ICBA Annual Report 2005 (1425-26H)

Annual Report 2005

(1425-26H)

International Center for Biosaline Agriculture

Our mission

To demonstrate the value of 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 management systems to irrigate food and forage crops and ornamental plants with saline water, and to encourage the use of salt-tolerant plants for socio-economic development in salt-affected areas.

ICBA's founding 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 is a multilateral development finance institution established in 1976 by the member countries of the Organization of Petroleum Exporting Countries (OPEC).

The OPEC Fund 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.

Ministry of Agriculture and Fisheries, United Arab Emirates

The Ministry of Agriculture and Fisheries (MAF) provides support to farmers, fishermen and animal breeders to increase production and contribute to food security.

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(1425-26H)

International Center for Biosaline Agriculture

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Cover photograph: *An Emirati farmer inspects the saline groundwater that irrigates his alfalfa crop in R'as al-Khaimah Emirate.*

Contents

Foreword

As we move ahead into the new century, it is clear that one of the overriding problems confronting development agencies is the increasing scarcity of water resources. Water – or the lack of it – continues to demand ever greater attention from policymakers, scientists and all those with a stake in development issues. The United Nations Environment Outlook concludes that water security will become one of the major constraints to development over the next 30 years. World food security, which is absolutely dependent on water supply, is threatened by increasing demand. In 1995, total global water consumption was estimated at 4000 cubic kilometers. By 2025, when global population will reach 8 billion, it will increase to 5000 cubic kilometers. In view of the gravity of the situation, I am very pleased to note that ICBA has chosen to expand its research efforts on the water component of its mandate.

Agriculture's demand for water, which far outstrips both domestic and industrial demand, clearly justifies the adjustment of ICBA's scientific focus. Water scarcity, land degradation, desertification, loss of biodiversity, forest depletion, deterioration of marine and coastal environments, atmospheric changes, pollution and environmental disasters are all major causes of concern.

The fundamental question is: How can we address these constraints while simultaneously making sufficient water available to meet future demands? The solution to the problem is two-pronged.

First, we must improve the efficiency with which we use water. Half of the additional food we require will come from improved irrigation and drainage systems. Today, more than 250 million hectares of farmlands are irrigated and this figure is increasing. ICBA's research has shown that by utilizing more efficient irrigation methods farmers can increase the size of their irrigated lands by a third while using only about 12% more water.

Second, we need to seek alternative water resources. The long-term answer is not desalination of seawater. This method, while important in some parts of the world for supplying water for domestic use, is unlikely to solve the problems of wide-scale agricultural production. A more realistic alternative is the use of recycled waste water and brackish water.

ICBA, which was established to investigate how brackish and salty water can productively and sustainably be used in agriculture, is ideally placed to deal with both of these solutions.

I note that ICBA's Director General, Dr Mohammad Al-Attar, is stepping down after seven years of visionary leadership and great accomplishments. I take this opportunity to wholeheartedly thank him for leading ICBA since its inception in 1999. His dedication and commitment have made the Center what it is today: a world-class center of excellence in biosaline agriculture.

Finally, I extend the Bank's thanks and appreciation to the host country of ICBA, the United Arab Emirates, for its continued support of the Center's advances in biosaline agriculture.

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

MESSAGE FROM THE CHAIRMAN, BOARD OF DIRECTORS

The publication of *Annual Report 2005 (1425-26H)* is my first opportunity to formally greet the ICBA community as Chairman of the Board of Directors. As many of you know, the Islamic Development Bank decided to separate the positions of Director General and Chairman of the Board for the first time since the Center was established in 1999.

I take this opportunity to acknowledge the sterling leadership of Dr Mohammad Al-Attar, who has diligently and capably handled both positions for over six years. His guidance and advice have been invaluable to me since I accepted the post of Chairman in August 2005. His imminent retirement as Director General will leave an enormous gap at the helm of ICBA, and identifying a suitable successor is a daunting challenge.

ICBA is at a crossroads. Originally established to investigate how saline water and soils can be used in agriculture, the Center's research agenda is about to undergo something between transition and transformation. At the time of this writing, an elite panel of experts has been recruited to develop a Strategic Plan for 2007-2011. The indications are that ICBA's future activities will expand on water issues, particularly those which affect agriculture in the arid environments. Although biosaline agriculture will remain a focal point of the Center's scientific endeavor, it will no longer be our exclusive focus.

