unit area in which the crops benefit each other through nutrient and water management.

ICBA has successfully introduced different salt-tolerant species into the region and its partner countries. These also include a leguminous tree, *Acacia ampliceps*, that, in addition to fixing atmospheric nitrogen, provides forage/fodder for animals, a source for bio-energy and an environment conducive for under-storied plants. ICBA initiated an agroforestry trial with two salt-tolerant grass species, *Sporobolus arabicus* and *Paspalum vaginatum*, that analyzed the responses of salinity treatments and the absence and presence of fertilizers on growth and productivity of the test plants.

OBJECTIVES

- Test the potential of grass and tree species in an integrated form for increased productivity.
- Evaluate nitrogen placement after fixation by the legume *Acacia ampliceps*.
- Evaluate the potential of mixing grasses with trees for animals.

ACHIEVEMENTS IN 2006

Growth and productivity of the test plant species evaluated under three salinity levels (10-30 dS m^{-1}) with and without fertilizer treatment (N:P:K 20:20:20 @ 45 kg ha^{-1}) did not show any significant effect from the fertilizer treatment. This can be attributed to the species' N-fixing ability. The trial was commissioned in 2004 and the grasses were first harvested in 2005.

Results for both grasses harvested twice in 2006 (through August) showed that the absence of fertilizer on *Sporobolus arabicus* did not have any significant effect on the dry biomass at any salinity treatments. However, in 2005, plots of fertilized *S. arabicus* exhibited a yield increase of about 20% more than the unfertilized plots. *Paspalum vaginatum* plots, however, showed a positive response to fertilizer, exhibiting an increase of 29% at 10 dS m-1. At higher salinity levels of 20 and 30 dS m-1, non-significant differences were observed between the two fertilizer treatments (Figure 59). This indicates that nitrogen is fixed by *Acacia ampliceps* and translocated horizontally, although this assumption needs verification.

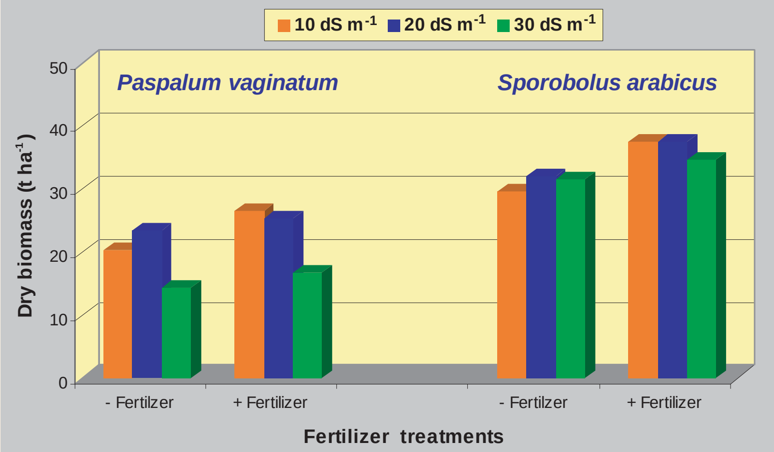


Figure 59: Total annual dry biomass of *S. arabicus* and *P. vaginatum* grown at various salinity levels and fertilizer treatments (Data presents the total of 3 cuttings/year)

Acacia ampliceps showed a higher growth rate, but also exhibited foliar injuries in lower branches due to saline water sprays from sprinklers installed in adjacent grass plots. Plants watered with drip irrigation did not show any such effects. Figure 60 shows an increase in height of more than 1.5 m after 18 months of growth. A slight increase was observed for plants that were fertilized.

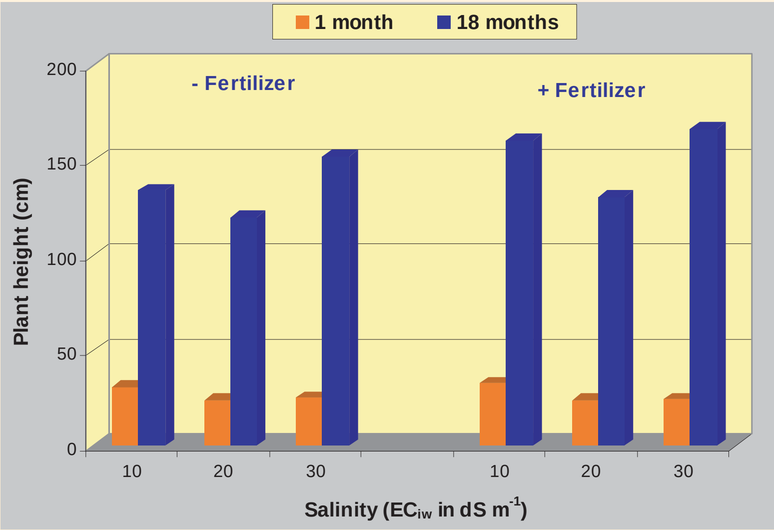


Figure 60: Height of *Acacia ampliceps* as affected by salinity and fertilizer treatments after 18 months of growth

Soil salinity (EC_e) increased with increase in salinity of irrigation water and was less at lower soil depth (75-150 cm) for *S. arabicus*. Plots treated with fertilizer application showed relatively higher soil salinity values. *P. vaginatum* did not exhibit any significant differences between the two fertilizer treatments (Figure 61).

pProposed activities for 2007

Growth and productivity of the different species will continue to be assessed in 2007 at different salinity levels, with and without fertilizer treatments. Efforts will be made to relate N content fixed by *Acacia ampliceps* at different salinity levels and fertilizer treatments to that of the grass species. The nutritional values of these grasses will be studied at different growth periods during the year.

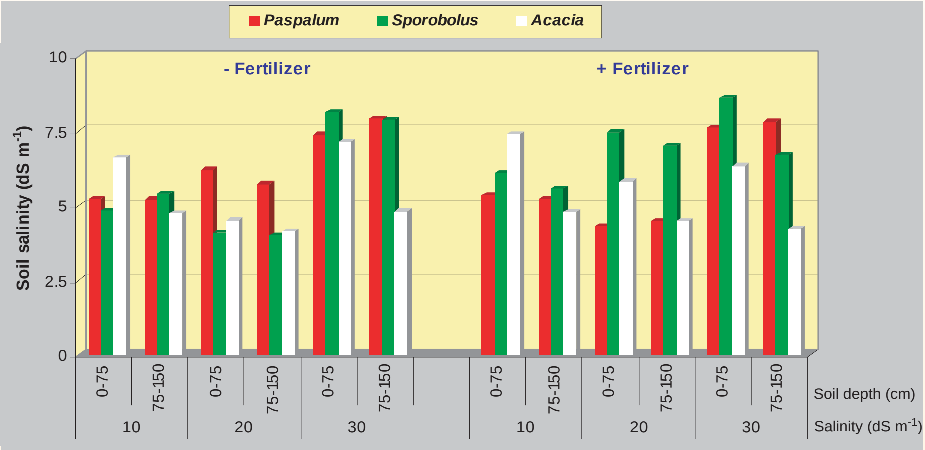


Figure 61: Soil salinity measured at two soil depths, with and without fertilizer treatments

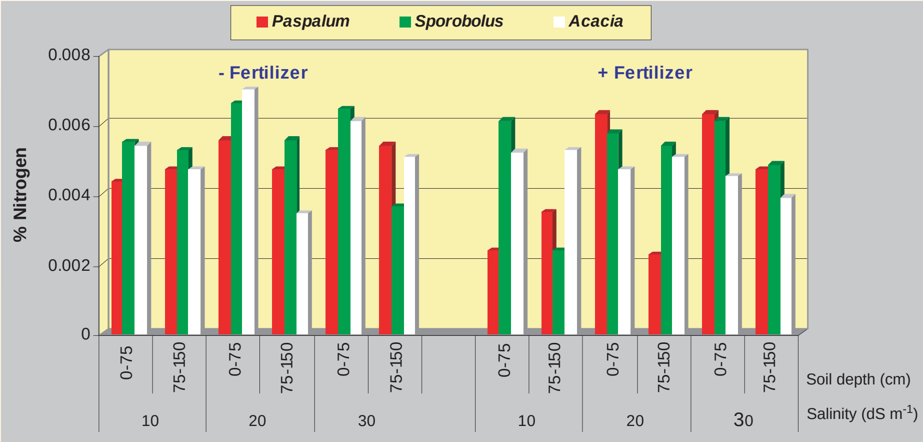


Figure 62: Percentage of N on both fertilized and unfertilized treatments of the two grasses and the tree species

Acacia *is both salt-tolerant and useful as organic mulch for grasses*

Sporobolus *(foreground) and* Acacia *(background) have proved complementary crops in agroforestry trials*

Enabling communities in the Aral Sea Basin to combat land and water resource degradation through the creation of 'bright spots' (PMS35)

Duration: 2005-07
Collaborators: Kazakhstan, Turkmenistan, Uzbekistan, ICARDA, IWMI
Resources: Asian Development Bank (ADB)

Significance of the project

Mismanagement of irrigation practices, climatic changes, drainage problems and other factors have caused a significant reduction in agricultural production in Central Asian states. These problems have resulted in land degradation and a rise in the water table. Based on earlier experiences, ICARDA, IWMI and ICBA have demonstrated that appropriate water management techniques and soil conservation practices can significantly increase agricultural productivity and income generation. The project work aims to introduce innovative and integrated methods of land, water and plants to improve the agriculture sector.

Mismanagement of irrigation practices, climatic changes and drainage problems has resulted in land degradation and a rise in the water table

ICBA leads the project component related to evaluation and introduction of salt-tolerant, conventional and non-conventional forage species in salt-affected areas. Human capacity building is also an important aspect of the program.

It is expected that the diversification of cropping systems under prevailing saline conditions could sustain agricultural production from salt-affected areas and increase farmers' profits. Introduction of new species and varieties of forage crops, grasses, legumes and shrub species can reduce waterlogging and contribute to restoration of degraded soil.

Objectives

- Develop agronomic practices (plant density, fertilizer application, time of planting, etc.) on seedling establishment, crop management and yield.
- Select appropriate plant species to match the environment, with particular attention to the salinity conditions and types of production system for different ecological zones in the three countries.

These objectives will be addressed by assisting disadvantaged rural farmers to effectively manage problematic saline and sodic soils and water.

Kazakhstani farmer measuring pearl millet

Achievements in 2006

Project activities were conducted at three experimental stations: Makhtaral (South Kazakhstan), Dashauz province (Turkmenistan) and three stations in Uzbekistan (in collaboration with Gulistan State University, the Plant Research Institute and the Karakul Sheep Breeding Institute).

ICBA provided seeds of 50 different species/cultivars/lines of salt-tolerant crops, shrubs and trees. In addition, 300 vegetative cuttings were also sent for propagation. These materials were used at different sites. Amongst conventional forage crops, sorghum, pearl millet and fodder beet proved successful. Amongst non-conventional crops, *Atriplex* spp. and *Acacia ampliceps* were especially promising. Local varieties and cultivars were also used for purposes of comparison.

Kazakhstan

A range of germplasm of halophytes and salt-tolerant crops was identified and introduced based on an earlier assessment of climatic and edaphic conditions and studies undertaken in the 2005 growing season.