The panel of experts has been asked to identify the critical areas of need that ICBA should focus on during the next several years. Questions they will address include: How much of the program will be demand driven? How will the private sector react to the Gulf and the UAE's vision of attracting services and new technologies? How can these be linked to ICBA? How can ICBA promote this vision and work with universities and other partners to encourage research? How can resource mobilization be linked to activities?

These are key questions and answering them is crucial. Of course, much of the information and guidance needed by the panel is already available with the excellent scientific staff at ICBA, and a number of forums are in place to bring our stakeholders together. In any case, we have embarked on a new journey, and although the road ahead is a challenging one, I am confident that by working together we will find the right pathway to progress.

Let me conclude by offering my sincere congratulations to Dr Al-Attar, the leading light of the Center since its inception. I wish him every success in the next chapter of his life.

Fawzi AlSultan
Chairman, Board of Directors, ICBA

Message from the Director General

During 2005, ICBA's reputation as a world-class center of excellence was enhanced in several ways.

In February, our largest project to date got under way. The project, which focuses on forage crop improvement in West Asia and North Africa, is truly an international effort. Supported by cash contributions from three donors and in-kind contributions from several international research institutes as well as seven national programs, the project has done much to raise the profile of the Center by making research on forage systems accessible to farmers throughout the region.

Another important research initiative during the year was a collaborative project with ICARDA and IWMI on combating land and water resource degradation in three Central Asian countries: Kazakhstan, Turkmenistan and Uzbekistan.

Another major undertaking by ICBA is the technical supervision and contract management of a soil survey for the Emirate of Abu Dhabi. Environment Agency-Abu Dhabi (EAD) signed a 42-month contract with ICBA stipulating that the Center will oversee the implementation of the project by the international firm GRM Inc.

During 2005, the IDB decided to split the dual functions of the Center's Director General and the Chairman of the Board of Directors as a result of a recommendation of an external review in 2004. Mr Fawzi AlSultan, a Kuwaiti national and former Executive Director of the World Bank and President of the International Fund for Agricultural Development (IFAD), was selected as the new Chairman. This enlightened decision has freed me from the necessity of wearing two hats, leaving me to attend to the research agenda so vital to our stakeholders.

In conclusion, let me take this opportunity to announce my retirement as Director General of ICBA. I have been enormously enriched through my involvement with ICBA and will certainly cherish the memories my interactions with partners and colleagues in the years to come.

As always, I offer my profound thanks to Dr Ahmad Mohamed Ali, Chairman, and Dr Amadou Cisse, Vice-President for Operations, IDB, for their unflagging support.

A special thank-you goes to Prof Dr Fasial Taha, Director Technical Programs, for his able leadership and to the ICBA team for their dedication to improving lives through the application of good science. The ICBA family is a wonderful one.

Dr Mohammad H Al-Attar
Director General, ICBA

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Research Highlights

Alternatives for Bangladeshi Farmers

Improved irrigation and cultivation practices are promising for farming families faced with seawater intrusion

Saline areas traditionally left fallow during the dry season can be sown with economically useful crops like tomatoes and chilies.

For more about PMS09, see page 30.

SOIL SURVEY IN ABU DHABI

In partnership with Environment Agency-Abu Dhabi (EAD), ICBA is overseeing and managing the Emirate's first soil survey conducted by an international firm.

- *Invaluable tools for land use planning and protection of the environment*
- *Identification of high-risk areas*
- *Capacity building of UAE nationals*

The saline soils of Abu Dhabi are typified by a shallow water table.

Capacity building – an important ingredient of the project.

For more about PMS36, see page 37.

The Forage Project

7 countries

3 donors

4 years

4 million dollars

It all adds up to huge benefits for farmers over a wide area with little in common but poverty.

Members of the Technical Committee inspecting forage germplasm preserved in the ICBA Genebank.

Regular visits of technicians from the national programs gives them a chance to visit field experiments in various participating countries during traveling workshops like this one in Oman.

Beneficiaries of the research.

For more about PMS27, see page 61.

HALOPHYTES FOR IRAN

Introducing native halophytes into agricultural production in salt-affected areas

- *Evaluation of optimal fertilizer requirements and irrigation systems for halophyte productivity*
- *Field and farmers' days in collaboration with local ministries and extension services*

Working with extension agents and farmers to adapt and optimize different species.

Identifying suitable water management methods to introduce halophytes into production systems.

For more about PMS22, see page74.

Bright spots in the Aral Sea

Enabling communities in the Aral Sea Basin to combat land and water resource degradation: promoting strategies to enhance irrigated farming systems

The donor

ADB Asian Development Bank
Fighting Poverty in Asia and the Pacific

The international collaborators

International Water Management Institute

The national collaborators

Kazakhstan

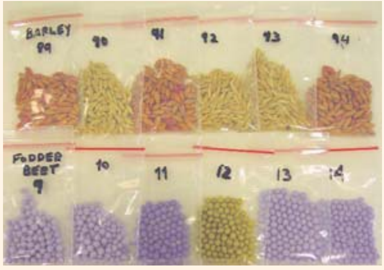
Turkmenistan

Uzbekistan

Identifying appropriate crops and cropping systems for needy farmers.

For more about PMS35, see page 84.

TECHNICAL PROGRAMS



Plant Genetic Resources Program

Acquisition, conservation and dissemination of plant genetic resources (GR01)

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

Significance of the project

Preserving seeds, the genetic resources of plants, is one of the most important functions of any agricultural research center. By keeping seeds viable in the controlled environment of a well-maintained genebank, the transfer and re-growth of plants is safeguarded. Genebanks also facilitate plant survival in harsh circumstances. Although *in situ* husbandry is the most effective way of preserving plant genetic resources, natural and manmade circumstances such as climate change, irresponsible plant exploitation and overgrazing make *ex situ* conservation essential.

Key points

- 289 accessions of 8 species procured.
- Genebank collection increased to 8478 accessions of 255 species.
- 843 seed accessions disseminated to 11 countries.

Acquisition of salt-tolerant germplasm, the primary goal of GR01, provides ICBA researchers and their colleagues at other research institutes the opportunity to test, identify and select appropriate materials for dissemination.

Objectives

- Identify and procure salt-tolerant plant accessions
- Maintain a world-class genebank to supply interested agricultural researchers and other beneficiaries with suitable plant materials

Achievements in 2005

Throughout 2005, ICBA continued to acquire salt-tolerant and potentially salt-tolerant plant accessions from various sources. A total of 289 accessions belonging to 8 species were added to the genebank during 2005 (Table 1). By the end of the year, 8478

Barley seed stored in the genebank.

Table 1. Plant accessions procured in 2005

Scientific name	Common name	No.	Origin
Acacia cyanophylla	Blue leaf wattle	1	Tunisia
Carthamus tinctorius	Safflower	3	Iraq
Hordeum vulgare	Barley	195	Australia
Medicago arborea	Trefoil	1	Tunisia
Pennisetum glaucum	Pearl millet	64	India (ICRISAT)
Sesbania aculeata	River hemp	1	Pakistan
Sorghum bicolor	Sorghum	18	India (ICRISAT), Iraq
Triticum aestivum	Wheat	6	Iraq
Total		**289**	

accessions of 255 species were held in storage in the ICBA genebank (Appendix 1).

Barley (*Hordeum vulgare*). The seed of two haploid populations of Skiff x CM72 and CM72 x Gairdner plus parents (195 lines) was obtained from the School of Biology, University of Western Australia, Perth. The study of haploid populations of CM72 will help identify molecular markers for salt tolerance in barley. After multiplication, the seed will be tested for salinity tolerance at various levels.

Pearl millet (*Pennisetum glaucum*). Seed of 64 accessions of pearl millet were acquired from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) for salinity testing.

Sorghum (*Sorghum bicolor*). Fifteen prominent sorghum accessions were acquired from ICRISAT and three varieties were obtained from the Agriculture Faculty of Basra University, Iraq. The samples will be used for seed multiplication.

Blue leaf wattle (*Acacia cyanophylla*) and trefoil (*Medicago arborea*). Seed was sent by Tunisia's National Research Institute for Rural Engineering, Water and Forests. These salt-tolerant shrubs are good sources of fodder during drought. The seed was acquired as part of PMS27 (page 61).

River hemp (*Sesbania aculeata*). A salt-tolerant plant, river hemp is used as green manure while its seed is consumed as food. The plant also has medicinal value. Seed was procured from the Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad, Pakistan.

Wheat (*Triticum aestivum*). Six varieties of wheat were acquired from the Agriculture Faculty of Basra

Disseminated seed of three species.

University, Iraq. The varieties were developed in southern Iraq, which has severe salinity problems.