In the case of sorghum, low seed germination was evident for ICSV 745, SP 40516 and SP 3905, while seed germination values of varieties of Super Dan, Speed Feed and SP 40516 varied from 75 to 95%. Based on growth rate observations of the 14 introduced accessions, the following classifications were identified:

- Fast-growing: Speed Feed, Super Dan, Sudan Graze, Pioneer 859
- Slow-growing: ICSV 112, SP 3905, SP 47529

Under farmers' field conditions in southern Kazakhstan, green fodder production in the top-yielding sorghum varieties/lines varied from 97-113 tons of fresh weight per ha, equivalent to 16-27 tons dry weight per ha. Similarly, top-yielding populations/lines of sorghum exhibited grain yield 2-2.5 times higher than that of the local variety. As evident from Table 11, Sudan Graze, Pioneer 858, ICSV 682, Super Dan and SP 39105 lines are promising lines for seed (grain) production under moderately saline conditions.

Screening of pearl millet germplasm indicated that accessions IP 6112, IP 19612,

Table 11: Fresh and dry weight biomass production of 14 introduced sorghum accessions, Makhtaral site, Kazakhstan

Accessions/Lines	Fresh biomass ($t\ ha^{-1}$)	Dry biomass ($t\ ha^{-1}$)
ICSV 745	58.0	12.0
ICSV 112	37.0	8.5
ICSR 712	-	-
ICSV 682	45.0	13.9
SP 39105	36.0	11.2
SP 40516	74.0	18.0
ICSB405	55.0	13.5
SP 47529	82.0	13.7
SP 47105	41.0	10.9
SP 39262	93.0	13.5
Pioneer 858	102.0	27.0
Sudan Graze	113.0	25.0
Super Dan	108.0	22.0
Speed Feed	97.0	16.0

ICMS 7704, IP 6110, IP 19586, ICMV 155 Brist, HHVDBC Tall, MC 94 C, Daura Genepool and Sudan Pop had excellent green biomass production. Yields of fresh biomass at the end of the vegetative period varied from 10.2 to 12.3 kg m^{-2} at a plant density of 65-100 plant m^{-2}. Height of plants ranged from 165 to 280 cm and the number of basal tillers varied from 9 to 32. Under irrigation with moderately saline water (EC 1.62-6.21 dS m^{-1}), the 10 top accessions of pearl millet were identified (Figure 63). The highest seed production capacity was observed for Sudan Pop III (3.85 kg m^{-2}) and ICMS 7704 (3.38 kg m^{-2}).

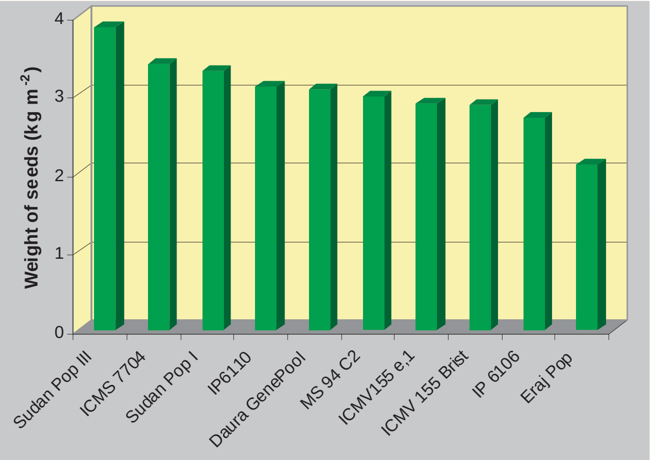


Figure 63: Seed production of pearl millet varieties

Poor plant performance was observed for fodder beet varieties, where only 45% of the plants survived due to low soil moisture and inappropriate seeding techniques. Seedlings emergence for three Atriplex species (*A. nummularia*, *A. amnicola* and *A. undulata*) were evaluated. *A. nummularia* and *A. undulata*, which produced nearly 50% seed germination, were transplanted in the field in late August. Assessment of these shrubs will be undertaken in 2007.

Turkmenistan

Trials were undertaken at the Akdepe experimental site in Turkmenistan with sorghum (14 varieties/lines), pearl millet (27 accessions/cultivars), fodder beet (4 varieties), alfalfa (2 varieties), *Acacia ampliceps* and *Atriplex* (3 species). In addition, another trial using poplar, *Thuya*, quince, mulberry, dog-rose and currants was undertaken. The groundwater at the site is highly saline with levels of total dissolved salts varying from 7,032 to 10,722 g L^{-1} (~ EC_{iw} 10-15 dS m^{-1}). Salinity of drainage water in November was 4,043 g L^{-1}. During the study period, the groundwater table fluctuated from 1.26 m to 1.89 m. Among introduced sorghum varieties/improved lines (namely

Table 12: Fresh and dry weight biomass production of 15 introduced sorghum accessions, Akdepe site, Turkmenistan, 2006

Accessions	Plant height at seed maturation (cm)	Fresh biomass (t ha^{-1})	Dry biomass (t ha^{-1})	Seed yield (g m^{-2})
172 Copro	140	28.0	13.3	266
SP 47105	142	28.2	13.3	400
ICSV 112	140	21.0	10.0	400
SP 39105	181	18.0	10.0	266
SP 47529	170	10.0	5.0	66
Pioneer 858	260	46.0	23.7	133
SP 40516	105	3.0	1.3	-
Sugar Graze	181	8.0	27.3	333
ICSB 405	101	5.0	2.0	-
Speed Feed	210	74.0	26.0	500
Super Dan	190	70.0	20.0	100
SP 39269	200	28.0	10.0	300
ICSV 745	194	28.0	10.6	300
ICSB 682	110	5.0	2.0	-
Local variety	-	16.0	8.5	-

Speed Feed, Super Dan, Sugar Braze, Pioneer 858, SP 40516 and SP 39269) showed significant advantages both in seasonal growth rate and plant height compared to the local variety (Table 12). The top-performing eight accessions of sorghum with an average dry matter production of 13.3-27.3 t ha^{-1} and seed yield of 0.26-0.50 t ha^{-1} tested under different seasonal ranges of soil salinity were selected for further dissemination in Turkmenistan.


Pearl millet in Turkmenistan

Pearl millet evaluated under saline conditions identified a group of 6-8 highly productive accessions for further assessment under saline conditions. The most promising accessions were ISCMS 7104 and IP 6105. Significant increases in plant height and fresh biomass was also observed for MC 94 C2, 11612, 6109, Sudan Pop 1 and HHVDBC Tall.

Medicago (alfalfa) varieties Eureka and Skeptre, introduced through the ADB-funded project, showed improved growth compared to the local variety Khivinskii. Fresh biomass varied from 1.9 kg m^{-2} for Eureka variety and 1.7 kg m^{-2} for Sceptre, respectively.

Acacia ampliceps transplanted in the field showed 89% survival, while *Thuya*, *Populus* and mulberry trees that were planted in the vicinity died. The growth rate of *Acacia* was very fast at 12-18 cm per month at the rooting stage and 25-30 cm when the basal stems developed a woody character.

Among *Atriplex* species, the highest seed germination (approximately 82%) under field conditions was observed for *A. undulata*. Biomass produced in 4 months was 1.6 kg m^{-2} of fresh biomass and was readily browsed by cattle and small ruminants.

Artesian water at Kyzylkum site in Uzbekistan


Uzbekistan

Studies were conducted at the Gulistan State University experimental farm in Syrdarya province and at the Plant Industry Institute. At the first site, groundwater was 1.7-2.2 m deep with total dissolved solubles (TDS) values ranging from 6,400 to 6,700 mg L^{-1}. Two major trials were undertaken at this site.

1. **Evaluation of forage species**
   - 4 species/varieties of oil crops: *Helianthus cultus*, *Arachis hypogaea* spp. *vulgaris*, *Carthamus tinctorius* and *Sesamum indicum.*
   - 8 species/varieties of fodder crops: *Zea mays* var. *indentata*, *Sorghum technicum*, *Phaseolus aureus*, *Sorghum sudanense*, *Beta vulgaris* var. *crassa*, *Medicago sativa*, *Panicum miliaceum* and *Hordeum vulgare.*
   - 10 varieties of safflower (*Carthamus tinctorius*); 10 accessions of *Hordeum vulgare*; 3 cultivars of *Sorghum bicolor* (Grif 612; Grif 619 and IS 29781); and 1 accession of *Pennisetum glaucum.*
   - 2 varieties of alfalfa (Anand 2 and Anand 3) from ICARDA.
   - Cultivars for double cropping after harvesting winter wheat: maize (fast-ripening), sunflower (fast-ripening) and mung bean.

Sorghum trials in Uzbekistan

2. **Evaluation of azolla as a potential organic fertilizer source**
   - Maize + azolla (0.2 and 0.4 kg m^{-2}).
   - Sunflower + azolla (0.2 and 0.4 kg m^{-2}).
   - Sorghum + azolla (0.2 and 0.4 kg m^{-2}).

Among the oilseed crops evaluated, two varieties of safflower (*Carthamus tinctorius*), were distinguished by high seed germination, high growth rate, good yield capacity (both fresh and dry biomass) as well as seed weight. Introduced cultivars from ICBA were better for early flowering and seed maturity (Table 13).

Table 13: Growth parameters and biomass of safflower at the Gulistan site

Cultivar	Height (cm)	Biomass during flowering stage ($t\ ha^{-1}$)		Seed yield ($t\ ha^{-1}$)	Biomass at end of vegetation ($t\ ha^{-1}$)		Number of plants m^{-2}
		Fresh	Dry		Fresh	Dry	
ICBA-1	45.0	26.20	9.20	0.09	2.28	0.90	20
ICBA-2	70.2	67.70	23.70	2.77	7.42	2.97	22
ICBA-3	48.8	36.70	12.80	1.91	3.31	1.32	28
ICBA-4	51.8	56.60	19.80	1.50	4.66	1.86	25
ICBA-5	53.8	53.80	18.80	0.93	4.10	1.64	26
ICBA-6	50.0	30.60	10.70	0.42	2.46	0.98	21
ICBA-7	31.8	21.20	7.42	1.40	1.68	0.64	26
ICBA-8	41.6	24.90	8.70	1.42	1.89	0.54	27
ICBA-9	35.2	35.80	12.50	2.01	2.51	0.20	28
ICBA-10	57.4	52.00	18.20	1.77	4.00	1.60	24
Local	35.2	42.10	16.00	2.78	22.60	7.00	58

Significant differences were also observed in biomass and grain yield of fast-growing and early-maturing Sorghum Grif 619 and IS 29781. Tall sorghum varieties were characterized by high productivity of both fresh and dry biomass at maturity. These varieties had a short-term and uniform flowering.

Application of azolla at the rate of 0.2 kg m^{-2} showed an increase in fresh and dry biomass for the three crops tested, as compared to using no azolla or higher doses of azolla.

At the Plant Industry Institute site, ICBA germplasm was evaluated for phenological characteristics in addition to seed production. Since this site also serves as the plant quarantine site, trials were conducted under non-saline conditions to evaluate the adaptability of the introduced germplasm from ICBA and produce seeds of successful accessions/varieties for further distribution to farmers. Both varieties of alfalfa exhibited better adaptability than local varieties. In addition, early- and late-flowering sorghum and pearl millet varieties were identified.

Acacia ampliceps *in Plant Industry site, Uzbekistan*

Acacia ampliceps and three species of *Atriplex* were also evaluated. It was interesting that *A. ampliceps* and *Atriplex undulata* not only adapted well but exhibited very high growth rate. Approximately 90% establishment was observed in *A. ampliceps* seedlings, which reached a plant height of 1 m or more after nine months (Table 14).

In addition, trials were undertaken at the Central Kyzylkum desert site, where various halophytic species were evaluated using saline artesian water, the EC varying between 11.6 and 19.38 dS m^{-1} and pH from 7.3 to 8.1. Naturally growing halophytes with high potential as forage species for the area, if irrigated with the artesian water, were studied for their chemical characteristics. These included *Tamarix, Climacoptera, Halochnemis, Halostachys, Alhagi pseudolahagi, A. nitens, Agropyron desertorum, Kochia scoparia, K. prostrta, Salsola, Halothamnus, Ceratoides, Camphorosma, Glychyrrhiza glabra, Atriplex canescens, A. nitens* (from Karakalpakstan) and *Climacoptera lanata*. Detailed analyses are in

Table 14: Plant growth of *Acacia ampliceps* and *Atriplex* spp. under field conditions

Species	Plant height (cm)	Canopy diameter (cm)	Leaf area (mm^2)
At 2 months' growth			
Acacia ampliceps	25.66	39.22	25.91
Atriplex nummularia	8.90	11.90	12.60
A. amnicola	9.40	9.80	3.20
A. undulata	10.20	10.50	14.30
At 9 months' growth			
Acacia ampliceps	107.92	74.60	103.12
Atriplex nummularia	98.70	48.30	98.60
A. amnicola	53.70	92.60	14.90
A. undulata	102.30	56.10	87.90

progress and will be reported in 2007. In addition, some of the potential species were grown in small pilot-scale plots and irrigated with saline artesian water. Preliminary results are very encouraging and more detailed work will be undertaken in 2007.

Rector and scientists of Gulistan University visiting ICBA headquarter

Proposed activities for 2007

The following activities are planned for each partner country:

- Optimization of various technologies (azolla efficiency, intercropping systems, crop rotation) and productivity of potential salt-tolerant species for further dissemination under saline environments.
- Up-scaling and development of agronomic practices to optimize plant yield of selected ICBA germplasm (most prominent: sorghum, pearl millet and *Acacia ampliceps*).
- Seed production of salt-tolerant plants for testing in farmers' fields.

In addition, training courses will be conducted on project-related aspects based on specialized work groups.

Salt tolerant halophytes being tested at Kyzylklum site in Uzbekistan

Horticulture Crop Production

Investigation of elite date palm varieties for salt tolerance (PMS06)

Duration: 2001-06
Collaborator: MOEW
Resources: Core

Highlights

- *Based on growth indicators such as trunk height and diameter, the best-performing local varieties were Abu-Maan, Jabri, Khinizi, and Lulu. Fruit setting was best in Khinzi, Fardh, Jabri, Khisab and Lulu. Fruit production declined with increased level of water salinity.*
- *Among imported cultivars, Um-Al-Hamam showed the weakest performance and could not survive at any salinity levels under the local environmental conditions. Among other varieties, Ajwat-ul-Madinah, Nabatat Saif, Nabatat Sultan and Sukkari showed best growth indicators. Average fruit production of the imported varieties was lower than the local varieties. Ajwat-ul-Madinah, Rhothan and Sukkari showed best performance among the varieties tested.*

Significance of the project

Sustainable agro-ecosystems need continuous adjustments in structure and management strategies to keep pace with changing production environments. The biotic and abiotic stresses like salinity limit plant growth. It is therefore extremely important to develop stress-tolerant varieties and improve production and management techniques to enable the proper functioning of the agro-production system and survival of the plants. The Arabian Peninsula, which is typified by many abiotic agricultural constraints, is home to a wide range of genetic diversity of date palms.

Two long-term experiments comprising 10 local varieties (Experiment I) and 8 imported varieties (Experiment II) were planned to run for 5-6 years at ICBA to obtain scientific information on the salt tolerance potential of elite date palm varieties.

In Experiment I, varieties Abu-Maan, Barhi, Fardh, Jabri, Khalas, Khisab, Khinizi, Lulu, Naghal and Shahlah were selected from preferred local varieties in collaboration with MOEW.

Elite date palm varieties at ICBA farm

In Experiment II, varieties Um-Al-Hamam, Rhothan, Sukkari, Shagri, Ajwat-ul-Madinah, Maktoumi, Nabtat-Saif and Nabtat-Sultan were selected and imported from Saudi Arabia for evaluation. Information on the salinity tolerance of date palm is limited and few studies have been conducted to evaluate their salinity tolerance.

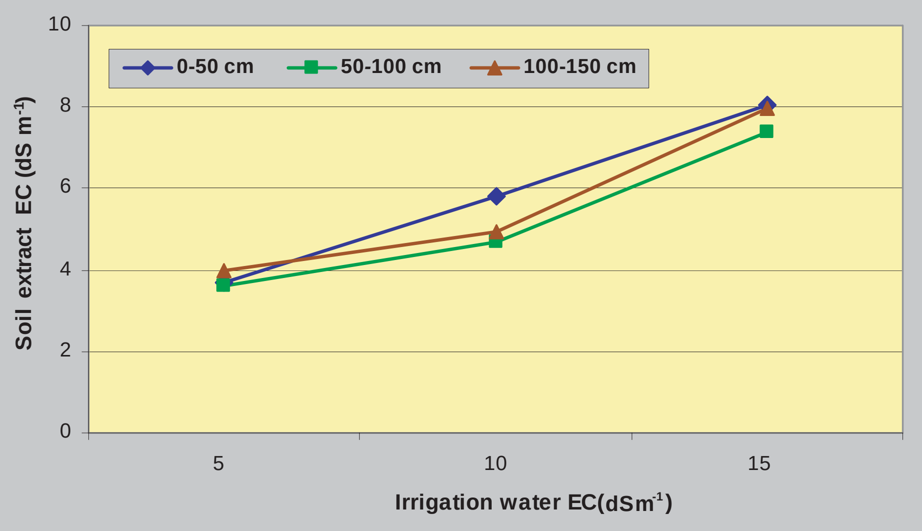


Figure 64: Average soil salinity (EC_e in dS m^{-1}) in 10 date palm varieties at 3 levels of irrigation water salinity and 3 soil depths

Objectives

- Evaluate salinity tolerance among elite date palm varieties in the Arabian Peninsula.
- Assess long-term impact of salinity on date palm growth and productivity.
- Assess the effects of various salinity levels on date palm fruit quality.

The Arabian Peninsula, which is typified by many abiotic constraints, is home to a wide range of genetic diversity of date palms

Achievements in 2006

Three salinity levels, (5, 10 and 15 dS m^{-1}) were applied to the first planting (10 local varieties) in late 2002, and to the second planting (8 imported varieties) in 2003. The growth and development of each plant was monitored by recording basic growth parameters: plant height, trunk circumference, fruit production, number of leaves and phenology. Three measurements were completed on each plant in all treatments.

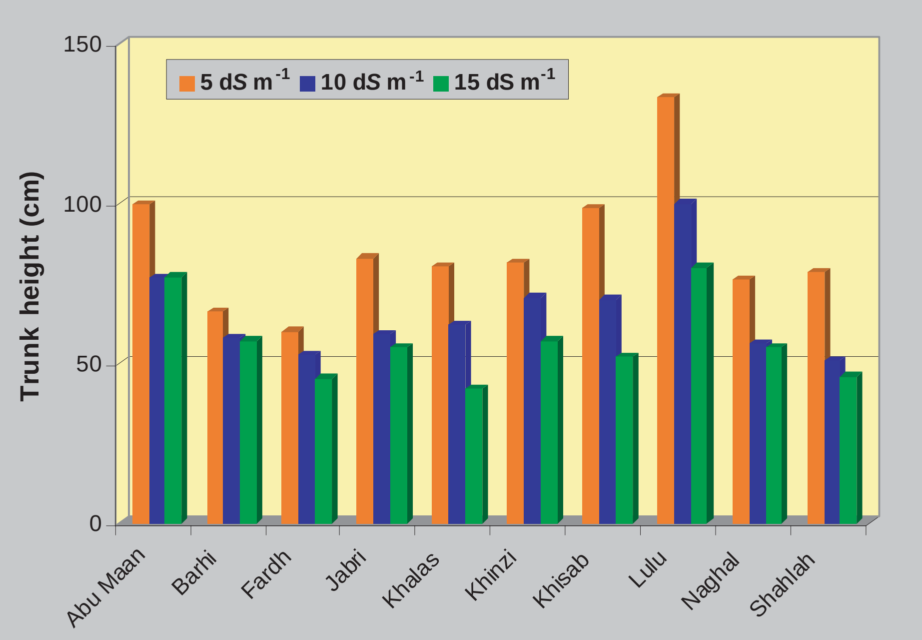


Figure 65: Average trunk height of 10 date palm varieties (Experiment I) at 3 salinity levels

Soil samples were collected at various depths at regular intervals. The samples were analyzed to monitor the physical and chemical characteristics of the soil. Fruit was harvested at maturity and yield measured. The samples have been preserved and will be sent to UAEU for chemical analysis.

Results

Results of the growth parameters and soil salinity are summarized in the following graphs. Soil salinity increased linearly under the three salinity treatments. However, after four seasons soil salinity remained well below the irrigation water salinity. Irrigation management applied proved to be working adequately in the sandy soil that dominates the area (Figure 64).