Safflower (*Carthamas tinctarius*). The Agriculture Faculty of Basra University also provided ICBA with three varieties of safflower, a salt-tolerant plant. A multi-purpose plant, safflower yields a dyestuff and its seeds contain oil used in cooking, cosmetics, paints and medicine.

SEED DISSEMINATION

Seed was supplied to various research institutes, universities and other organizations conducting research on various aspects of salt tolerance in plants. In 2005, 843 seed samples belonging to eight species were disseminated to organizations in 11 countries (Table 2).

The seed of 25 salt-tolerant barley accessions was supplied to the School of Biology, University of Western Australia, Perth, Australia. The same set of barley seed was also sent to the Agrarian Science Center, University of Hajibayov, Baku, Azerbaijan. Scientists at the former university are working on salt-tolerant markers in barley, while their counterparts at the latter institution are involved in the development of salt-tolerant barley.

The seed of four alfalfa (*Medicago sativa)* varieties was provided to Oman's Ministry of Agriculture and Fisheries.

Sorghum seed stored in the Genebank.

Table 2. Plant accessions disseminated in 2005

Country	**Crop**	**No. samples**	**Sub-total**
Australia	Barley	25	25
Azerbaijan	Barley	25	25
Oman	Alfalfa	4	4
Uzbekistan	Alfalfa, sorghum, fodder beet, pearl millet	2,7,7,25	41
Kazakhstan	Alfalfa, sorghum, fodder beet, pearl millet	2,7,7,25	41
Turkmenistan	Alfalfa, sorghum, fodder beet, pearl millet	2,7,7,25	41
Jordan	Pennisetum, alfalfa, rape, fodder beet, sorghum, barley, pearl millet, buffel grass	1,4,4,7,25,25,29,38	133
Oman	Pennisetum, alfalfa, rape, beet, sorghum, barley, pearl millet, buffel grass	1,4,4,7,25,25,29,38	133
Pakistan	Pennisetum, alfalfa, rape, beet, sorghum, barley, pearl millet, buffel grass	1,4,4,7,25,25,29,38	133
Syria	Pennisetum, alfalfa, rape, beet, sorghum, barley, pearl millet, buffel grass	1,4,4,7,25,25,29,38	133
Tunisia	Pennisetum, alfalfa, rape, fodder beet, sorghum, barley, pearl millet, buffel grass	1,4,4,7,25,25,29,38	133
UAE	Buffel grass	1	1
Total			**843**

The seed was used during a training course in Muscat arranged by ICBA.

ICBA also supplied the partners of its project in Kazakhstan, Turkmenistan and Uzbekistan (PMS35) with 2 alfalfa, 7 sorghum, 7 fodder beet (*Beta vulgaris*) and 25 pearl millet accessions.

Partners in the Forage Project (PMS27) in Jordan, Oman, Pakistan, Syria and Tunisia were supplied with seed of 1 pennisetum (*Pennisetum purpureum*), 4 alfalfa, 4 rape/canola (*Brassica napus*), 7 beet, 25 sorghum, 25 barley, 29 pearl millet and 38 buffel grass (*Cenchrus ciliaris*).

Buffel grass seed from winter and summer harvests was provided to a graduate student at UAE University.

Plans for 2006

During 2006, ICBA will continue to acquire seed of salt-tolerant plants from different organizations around the world. After it is evaluated, selected seed will be multiplied and conserved for further evaluation and dissemination. The seed of perennial plant species like *Cenchrus ciliaris* and *Atriplex* spp. will continue to be collected. For the various accessions of annual crops including pearl millet, sorghum and lotus, which were planted in the winter, seed will be harvested, cleaned and stored.

His Excellency Dr Mahmoud Abu Zaid, Egyptian Minister of Water Resources and Irrigation (left) and Dr Karim Allaoui, Water Resources Specialist, IDB, visiting the genebank with Prof Dr Faisal Taha.

Seed multiplication of salt-tolerant germplasm (GR02)

Duration: Ongoing
Resources: Core

Significance of the project

Most of the germplasm obtained by ICBA comes in small amounts. Because these quantities are insufficient for salinity testing at ICBA headquarters, seed must be multiplied before it can be distributed to research collaborators. To obtain sufficient seed for this purpose and to conserve it in the genebank, multiplication of the acquired seed is necessary. Apart from multiplication, the planting of the imported accessions provides an opportunity to observe their adaptability to the local climate.