Growth of the 18 varieties was monitored through frequent measurements of trunk height and diameter and leaf length. In the fourth season, effects of salinity on growth became very evident with a clear gradient in all growth indicators. However, among the varieties evaluated, Abu-Maan, Jabri, Khinizi, Fardh and Lulu performed best in terms of relative trunk cicumference and height (Figures 65 and 66

Fruit setting is still at an early stage, but several varieties showed relatively

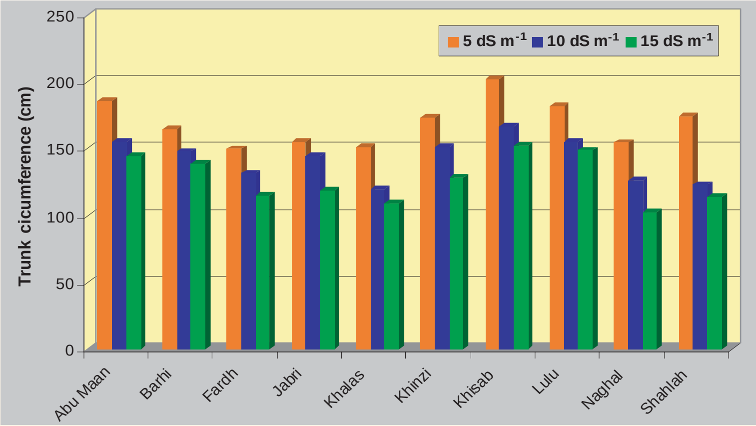


Figure 66: Average trunk cicumference of 10 date palm varieties (Experiment I) at three salinity levels

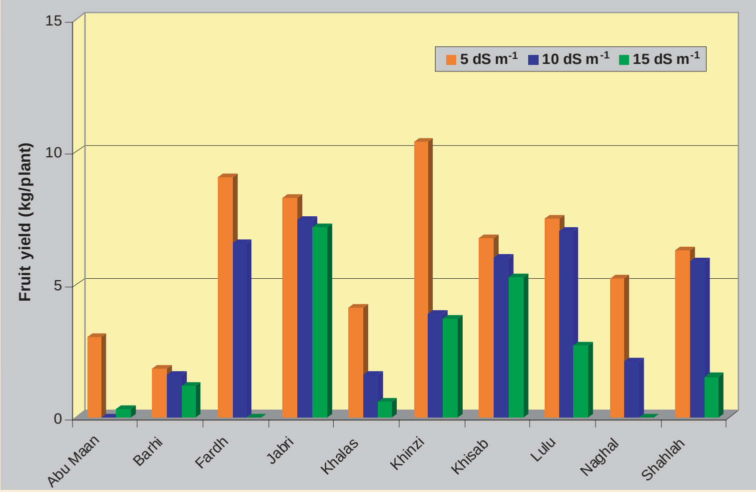


Figure 67: Average fruit production of 10 varieties (Experiment I) at 3 salinity levels

Fruit setting of date palm trees at ICBA farm higher yield under the salinity levels evaluated up to 15 dS m^{-1}. Khinzi, Fardh, Jabri, Khisab and Lulu showed best performance at this stage. Fruit production declined sharply with increased levels of soil and water salinity (Figure 67).

The varieties imported from Saudi Arabia are still at an early stage of growth. Nonetheless, several varieties started fruiting, with varieties Ajwat-ul-Madinah, Rhothan and Sukkari showing the best performance among the varieties tested (Figure 68).

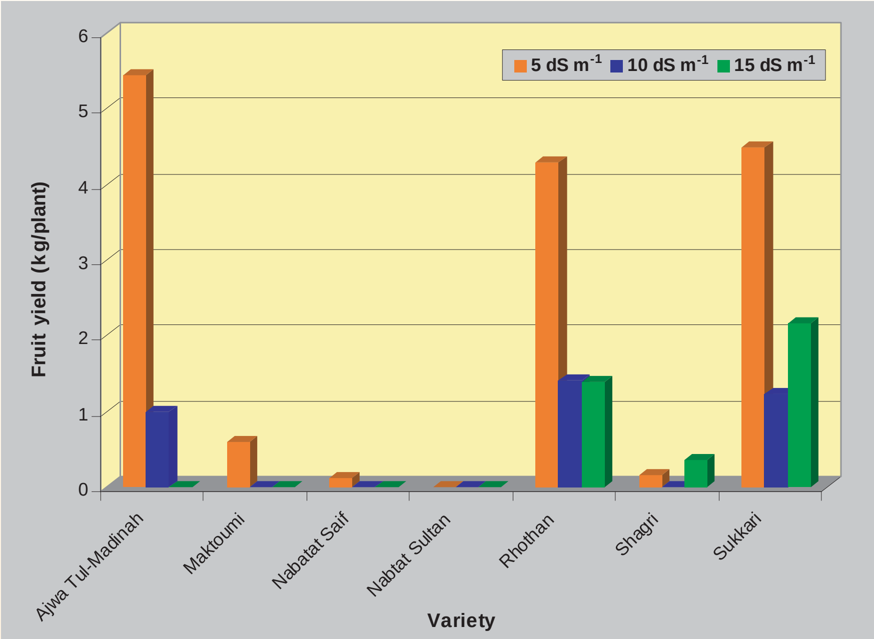


Figure 68: Average fruit production of 7 varieties (Experiment II) at 3 salinity levels

Date palms under cultivation on the ICBA farm

Communications, Networking and Information Management Program

Communication, Networking and Information Management Program

Objectives

- Establish both formal agreements such as memoranda of understanding and informal collaborations through individual contacts.
- Develop joint programs/projects for the delivery of biosalinity technology (Table 15).
- Prepare and distribute information about biosalinity and maintain a network of communication with individuals and agencies with an interest in biosalinity.

Ms Barbara Castek, CEO, Dubai Aid and Humanitarian City, with ICBA Director General Dr Mohammad Al-Attar

Communication

Memoranda of understanding

Three MoUs were signed during 2006. These agreements establish organizational links with a view to exchanging information and developing collaborative relationships relating to the delivery of technologies for managing saline environments.

1. Dubai Aid and Humanitarian City

This agreement established a link with Dubai Aid and Humanitarian City .

2. Environment Agency-Abu Dhabi (EAD)

This project (PMS36) is described in detail on pp 24-27.

3. Tajikistan Academy of Agricultural Sciences (TAAS)

The problem of salinity and waterlogging in Tajikistan is increasing each year. As a result, formerly productive irrigated lands are turning into degraded marginal lands, which are then abandoned by farmers. Salinization is caused by the rising water table resulting from high irrigation and poorly managed drainage. An MoU between the Tajikistan Academy of Agricultural Sciences and ICBA was therefore signed in July to test biosaline agriculture technologies in these abandoned farms with a view to bringing the abandoned farms back to production.

Mr Majid Al Mansouri, Secretary General, EAD, at the signing ceremony in April. Looking on are Prof Dr Faisal Taha, Director of Technical Programs, ICBA, and Dr Stewart Rutledge of GRM International, Project Director

Bilateral projects

During 2006, ICBA had ongoing joint projects in Bangladesh, Egypt, Jordan and the UAE (Table 15).

Networking

Global Biosalinity Network

The web-based Global Biosaline Network (GBN) promotes collaboration between individuals involved in research and development on biosaline agriculture.

The ICBA website includes 15-20 pages of information covering the main program areas. In addition, an online registration form for GBN membership is available at www.biosaline.org/join.cfm. When a new member joins the network, his/her information is entered into temporary tables and new registrations are checked by designated personnel. The information is then uploaded to the GBN database.

GBN allows individuals to identify others with similar interests and to initiate contact with them. Interest in an interactive internet discussion forum facilitated by ICBA is keen, and the resources required to undertake such an activity are important considerations for 2007.

Because GBN is not facilitated, no statistics for hits and downloads are at present available from the website hosting service. Evaluation of the

Table 15: Joint projects 2006

Organization	Project	Location	Duration
Bangladesh			
Bangladesh Agricultural Research Institute (BARI)	Demonstration of biosaline agriculture in salt-affected areas in Bangladesh (PMS09)	Bangladesh	2003-07
Egypt			
Desert Research Center (DRC)	Introduction of salt-tolerant forage production systems to salt-affected lands in Sinai Peninsula in Egypt: A pilot demonstration project (PMS37)	Egypt	2006-09
Jordan			
National Center for Agricultural Research and Technology Transfer	Expanding date palm cultivation under saline conditions in Jordan (PMS23)	Jordan	2003-06
United Arab Emirates			
Ministry of Environment and Water (MOEW)	Investigation of elite date palm and olive varieties for salt tolerance (PMS06)	ICBA	2001-06
MOEW	Application of biosaline agriculture in a demonstration farm in the northern Emirates (PMS05)	R'as al-Khaimah	Ongoing
MOEW	Feasibility study for biosaline agriculture in the UAE (PMS32)	UAE	2004-06
United Arab Emirates University (UAEU)	Development of sustainable salt-tolerant forages for sheep an goat production (PMS16)	ICBA, UAEU	2003-06

Table 16: GBN membership data

Country	Members	Country	Members	Country	Members
Algeria	5	Indonesia	1	Qatar	5
Argentina	2	Iran	36	Russia	1
Australia	25	Iraq	6	Saudi Arabia	15
Austria	1	Italy	3	Senegal	2
Azerbaijan	3	Japan	4	Somalia	1
Bahrain	3	Jordan	13	South Africa	5
Bangladesh	3	Korea	2	Spain	4
Belarus	1	Kuwait	6	Sri Lanka	2
Belgium	1	Lebanon	1	Sudan	15
Bosnia	1	Libya	4	Sweden	2
Cameroon	2	Luxembourg	1	Syria	9
Canada	13	Malaysia	2	Tajikistan	1
Chile	2	Malta	1	The Netherlands	8
China	7	Mauritania	1	Trinidad and Tobago	1
Djibouti	1	Mexico	1	Tunisia	14
Dominican Republic	1	Morocco	4	Turkey	4
Egypt	30	Nepal	1	UAE	51
Eritrea	3	New Zealand	3	UK	12
France	2	Nigeria	4	USA	21
Germany	9	Oman	12	Uzbekistan	3
Ghana	1	Pakistan	66	Venezuela	1
Greece	1	Peru	3	Yemen	6
India	75	Philippines	2		
Total					**552**

impact of GBN is therefore unavailable at present, although plans to improve this situation are under study for implementation in 2007.

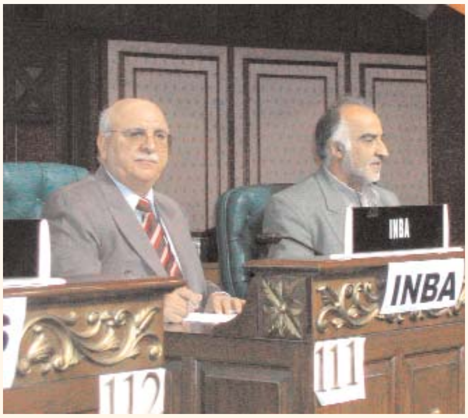
GBN members (Table 16) are continually reminded that they can request direct web access to the bibliographic databases AGRIS and AGRICOLA. Direct access provides speedy and efficient searching. Members can also request searches on CAB Abstracts® through the ICBA Librarian. AGRIS is the information system for agricultural sciences and technology of the Food and Agriculture Organization of the United Nations (FAO). AGRICOLA (Agricultural On-line Access) is a bibliographic database encompassing agriculture and allied disciplines. CAB Abstracts® is a bibliographic database covering agriculture and the management and conservation of natural resources. For information concerning web access to AGRIS and AGRICOLA, or to request a search on CAB Abstracts®, members can email ICBA at library@biosaline.org.ae.

Inter-Islamic Network for Biosaline Agriculture (INBA)

INBA is a non-political, non-profit, independent, and autonomous body promoting biosaline agriculture under the auspices of the OIC, which established INBA through its Ministerial Committee on Scientific and Technological Cooperation (COMSTECH) in 2002 (1422H).

The aims of INBA are:

- To establish a mechanism for coordinating research on biosaline agriculture among participating countries and organizations.
- To develop a database of scientists, NGOs and others involved in biosaline agriculture.
- To prepare a directory of scientists working on biosaline agriculture in the Islamic countries.
- To train human resources in the field of biosaline agriculture among Muslim Ummah countries.
- To work with other international institutions and donors to strengthen the work on biosaline agriculture among Muslim countries.



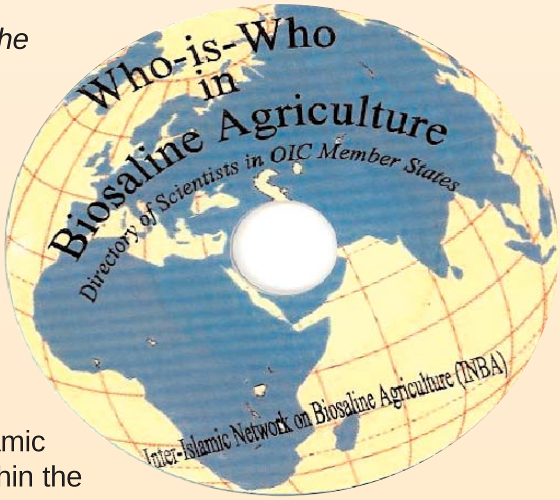
Dr Mohammad Al-Attar, President of INBA, presented the network achievements for the year 2004-05 at the 12th COMSTECH meeting in Islamabad, 21-23 February

INBA targets national, regional, and international institutions in developing and developed countries, and aid agencies, in particular those in OIC member states. Network members 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 NGOs.

Achievements in 2006

INBA published the first version of the research scientists database entitled *Who-is-Who in Biosaline Agriculture* in 2005. A CD version was prepared in Microsoft Access and launched at the 12th COMSTECH meeting in Islamabad in February 2006. In addition to profiling the scientists, the database provides information on fields specialization, publications and area of research conducted.

INBA/ICBA also completed a short consultancy on *The viability of biosaline agriculture in Cape Verde*. This consultancy was supported by two Netherlands-based organizations, Ocean Desert Enterprises and the Organization for Agriculture in Saline Environments Foundation. INBA prepared the complete package of proposal, including infrastructure, land preparation, irrigation/drainage and plant production system. The proposal included the technical and socio-economic benefits and the expected impacts of the project.



The INBA database of scientists is now available on CD

News and other updates on INBA and other Inter-Islamic Network activities are posted at INBA's web page within the ICBA website: www.biosaline.org. In addition, INBA news is published in the ICBA newsletter *Biosalinity News*.

Proposed activities for 2007

INBA will organize an expert consultation workshop on *status and prospects of biosaline agriculture for Islamic countries* to meet emerging global challenges. INBA will invite policy makers, senior scientists and administrators from OIC members to join INBA and ICBA scientists at a 2-day meeting/workshop to investigate future directions for OIC members in biosaline agriculture of benefit to IDB-member countries. The event will provide international visibility to the COMSTECH-IDB activities and provide INBA/ICBA with a realistic roadmap.

INBA will continue to work on its database, arrange seminars/workshops and negotiate proposals for bilateral collaborative projects.

INFORMATION MANAGEMENT

Activities in 2006

Additional information resources have been acquired, and requests for information satisfied, to support the needs of ICBA staff and its partners (Table 17). Information resources were catalogued, classified and promoted to all. Research was undertaken to identify ICBA user needs and the most suitable Integrated Library Management System software to meet these needs. The new system has been chosen and implementation will occur during early 2007.

Client database

A key tool for dissemination of information is a comprehensive and well-maintained stakeholder database. In early 2000, a contact database was

Table 17. Distribution of ICBA annual reports and newsletters, 2000-06

	English		Arabic		French		**Total**
	Recipients	Countries	Recipients	Countries	Recipients	Countries	**Recipients**
2000	314	48	302	17	-	-	616
2001	635	72	472	17	28	13	1135
2002	908	91	659	20	164	51	1731
2003	1055	91	758	24	180	51	1993
2004	1255	110	864	29	-	-	2119
2005	1413	111	944	32	-	-	2357
2006	1049	105	830	26	-	-	1879

Table 18. ICBA visitors, 2000-06

	2000	2001	2002	2003	2004	2005	2006	**Tota**
Ministers	-	3	7	2	2	2	2	18
Diplomats	1	6	7	8	3	4	1	30
Regional / international organizations	15	17	25	26	25	20	16	144
IDB	2	4	9	4	4	13	7	43
UAE	20	29	31	26	34	33	17	190
Others	22	50	58	119	65	68	52	434
Total	**60**	**109**	**137**	**185**	**133**	**140**	**95**	**859**

developed and made accessible to all staff on the ICBA network. The database is used for targeted distribution of annual reports, newsletters and other ICBA communication activities.

In 2003, the database was developed further to include alumni of ICBA capacity development activities, both their contact details and the details of their participation in related activities. This information provides the basic data for developing targeted communication products such as the ICBA and IDB-member countries brochure.

The database also records the details of visitors to the Center (Table 18). The main issues discussed during these visits are added to the database for subsequent reference.

Image database

The image database, which contains over 20,000 images relating to ICBA projects and activities, catalogued by topic and year, provide a useful resource for reports, publications and presentations.

Exhibitions

WETEX, Dubai, March

IDB Annual Governors Meeting, Kuwait, May

CGIAR Annual Meeting, USA, December

Director General Dr Al-Attar with ICBA's three key supporters: Mr Fawzi AlSultan, Chairman of the Board of Directors; Dr Ahmad Mohamed Ali, President, Islamic Development Bank; and Dr Saeed Al-Kindi, Minister of Environment and Water, UAE.

Publications

Salt-tolerant Plants of the United Arab Emirates (English)

ICBA Annual Report 2005 (English and Arabic)

Biosalinity News Vol 7 No 1 (English and Arabic)

Biosalinity News Vol 7 No 2 (English and Arabic)

Biosalinity News Vol 7 No 4 (English and Arabic)

The United Arab Emirates and ICBA (English and Arabic)

JOURNAL ARTICLES, PAPERS AND BOOK CHAPTERS

Journal articles and papers

Abdelfattah MA and **Shahid SA**. 2006. Characterization and classification of soils in the coastline of Abu Dhabi Emirate. *In* Proceedings of the International Symposium on Agricultural Constraints in Soil-Plant Atmosphere Continuum. Ghent, Belgium, 4-7 Sep 2006, pp 347-354.

Al-Maskri AY, **Shahid M** and **Jaradat AA**. 2006. Multivariate phenotypic structures in the Batini barley landrace from Oman. Journal of Food, Agriculture and Environment 4(2): 208-212.

Al-Shorepy SA, **Alhadrami GA** and **Dakheel AJ**. 2006. Effect of feeding saltbush (*Atriplex* spp.) and *Sporobolus* grass hay on growth of indigenous goats. Proceedings of the 7th Annual Research Conference, UAE University, Al Ain, UAE.

Al-Shorepy SA, **Alhadrami GA** and **Dakheel AJ**. 2006. Indigenous goats and salt tolerant forages: Towards sustainable meat production in the United Arab Emirates. 12th Asian Australian Animal Science Congress, South Korea.

Dakheel AJ, Alhadrami GA, Al-Shoreby SA and AbuRumman G. 2006. Optimizing management practices for maximum production of two salt-tolerant grasses: *Sporobolus virginicus* and *Distichlis spicata. In* Proceedings of the 7h Annual Research Conference, UAE University, Al Ain, UAE.

Dakheel AJ, **Alhadrami GA** and **Al-Shoreby SA**. 2006. The economic and environmental potential of two non-conventional salt-tolerant grasses: *Sporobolus virginicus* and *Distichlis spicata*. *In* the International conference on biosaline agriculture and high salinity tolerance, Tunis, 3-8 Nov 2006.

Jaradat AA and **Shahid M**. 2006. Patterns of phenotypic variation in a germplasm collection of *Carthamus tinctorius* L. from the Middle East. Genetic Resources and Crop Evolution. 53(2): 225-244.

Jaradat AA and **Shahid M**. 2006. Population and multilocus isozyme structures in a barley landrace. Plant Genetic Resources: Characterization and utilization. 4(2): 108-116.

Omar SAS, **Cook S**, **Grealish G** and **Shahid SA**. 2006. Statistical assessment of variations in soil properties within and among map units generated by GIS. Kuwait Journal of Science and Engineering 33(1): 53-70.

Shahid SA and **Hasbini BA**. 2006. Optimization of modern irrigation for biosaline agriculture. Arab Water Magazine. July-August 2006, Vol XXX, Issue 6:30-31.

Book chapters

McGaw EM. A unique center with a unique mandate. *In* The Cooperation Council for the Arab States of the Gulf 2006. London: International Systems and Communications Limited. 2006.

Shahid SA. 2006. Soils. *In* Sector paper on physical geography. Abu Dhabi Global Environment Data Initiatives (AGEDI). Environment Agency-Abu Dhabi, pp 4-42.

Published abstract

Shahid SA. 2006. Real time dynamic automated salinity monitoring in biosaline agriculture. International conference on saline agriculture: Sustainable crop production on salt-affected land, Faisalabad, Pakistan, 4-6 Dec 2006. Abstract book, p. 5.

TRAINING, WORKSHOPS AND EXTENSION PROGRAM

Training, Workshops and Extension Program

Objectives of the program

- Provide specialized courses for scientists and technicians in aspects of managing salinity.
- Organize seminars and meetings to exchange information on managing salinity.
- Identify priority areas that need to be addressed locally, regionally and globally.

Training courses and Workshops

Workshop on sand dune movement of the United Arab Emirates

Date: 18 January

Venue: Renaissance Hotel, Dubai

Collaborators: Federal Environment Agency of the UAE (FEA), Global Scan Technologies

Resources: FEA, Core

Soil survey concepts and framework

Dates: 11-15 February

Venue: ICBA Headquarters

Collaborator: EAD

Resources: EAD

The inaugural session of the training at ICBA Headquarters was attended by senior management and scientific personnel from EAD and ICBA. The workshop covered satellite imagery, GIS, database management, Real Time Dynamic Salinity Logging System, soil survey procedures and interpretation of results. During an excursion participants received hands-on experience on soil profile description. The workshop was attended by 17 participants from MOEW, several Municipalities and UAEU.

Soil workshop at ICBA

Training workshop on biosaline agriculture

Dates: 29-30 April

Venue: Bahrain

Collaborator: Ministry of Municipalities and Agricultural Affairs

Resources: Ministry of Municipalities and Agricultural Affairs

Advances in biosaline agriculture with reference to Central Asia and the Caucasus region

Dates: 15-22 May

Venue: Tashkent, Uzbekistan

Collaborators: IWMI, ICARDA, Central Asian NARS

Resources: OFID, ADB

This course benefited 44 scientists, researchers and technicians from Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan. The course was organized by ICBA in close collaboration with ICARDA and IWMI and sponsored by OFID and ADB.