Key points

- Of 821 buffel grass accessions, 614 produced seed during winter and 443 during summer.
- More than 97% of sorghum accessions produced seed.
- Each of 293 wheat accessions produced seed.

Objectives

- Propagate newly acquired accessions to obtain adequate seed for salinity testing, dissemination and conservation.
- Assess the adaptation of newly introduced species.

Achievements in 2005

Some species sown in 2004 were kept in the field for assessment during 2005, and several new species were planted. Each annual species was evaluated, as were several perennials. Because the purpose of this exercise is to increase seed for additional testing, the germplasm was irrigated with fresh water to safeguard its viability.

Buffel grass. Under irrigated conditions, this species produces seed twice a year. In 2005, of 821 accessions planted, 614 produced seed during the winter season, while in summer 443 bore seed.

Sorghum. Of 353 accessions, 344 produced seed.

Pearl millet. 29 accessions were planted for seed production of this highly cross-pollinated crop. To prevent cross pollination, the heads

Multiplication of sorghum seed.

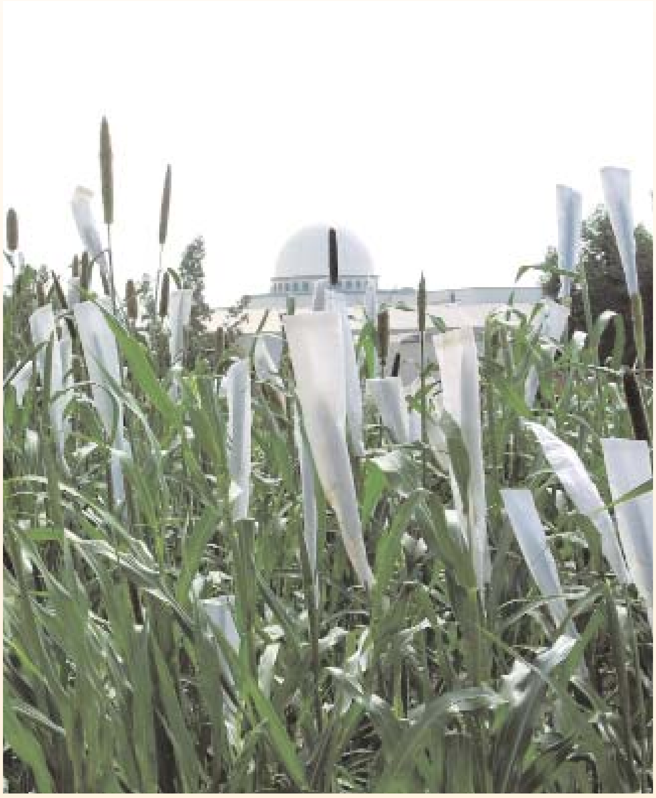
were covered with paper bags. Later, self-pollination was done to ensure good seed production. Only seed from the covered heads was collected for distribution and further experimentation.

Wheat. 296 accessions, including observation nurseries of the International Maize and Wheat Improvement Center (CIMMYT) and Omani landraces were sown for seed production. All planted wheat accessions produced seed.

Barley. 83 barley accessions, selected on the basis of performance, were grown for seed multiplication.

Plans for 2006

Seed propagation of annual species planted during winter will continue. Perennial species planted in 2005 and earlier will remain in the field for seed multiplication in 2006 and beyond. Evaluation of new accessions for adaptability to the local climate will also be conducted.



Seed multiplication of pearl millet.

Barley seed multiplication.

Barley yield trials and observation nurseries (GR04)

Duration: 2005-06
Collaborator: International Center for Agricultural Research in the Dry Areas (ICARDA)
Resources: ICARDA, Core

Significance of the project

Barley is one of the hardiest cereal crops. It is more salt-tolerant than wheat, which might explain the increase of barley cultivation in Mesopotamia from the second millennium BC when salt began to build up in the Tigris-Euphrates Basin. More salt-tolerant varieties/lines of barley have evolved with improved grain production under saline conditions than any other major cereal crop.

The nurseries and yield trials provided by ICARDA have enhanced and widened the genetic base available to barley improvement. These accessions were developed through multi-location screening for salt tolerance as well as for other characteristics such as high yield, high quality grain and disease resistance.

Key points

- Seed for three observation nurseries and one yield trial were acquired from ICARDA.
- 4 experiments consisting of 324 barley lines were conducted.
- Top-performing lines were selected for the genebank.

Objectives

- Participate in the barley improvement program conducted by ICARDA.
- Select top-performing lines of barley and add them to the genebank.