Participants of the CAC training course, Tashkent, Uzbekistan

Conventional and non-conventional production systems for saline environments

Date: 27 May

Venue: IDB 31st Governors Annual Meeting, Kuwait

Collaborator: Kuwait Institute for Scientific Research

Resources: ICBA, IDB

ICBA Seminar in Kuwait

Cross-cultural management and team building

Date: 6-7 June

Venue: ICBA

Resources: Pipal Limited, ICBA

Strengthening Niger's technical expertise in managing salinity by adopting biosaline agriculture

Date: 21-27 August

Venue: Niamey, Niger

Collaborator: INRAN

Resources: COMSTECH

A major capacity-building initiative began in 2006. For the first time, ICBA organized a training course in sub-Saharan Africa. Through an IDB-funded program coordinated by COMSTECH, ICBA ran a training course

Team building brings dividends to all staff in Niger. Farmers in Niger, one of the poorest countries in the world, are experiencing the onslaught of salinity in their fields due to improper irrigation methods and water quantities resulting in rising water tables. Consequently, many of them are abandoning their fields. Because Niger's NARS, the Institut National de Recherches Agronomiques du Niger (INRAN), conducts only limited work on salinity, the government of Niger sought an MoU with ICBA to provide an umbrella for joint technology exchange.

For the first time, ICBA organized a training course in sub-Saharan Africa

Acting on the milestone MoU, ICBA's first with a sub-Saharan African country, a proposal was submitted to IDB/COMSTECH for human capacity building and collaborative research. The proposal was accepted, and the objectives of the first phase of the project were threefold:

- Enhance the technical capabilities of INRAN and its partners in Niger on biosaline agriculture.
- Introduce and apply biosaline agricultural techniques in salt-affected areas.
- Improve irrigation and drainage methods for rehabilitating salt-affected areas.

Group photo of the participants of the training course at Niamey. His Excellency Moussa Labo, Minister of Agricultural Development, stands between Dr Nurul Akhand (blue necktie) and Dr Shoaib Ismail, (red necktie). Dr Samba Ly, Director General of INRAN, is to the left of Dr Akhand.

As part of the first component, ICBA and INRAN organized the training course in Niamey. In addition to INRAN, local participants included staff from the Ministry of Agricultural Development, the University of Niamey and ICRISAT. The course included lectures and hands-on training sessions by ICBA scientists on different aspects of biosaline agriculture related to soil salinity, water and plant production systems. Scientists from INRAN, ICRISAT and the University of Niamey also gave lectures. Two field trips were organized, one at ICRISAT's research farm at Sadoré, the other at INRAN's station at Kollu.

Four participants from INRAN and ICRISAT were subsequently invited to work at ICBA headquarters for a 6-weeks internship, where the interns were given hands-on training on different aspects of biosaline agriculture.

Dr Ly and Dr Ismail presenting Certificate of Appreciation to INRAN’s Dr Fatouma Seyni

Traveling workshop in capacity building in integrated management of saline water resources for forage production in the WANA region

Dates: 9-15 September

Venue: Syria

Collaborator: GCSAR

Resources: IFAD, AFESD, OFID

Workshop on quality assurance for analytical laboratories

Dates: 30 October to 1 November

Venue: College of Agriculture and Marine Sciences, Sultan Qaboos University (SQU), Sultanate of Oman

Collaborators: SQU and UAEU

Resources: SQU, UAEU, Core

Realizing the importance and need for a certified and an accredited laboratory in the Sultanate of Oman, SQU joined with UAEU and ICBA to organize the workshop. A total of 21 trainees from SQU, Petroleum Development of Oman (PDO), the Ministry of Agriculture, the Ministry of Water Resources, Oman Waste Water Services and Oman Cement Company attended the workshop. The workshop covered such topics as quality audits and system review, accreditation procedures and requirements and the statistical quality control techniques used in analytical laboratories.

Participants of the workshop

Communications skills

Dates: 12-15 November

Venue: ICBA

Resources: ICBA

Use of saline water resources in agricultural production

Dates: 19-25 November

Venue: UAE

Collaborator: AOAD, MOEW

Resources: AOAD, AFESD, IFAD


Participants of the AOAD/MOEW training course at ICBA

Apprenticeship

Dates: November-December

Venue: ICBA

Resources: IDB/COMSTECH

One of the components of the IDB/COMSTECH-funded project was an *Apprenticeship for human capacity building on Biosaline Agriculture in Islamic countries*.

Several OIC countries do not have adequate trained human capacity for management of saline land and water resources to grow crops, grasses and trees. Unless proper management techniques are applied, there is a great risk of damaging lands and ecosystems throughout the Islamic world.

The technologies of biosaline agriculture can be disseminated faster by providing sufficient exposure to a few middle-level scientists who in turn can provide training in their respective countries to junior scientists and technicians. This is a cost-effective method of technology transfer.

The objectives of the internship:

- Increase trained human capacity of OIC countries in biosaline agriculture.
- Provide opportunities for apprentices to interact with senior scientists working in biosaline agriculture and visit state-of-art research stations.
- Develop national-level experts in biosaline agriculture.
- Identify country-specific issues in biosaline agriculture for OIC members.
- Contribute to a better understanding of saline irrigation water and salt-affected areas with the aim of increasing food and feed production.

In addition to the four interns supported by the project described above, *Strengthening Niger's technical expertise in managing salinity by adopting biosaline agriculture*, three additional interns were selected from Burkina Faso, Indonesia and Somalia. The seven interns visited ICBA headquarters for 4-6 weeks in November. Activities included laboratory research, field work, monitoring and evaluation strategies and report preparation. Visits to farmers' fields and exposure to day-to-day problems relating to the ongoing and planned experiments in the UAE were part of the program.

An apprentice from Indonesia receiving his certificate from Director General Dr Al-Attar

Administration and Finance

FINANCE AND ADMINISTRATION

BOARD OF DIRECTORS

The terms of the members of ICBA's Board of Directors (BoD) expired at the end of 2005, with the exception of the Chairman, Mr Fawzi AlSultan, who was appointed by IDB President HE Dr Ahmad Mohamed Ali on 7 November 2005 for a period of three years.

In December 2005, Director General Dr Mohammad Al-Attar submitted recommendations for new BoD members to Mr AlSultan. Mr AlSultan endorsed the recommendations and forwarded them to Dr Ali on 25 December 2005. Dr Ali wrote to the UAE Government, asking for host country nominations for the BoD in early 2006. Although the new Board was not in place at the end of the year, the host country nominations were sent to IDB in early 2007 and the new members will meet in May 2007.

ADMINISTRATIVE MATTERS

The Finance and Administration Division made considerable achievements in 2006. These achievements were facilitated by a substantial increase in ICBA's operational budget. Considerable time and effort was spent in carrying out all pending maintenance and renovation work that had been postponed because of earlier budget limitations.

GOVERNMENT RELATIONS OFFICE, ABU DHABI

The Government Relations Office (GRO) in Abu Dhabi continued to play an important role in developing and enhancing the Center's relations with the Government and governmental agencies. GRO staff participated in several international conferences and exhibitions. The office also participated in a training course on Concepts and Strategies of Public Relations in Government Institutes in Kuwait. The GRO was moved in 2006 to a new location in Abu Dhabi to accommodate the GRM International staff working on the Soil Survey Project for Abu Dhabi. The office was supplied with all necessary facilities, including telecommunications and networking devices.

INFORMATION TECHNOLOGY

The IT section made a significant progress in 2006 due to budget availability. Progress included raising the flooring inside the data room, completing structured cabling, installing racking cabinets in the data room, and upgrading the file and printer server. Moreover,

The new ICBA server

hardware and software facilities such as laptops, network components, a data back-up system and networking were upgraded. ICBA spent nearly AED 400,000.

Insurance

ICBA staff continued to be insured for life and medical coverage throughout the year. ICBA buildings and facilities were also insured. The life and medical insurance was provided by MedNet, the property insurance by Norwich Union.

Staffing

Departures

Mr Ghazi Abu Rumman, Agronomy Laboratory Technician, February

Ms Abeer Abu Alzuluf, Executive Secretary, March

Mr Jugu Abraham, Donor Relations Specialist, April

Ms Souhad El Zahed, Administrative Services Supervisor, April

Ms Ayat Abed Rasheed, Office Assistant, Abu Dhabi, June

Mr Zaynal T Younis, Acting Director, Finance and Administration, November

New staff

Dr Nurul Akhand, Irrigation Management Scientist, February

Dr Kristina Toderich, Plant Scientist, Tashkent Office, March

Mr Abdul Qader Abdul Rahman, Agricultural Research Station Technician, March

Mr Bassam Razzak, Field Assistant, Soil Unit, March

Mr Abdul Sather Chedanguil, Driver, Abu Dhabi Office, March

Ms Lina Al Cherkawi, Receptionist, May

Ms Badryh Bochi, Administrative Assistant, DG's Office, June

Mr Ghulam Shabbir, Agronomy Laboratory Technician, June

Dr NK Rao, Plant Genetic Resources Scientist, July

Ms Baedaa Ismail Khalil, Communications Assistant, July

Ms Hiba Kamal Abdul Kareem, Administrative Assistant, Abu Dhabi Office, August

Promotions

Mr Ghazi Al Jabri was promoted from Communications Assistant to Communications Coordinator.

Ms Carla Mellor was promoted from part-time Librarian to full-time Library Specialist.

Mr Akhtar Ali was promoted from Driver to Public Relations Assistant, DG's Office.

Vacancies advertised

Hydrologist

Director of Finance and Administration

Human Resources Coordinator

General Maintenance Technician

Driver

The post of **Deputy Director General** remained vacant during the year, but IDB has announced its intention to fill the position in 2007.

The **Director General**, Dr Mohammad H Al-Attar, announced his intention to retire at the end of his contract in August. However, the IDB requested him to extend to 31 January 2007. The search for a new Director General was initiated in August, with Dr Al-Attar serving as a member of the Search Committee, which was chaired by BoD Chairman Mr Fawzi AlSultan. Of the 62 applications screened by the committee, four were shortlisted for interview. The interviews took place in early September, and the committee submitted its recommendation to the IDB. Prior to the end of the year, Dr Shawki Barghouti was named as Dr Al-Attar's successor as Director General.

Budget Analysis

Audit Report

The external auditors issued their unqualified audit report on the Center's financial statement for 2006. The audit was approved by the Board of Trustees in May.

Total budgeted expense analysis

By the end of 2006, the Center incurred total core operational and capital expenses of USD 4,231,788 compared to a total budget of USD 4,599,819 (Appendix 4), resulting in a variance of USD 368,031. This favorable variance came mainly from staff salaries and benefits resulting mainly from the vacating of key staff positions, including Donor Relations Specialist, Director of Finance and Administration and Administrative Supervisor. These posts remained vacant for the remainder of the year. Moreover, the posts of two scientists (Irrigation Scientist and Plant Genetic Resources Scientist), which were included in the 2006 budget, were not filled until the second and third quarters. Also, the budgeted post of Hydrologist remained vacant.

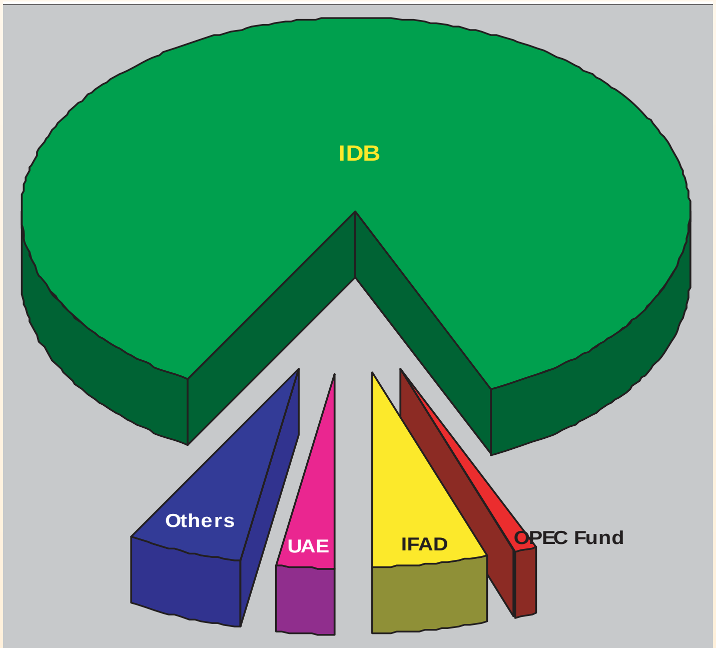


Figure 69: Funding, 2006

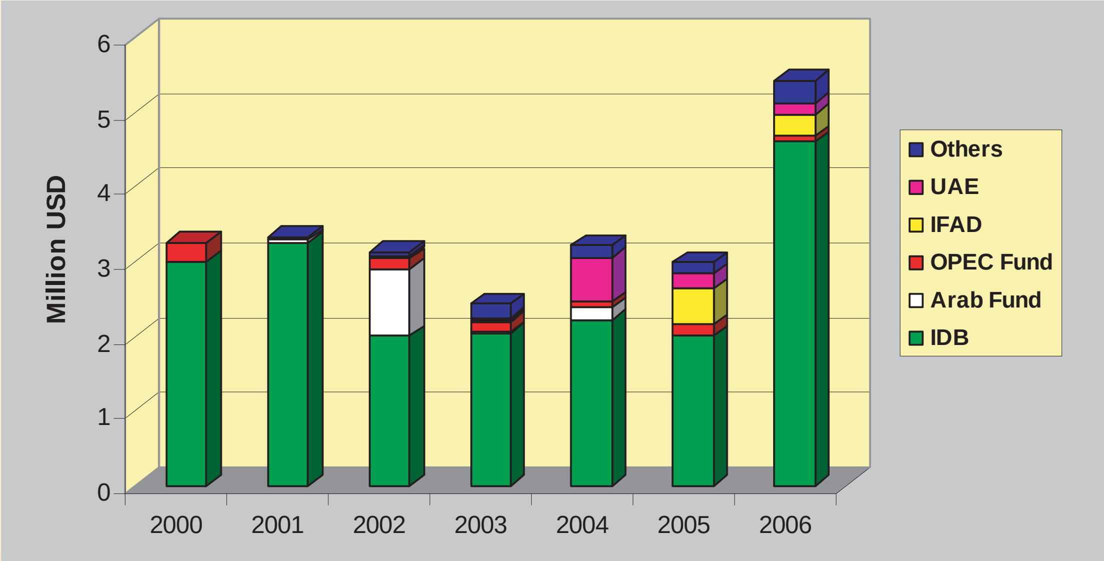


Figure 70: Donor contributions, 2000-06

The operating expenses resulted to a favorable variance which was caused mainly from savings in maintenance expenses and board expenses.

Capital expenses

Capital expenses in 2006 totalled USD 704,384 of a budgeted amount of USD 707,000. The favorable balance in capital was USD 2,616. The major expenditures were for computers, laboratory equipment and infrastructure.

Resource Mobilization

Total donor contributions are shown in Table 19 and Figures 69 and 70.

Table 19: Donor contributions, 2000-06 (USD)

	2000	2001	2002	2003	2004	2005	2006
IDB	3,000,000	3,249,375	1,999,946	2,040,000	2,215,000	2,000,000	4,599,819
Arab Fund		43,874	900,000	20,000	169,000		
OPEC	250,000		140,000	130,000	70,000	160,000	72,800
IAEA			18,612	139	40,000		
PDO		18,489	31,409	106,000	18,000		
Abu Dhabi Municipality			27,734		67,337	12,850	
BEHAR (Saudi Arabia)		22,500					
IFAD			9,600	28,700	3,300	477,000	294,000
USAID/ICARDA				78,350			
COMSTECH				4,969		7,975	18,175
HH President of UAE				20,000	450,000		
DFID (UK)				3,000			
NWICDP					4,000		
Bank Keshavarzi (Iran)					16,720		
CGIAR-CA (IWMI)					45,000	30,000	
National Prawn Company					31,000	95,977	46,678
Abu Dhabi Public Works					59,380		
Nakheel					10,000		
Dubai Islamic Bank					6,793		
AAAID					5,978		
CGIAR-CP (IRRI)					5,000	10,000	
EAD						185,462	148,370
ADB						12,546	19,430
IDB/COMSTECH							149,592
Mexico World Water Forum							47,590
DAHC							3,397
ICBA-IDB Internship							20,000
	3,250,000	**3,334,238**	**3,127,301**	**2,431,158**	**3,216,508**	**2,991,810**	**5,419,851**

Appendixes

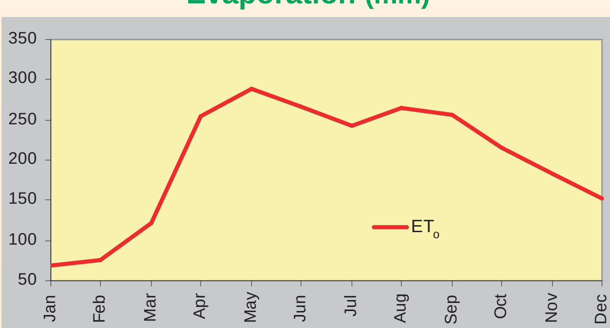
APPENDIX 1: SUMMARY OF GENEBANK HOLDINGS *(as of December 2006)*

	Genus	Family	No. of accessions	No. of species	Nature of crop
1	*Acacia*	*Fabaceae*	1	1	Forage/fuel
2	*Asparagus*	*Liliaceae*	11	1	Food
3	*Astragalus*	*Fabaceae*	68	21	Forage
4	*Atriplex*	*Chenopodiaceae*	36	8	Forage
5	*Avena*	*Poaceae*	1	1	Food/forage
6	*Beta*	*Chenopodiaceae*	108	1	Forage
7	*Brassica*	*Brassicaceae*	100	1	Oilseed/forage
8	*Cajanus*	*Fabaceae*	137	1	Forage
9	*Carthamus*	*Asteraceae*	642	2	Oilseed
10	*Cenchrus*	*Poaceae*	710	1	Forage
11	*Chenopodium*	*Chenopodiaceae*	121	1	Forage/food
12	*Chloris*	*Poaceae*	116	1	Forage
13	*Cicer*	*Fabaceae*	10	1	Food
14	*Coelachyrum*	*Poaceae*	1	1	Forage
15	*Cyamopsis*	*Fabaceae*	99	1	Food/forage
16	*Dichanthium*	*Poaceae*	5	1	Forage
17	*Echinochloa*	*Poaceae*	145	10	Forage
18	*Haloxylon*	*Chenopodiaceae*	1	1	Forage
19	*Hedysarum*	*Fabaceae*	16	5	Forage
20	*Helianthus*	*Asteraceae*	100	1	Oilseed
21	*Hordeum*	*Poaceae*	2,088	1	Food/forage
22	*Hymenocarpos*	*Fabaceae*	2	1	Forage
23	*Lablab*	*Fabaceae*	16	1	Forage
24	*Lasiurus*	*Poaceae*	3	1	Forage
25	*Lathyrus*	*Fabaceae*	254	2	Forage
26	*Leptochloa*	*Poaceae*	3	1	Forage
27	*Leucaena*	*Fabaceae*	232	1	Forage
28	*Lotus*	*Fabaceae*	414	23	Forage
29	*Lupinus*	*Fabaceae*	276	18	Forage
30	*Maireana*	*Chenopodiaceae*	1	1	Forage
31	*Medicago*	*Fabaceae*	577	38	Forage
32	*Melilotus*	*Fabaceae*	481	2	Forage
33	*Ochthochloa*	*Poaceae*	1	1	Forage
34	*Panicum*	*Poaceae*	18	1	Forage
35	*Paspalum*	*Poaceae*	2	1	Forage
36	*Pennisetum*	*Poaceae*	18	1	Forage
37	*Prosopis*	*Fabaceae*	1	1	Forage/fuel
38	*Rhanterium*	*Asteraceae*	2	1	Forage
39	*Scorpiurus*	*Fabaceae*	27	1	Forage
40	*Sesbania*	*Fabaceae*	1	1	Forage
41	*Simmondsis*	*Simmondsiaceae*	29	1	Oilseed
42	*Sorghum*	*Poaceae*	281	1	Forage/food
43	*Sporobolus*	*Poaceae*	76	18	Forage
44	*Stipagrostis*	*Poaceae*	5	1	Forage
45	*Trifolium*	*Fabaceae*	225	17	Forage
46	*Trigonella*	*Fabaceae*	23	7	Forage
47	*x Triticosecale*	*Poaceae*	869	1	Forage/food
48	*Triticum*	*Poaceae*	58	1	Forage/food
49	*Vicia*	*Fabaceae*	11	1	Forage
50	*Vigna*	*Fabaceae*	431	2	Forage/food
		Total	**8,853**	**209**	

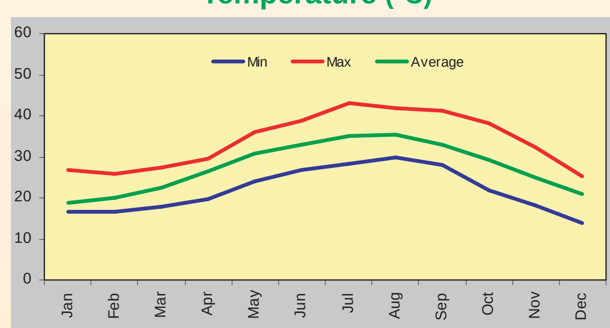
Appendix 2: Summary of weather data, ICBA station, 2006