Barley yield trials.

Barley yield trials.

Achievements in 2005

ICBA received seeds from one yield trial and three different observation nurseries from ICARDA. Seed for the yield trial in low rainfall areas (mild winter) consisted of 24 entries with 3 replications. Seed for the observation nurseries in low rainfall areas (mild winter), moderate rainfall areas, and the intermediate naked barley observation nursery consisted of 100 entries each. The seed was planted in the field during winter. Irrigation with fresh water and other standard agronomic practices were observed to optimize seed viability.

Plans for 2006

Data on different plant characteristics, including days to heading, days to maturity, height, lodging, susceptibility to leaf rust and grain yield of all four experiments will be collected and sent to ICARDA. The data will be also analyzed to identify the best-performing lines. The seeds will be conserved in the genebank for subsequent experimentation.

Salinity screening (GR05)

Duration: 2004-05
Collaborator: Advanta
Resources: Advanta, Core

Key points

- 11 varieties – 7 fodder beet, 2 rape and 2 canola – were tested for salt tolerance
- 5 salinity levels – 5, 10, 15, 20 and 25 dS/m were used for the testing
- Both hydroponics and soil-based media were used
- Beets performed better than rape and canola at high salinity levels

Significance of the project

Beet (*Beta vulgaris*), rape (*Brassica napus*) and canola (*Brassica napus*) are salt-tolerant crops used for both human food and animal feed. Although many commercial varieties are available throughout the world, no variety has been specifically developed for biosaline agriculture. Advanta, one of the world's leading seed companies, has developed dozens of beet, rape and canola varieties. To test these varieties for salt tolerance, ICBA requested the company to send some of their seed. Advanta responded with seeds of seven beet varieties, two rape varieties and two canola varieties.
Identification of salt tolerance will help to establish appropriate varieties for salt-affected areas.

Objectives

- Identify salt-tolerant fodder beet, rape and canola varieties.
- Recommend tolerant varieties for salt-affected areas.

Achievements in 2005

Eleven cultivars – seven fodder beet, two rape and two canola – were tested in hydroponics at five salinity levels. Once seedlings had been established with fresh water, salinity treatments were initiated after 10 days. Salinity levels were then increased gradually over two weeks. Plants were harvested when the plants had been irrigated with the highest salinity level for 6 weeks. Growth of beet varieties was not significantly different at 5, 10 and 15 dS/m, but harvested dry weights were reduced at 20 and 25 dS/m by approximately 30% (Figure 1). Rape cultivars were more severely affected by

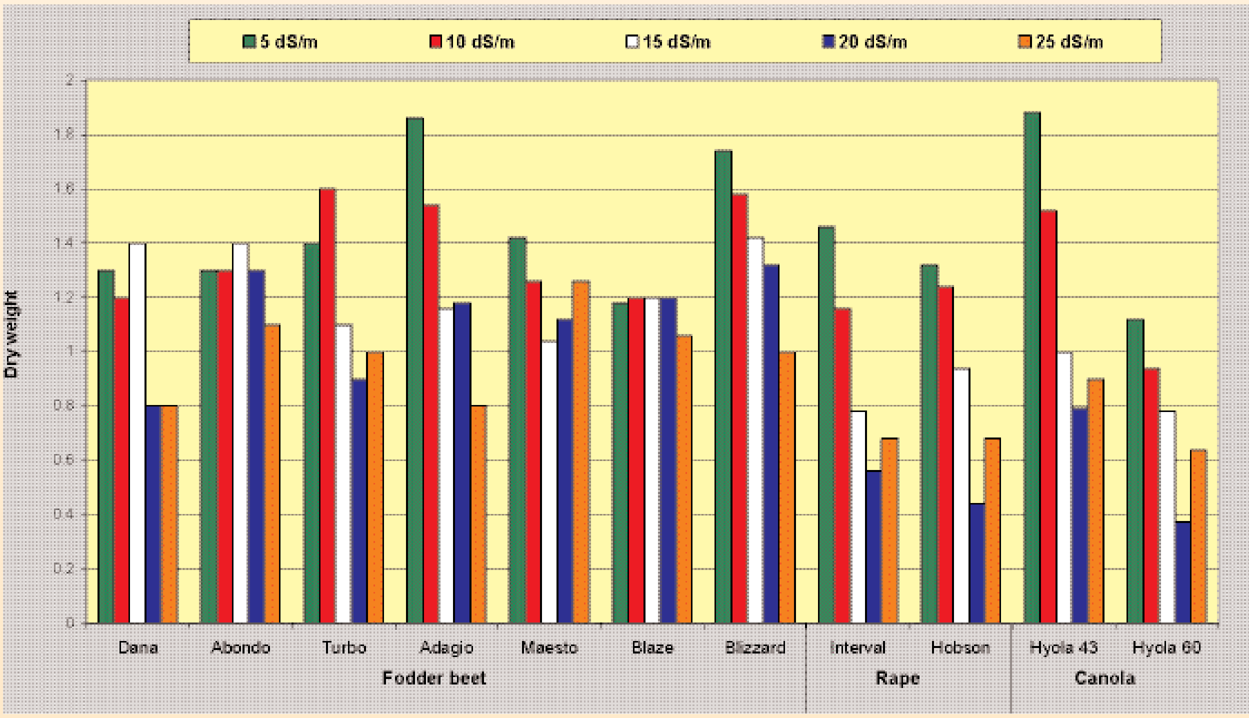
Canola flowering in pot at high salinity.

salinity, with harvested dry weights reduced by 50% at 15 dS/m.

The same cultivars were also tested in a soil-based medium in pots at 5, 10 and 15 dS/m, replicated three times. In this case, the irrigation treatments were saline throughout the growth period – no fresh water was used. Plants were harvested at 92 days and fresh and dry weights of green material (and tubers in the case of beet) were determined. Germination was reduced with increasing salinity for all species, but the effect was slight. Subsequent growth of beet was little affected by salinity. In fact, both 10 and 15 dS/m treatments for beet outyielded the 5 dS/m treatment, although the differences were insignificant. For rape/canola, growth patterns were erratic. Some replicates performed well at all salinity levels and others poorly for no obvious reason. In general, rape grew more robustly than canola.

Salinity test of fodder beet and Brassica *varieties in hydroponics.*

Figure 1: Total plant dry weight (g) of 7 fodder beet, 2 rape and 2 canola varieties at 5 different salinity levels



Production and Management Systems Program

Sustainable land and water use

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

Duration: 2003-06
Collaborator: Bangladesh Agricultural Research Institute (BARI)
Resources: BARI, Core

Key points

- Tomatoes are a promising cash crop for saline areas.
- Drip irrigation and raised beds decrease root zone salinity 40% as against flat beds and conventional irrigation.
- Rainwater harvesting is a viable option for supplying irrigation water to dry-season crops.

Significance of the project

Bangladesh is a developing country whose population of 140 million is growing at an alarming rate. To meet the food demands of an increasing population, salt-affected lands, which cover an estimated 0.88 million ha, must be brought under cultivation during the dry season.

Average annual rainfall in Bangladesh is 3,000 mm. However, almost all of this precipitation occurs during the monsoon season, which begins in June. During the dry months of March and April, salinity problems resulting from seawater intrusion are acute, and as a result land is commonly left fallow. Seawater intrusion into agricultural fields is significant because of the near-sea-level topography of coastal areas.

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

Objectives

- Grow crops using drip irrigation on raised beds and compare yield and salinity results against common agricultural practices.
- Convert yield data into economic returns and evaluate overall economics.
- Assess the feasibility of rainwater harvesting as an option for increasing irrigation water supply during the dry season.

Tomato under drip irrigation.

Achievements in 2005

Field experiments with tomato and chili were conducted in the saline soils of Charmajid, district of Noakhali, during the dry season. The treatments of the experiment were:

1. No irrigation in flat bed (the common practice in the area)
2. No irrigation in raised bed
3. Drip irrigation in raised bed with the dripper discharge maintained at 4.6 liters/hour with pond water (EC approximately 0.25 dS/m; elevated water tanks at 1.5m height provided the pressure head required for the drip systems)

Drip irrigation in the raised bed treatment yielded 28.4 t/ha tomatoes, an increase of 150% over yields obtained using traditional practices. Raising the bed without irrigation produced 21.9 t/ha tomatoes (1.2 times over traditional practices). In the case of chilies, drip irrigation in raised beds produced 1.42 t/ha, almost double the yield from traditional practices. The benefit-cost ratio of drip irrigation for tomato was 1.93, considerably lower than the result reported in 2004 (5.3). The lower result in 2005 was due to higher salt accumulation in the root zone and late planting of seedlings. For the same reason, chili cultivation was unprofitable in 2005 under drip irrigation.