	Temperature (^{0}C)				Relative humidity (%)				Sunshine	Solar Radiation (W m^{-2})				Windspeed (kph)				Rainfall (mm)		ET_0 (mm)	
	Min	Max	Avg	Med	Min	Max	Avg	Med	Hours	Min	Max	Avg	Med	Min	Max	Avg	Med	Total	Total to date	Monthly	Total to date
Jan	16.5	26.7	18.9	21.6	29.2	75.4	64.0	52.3	8.5	0.0	470.4	224.5	347.5	5.9	22.3	16.6	14.1	5.1	5.1	68.9	68.9
Feb	16.7	26.0	20.0	21.4	31.3	72.0	62.5	51.7	8.6	0.0	518.3	282.7	400.5	7.7	25.9	17.2	16.8	10.7	15.8	75.9	144.8
Mar	17.8	27.3	22.50	21.5	32.6	85.4	60.5	59.0	9.0	0.0	620.8	304.2	462.5	5.4	25.0	16.9	15.2	2.9	18.7	121.4	266.2
Apr	19.8	29.5	26.40	21.5	28.0	81.4	54.0	54.7	10.1	0.0	696.7	340.1	518.4	8.8	28.8	19.9	18.8	2.4	21.1	254.2	520.4
May	24.1	36.0	30.65	21.5	18.8	68.3	50.0	43.6	11.0	0.0	723.2	304.5	513.8	11.9	28.3	21.2	20.1	1.5	22.6	288.3	808.7
Jun	26.8	38.9	32.95	21.5	20.4	77.5	55.0	49.0	11.4	0.0	873.4	312.7	593.1	10.0	27.0	18.9	18.5	0.0	22.6	267.1	1075.8
Jul	28.2	43.0	35.10	21.5	18.4	71.7	54.0	45.1	11.0	0.0	612.1	422.1	517.1	7.5	19.8	15.0	13.7	0.0	22.6	243.1	1318.9
Aug	29.9	41.7	35.50	21.5	20.7	87.2	52.5	54.0	10.7	0.0	729.2	418.2	573.7	7.8	22.9	16.0	15.4	1.5	22.6	264.8	1583.7
Sep	28.0	41.2	32.95	21.5	24.8	83.1	56.0	54.0	10.2	0.0	661.8	431.8	546.8	6.5	19.7	15.0	13.1	1.1	23.7	255.5	1839.2
Oct	22.0	38.1	29.35	21.5	20.2	84.7	57.5	52.5	9.5	0.0	525.9	391.1	458.5	5.8	18.7	14.0	12.3	0.0	23.7	215.2	2054.4
Nov	18.1	32.2	25.05	21.5	28.2	86.2	60.0	57.2	8.8	0.0	481.6	350.2	415.9	7.9	22.1	14.0	15.0	1.5	23.7	183.6	2238.0
Dec	14.0	25.2	21.05	21.5	43.8	83.5	64.0	63.7	8.3	0.0	441.5	212.9	327.2	5.9	17.8	14.0	11.9	60.6	84.3	153.1	2391.1
Avg	**21.8**	**33.8**	**27.5**	**21.5**	**26.4**	**79.7**	**57.5**	**53.0**	**9.8**	**0.0**	**612.9**	**332.9**	**472.9**	**7.6**	**23.2**	**16.6**	**15.4**				

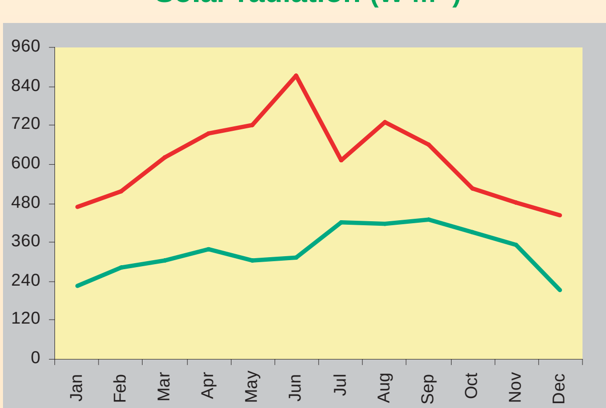
Evaporation (mm)



Temperature (^{0}C)



Solar radiation (W m^{-2})



ICBA weather station

Appendix 3: Core staff (*as of 31 December 2006*)

Office of the Director General		
Dr Shawki M Barghouti	Jordan	Director General
Mr Ibrahim Bin Taher	UAE	Government Liaison Officer
Ms Badryh Bochi	Syria	Administrative Assistant
Ms Hiba Kamal Abdul Karim	Iraq	Administrative Assistant, Abu Dhabi
Mr Akhtar Ali	India	Public Relations Assistant
Mr Abdul Sathar Chedanguil	India	Office Helper, Abu Dhabi
Technical Programs		
Prof Dr Faisal Taha	USA	Director
Dr Abdullah Dakheel	Syria	Field and Forage Crops Scientist
Dr Shoaib Ismail	Pakistan	Halophyte Agronomist
Dr Nurul Akhand	Canada	Irrigation Management Scientist
Dr NK Rao	India	Plant Genetic Resources Scientist
Dr Shabbir Shahid	Pakistan	Salinity Management Scientist
Mr Eric McGaw	USA	Communications Specialist
Dr Kristina Toderich	Romania	Plant Scientist, Tashkent
Ms Carla Mellor	Australia	Library Specialist
Dr Mahmoud Ali Abdelfattah	Egypt	Soil Scientist on Secondment
Dr Mohammed Shahid	Pakistan	Plant Genetic Resources Laboratory Technician
Mr Abdul Qader Abdul Rahman	Iraq	Research Station Technician
Mr Basel Al-Araj	Jordan	Irrigation Technician
Mr Wameed Monther	Iraq	Farm Technician
Mr Ghulam Shabbir	Pakistan	Agronomy Technician
Mr Ghazi Al Jabri	Syria	Communications Coordinator
Ms Loubna Baya	Morocco	Administrative Assistant, INBA/ICBA
Ms Diane Giessen	South Africa	Administrative Assistant
Mr Khalil ur-Rehman	Pakistan	Halophyte Laboratory Technician
Mr Khurshid Mufti	Pakistan	Soil Technician
Ms Baedaa Ismail Khalil	Iraq	Communications Assistant
Mr Bassam Razzak	Pakistan	Field Assistant, Soil Unit
Mr Saiful Islam Mehrab	Pakistan	Technical Support
Mr Balaguruswamy Santhanakrishan	India	Technical Support
Mr Mohammad Shah	Pakistan	Technical Support
Administration and Finance		
Mr Ghassan El Eid	Lebanon	IT and Network Supervisor
Mr Jamal Telmesani	Saudi Arabia	Facilities Supervisor
Ms Irene Galang	Philippines	General Accountant
Mr Bilal Al Salim	Jordan	Administrator, Government Relations
Ms Lina Al Cherkawi	Syria	Receptionist

Appendix 4: Audited Financial Statements

Statement of activities (USD, as of 31 Dec 2006)*

		2006	2005
Revenues	Grants - unrestricted	3,459,150	2,311,612
	Contribution for training courses and research	677,480	1,281,262
	Contribution from outreach projects	23,372	53,271
	Other income	68,254	14,895
	Total revenues	4,228,256	3,661,040
Expenses	Salaries	1,475,331	978,877
	Staff benefits	952,405	556,575
	Board expenses	140,878	24,211
	Supplies	67,862	108,655
	Contract services	177,362	49,909
	Travel	127,671	98,161
	Utilities	107,897	117,504
	Maintenance	148,301	117,251
	Depreciation	304,838	275,364
	Water expenses for irrigation	-	-
	Expenses of training courses and research	677,480	1,281,262
	Expenses related to outreach projects	23,372	53,271
	Other expenses	24,859	-
	Total expenses	4,228,256	3,661,040
Net income		-	-

* Capital expenditures were committed but not spent by 31 Dec 2006

Statement of financial position (USD, as of 31 Dec 2006)

		2006	2005
Assets			
Current assets	Bank balances and cash	2,292,921	1,135,744
	Receivables from staff	137,455	14,692
	Prepaid expenses	64,163	4,628
	Sub-total	2,494,539	1,155,064
Non-current assets	Property, plant & equipment	6,471,080	6,368,641
Total assets		**8,965,619**	**7,523,705**
Liabilities and net assets			
Current liabilities	Accounts payable	186,731	57,867
	Accrued expenses and other payables	1,543,039	26,501
	Sub-total	1,729,770	84,368
Non-current liabilities	Employee end-of-service benefits	52,027	69,904
Total liabilities		**52,027**	**69,904**
Net assets	Unrestricted-unappropriated	6,471,080	6,368,641
	Unrestricted-appropriated	22,612	429,889
	Temporarily restricted	690,130	570,903
	Net income	7,183,822	7,369,433
Total liabilities and net assets		**8,965,619**	**7,523,705**

Appendix 5: Acronyms and abbreviations

ADB	Asian Development Bank
ADF	Acid detergent fiber
ADSIS	Abu Dhabi Soil Information System
AFESD	Arab Fund for Economic and Social Development
AOAD	Arab Organization for Agricultural Development
BARI	Bangladesh Agricultural Research Institute
BCR	Benefit-cost ratio
BoD	Board of Directors (of ICBA)
CGIAR	Consultative Group on International Agricultural Research
COMSTECH	Standing Committee on Scientific and Technological Cooperation (of the Organization of the Islamic Conference)
CP	Crude protein
DAHC	Dubai Aid and Humanitarian City
EAD	Environment Agency-Abu Dhabi
ET	evapo-transpiration
FAO	Food and Agriculture Organization of the United Nations
FEA	Federal Environment Agency (UAE)
FT	Fertilizer treatment
GBN	Global Biosaline Network
GCSAR	General Commission of Scientific Agricultural Research
GIS	Geographic information system
GRIN	Genetic Resources Information Network
GRO	Government Relations Office (of ICBA in Abu Dhabi)
IAEA	International Atomic Energy Agency
ICARDA	International Center for Agricultural Research in the Dry Areas
ICBA	International Center for Biosaline Agriculture
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDB	Islamic Development Bank
IFAD	International Fund for Agricultural Development
INBA	Inter-Islamic Network on Biosaline Agriculture
INRAN	Institut National de Recherches Agronomiques du Niger
IR	Irrigation treatment
IRRI	International Rice Research Institute
IWMI	International Water Management Institute
MDG	Millennium Development Goal
MOEW	Ministry of Environment and Water (UAE)
MoU	Memorandum of Understanding
NARS	National agricultural research system
NDF	Neutral detergent fiber
NGO	Non-governmental organization
NPC	National Prawn Company (Saudi Arabia)
OFID	OPEC Fund for International Development
OIC	Organization of the Islamic Conference
PARC	Pakistan Agricultural Research Council
PDO	Petroleum Development Oman
QTL	Quantitative trait locus
RPIS	Regional Plant Introduction Station (USA)
SBC	Serial biological concentration
SQU	Sultan Qaboos University (Oman)
STI	Salinity tolerance index
TDS	Total dissolved solubles
UAE	United Arab Emirates
UAEU	United Arab Emirates University
USDA	United States Department of Agriculture
WANA	West Asia and North Africa

ICBA's major donors

Islamic Development Bank

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.

Arab Fund for Economic and Social Development

The Arab Fund for Economic and Social Development (AFESD) is an autonomous regional pan-Arab development finance organization. AFESD assists the economic and social development of Arab countries through (a) financing development projects, with preference given to overall Arab development and to joint Arab projects; (b) encouraging the investment of private and public funds in Arab projects; (c) providing technical assistance services for Arab economic and social development.

OPEC Fund for International Development

The OPEC Fund for International Development (OFID) is a multilateral development finance institution established in 1976 by the member countries of the Organization of Petroleum Exporting Countries. OFID aims to promote cooperation between OPEC member countries and other developing countries as an expression of South-South solidarity and in particular to help the poorer, lower-income countries to pursue their social and economic advancement.

The International Fund for Agricultural Development

The International Fund for Agricultural Development (IFAD) is a specialized international financial institution of the United Nations established in 1977. IFAD's mission is to enable poor rural people to overcome poverty.

Ministry of Environment and Water, United Arab Emirates

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

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.

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