Drip irrigation lowered soil salinity at the root zone of tomato and chili by approximately 40% in comparison with the farmers' traditional practice.

A survey was conducted to assess the feasibility of growing watermelon in the study area in comparison with a non-saline area. The results showed that cultivation of watermelon was profitable in the study area. The estimated benefit-cost ratio was 1.96, although a higher ratio (2.37) was recorded for the non-saline area.

Rainwater harvesting can provide a reliable source of irrigation water during the dry season. Existing ponds in the study area can provide storage of monsoon

Chili crop ready for harvest.

rainwater for dry season crops as well as fish production. These ponds, however, need renovation to increasing their storage capacities. A preliminary assessment shows that a pond with a surface area of 425m^2 and 3.5m depth can be used to irrigate 0.6 ha plots cultivated with tomato and chili. The estimated benefit-cost ratio using such a pond was 2.92 for tomato and 1.61 for chili.

Plans for 2006

In the pilot scheme, watermelon and cucumber will be tested along with tomato and chili. A comparative assessment of the results obtained during the three years of experimentation will be conducted, and a field day will be organized to demonstrate the results.

BARI-ICBA field day.

Feasibility study for biosaline agriculture in the UAE (PMS32)

Duration: 2004-06
Collaborator: Ministry of Agriculture and Fisheries (MAF)
Resources: International Atomic Energy Agency (IAEA), MAF, Core

Significance of the project

ICBA completed a research project with the International Atomic Energy Agency (IAEA) to examine the potential of salt-tolerant plants in the Middle East. Activities included developing a strategic document for submission to the IAEA in collaboration with MAF. After approving the document, the IAEA also approved a grant for preparation of a Feasibility Study on biosaline agriculture in the UAE. The objective was to review the current status of agriculture in the country, identify the gaps and provide a baseline for preparing a national program for biosaline agriculture.

Key points

- Update current agricultural production systems under saline conditions in the UAE.
- Select target areas, mainly abandoned agricultural farms, to demonstrate biosaline agriculture.
- Evaluate the socio-economic prospects of 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 2005

ICBA and Ministry scientists initiated the working draft for the Feasibility Study by collecting data from the various agricultural zones in the country according to land and water resources and use, agricultural production and commodities, etc. Gaps were also identified where few or no data were available. This information laid the groundwork for developing and expanding biosaline agriculture in the UAE. A study of the current socio-economic aspects and potential of the present agricultural system was also prepared. After review by all the concerned scientists and managers, the final report will be prepared for submission to both the IAEA and the Government of the UAE.

Plans for 2006

The Feasibility Report will be completed by the second quarter of 2006.

Utilization of biosaline agriculture by the National Prawn Company, Saudi Arabia (PMS33)

DURATION: 2004-06
COLLABORATOR: National Prawn Company (NPC)
RESOURCES: NPC

SIGNIFICANCE OF THE PROJECT

The National Prawn Company (NPC), one of the largest prawn farms in the world, asked ICBA to establish biosaline agriculture on its facility at Al Laith, Kingdom of Saudi Arabia, in 2004. Initially, the work focused on the utilization of seawater drained from prawn farms and previously discharged into the Red Sea. The scope of work now covers other initiatives, including a shadehouse for plant propagation and a demonstration farm for testing plants. The idea is to identify successful plants that can be used either for forage or for stabilizing the side slopes of the prawn farm dikes. In addition, the work covers increasing the stand of mangroves (*Avicennia marina*) on a barrier island and establishing them along the drainage canal.

KEY POINTS

- Effluent from shrimp farming can be used to grow halophytes.
- Expansion of mangrove plantations can enhance aquaculture.

OBJECTIVES

- Establish research and development activities leading to a large-scale utilization of return seawater for the production of halophytes.
- Expand mangrove plantation at the barrier island and return water canal.
- Establish research and development activities for selection and planting of ground cover for the stabilization of dikes.

ACHIEVEMENTS IN 2005

A demonstration site and a shadehouse nursery were selected according to specifications developed by NPC and ICBA. The 4-ha site was leveled and prepared for installation of irrigation system, and access roads were constructed.

A total of 100 plots, each 20m^2, were prepared – 50% allocated for grasses, 25% for shrubs and 25% for trees. A windbreak belt consisting of *Salvadora persica* and *Conocarpus lancifolius* was also included along with design and specifications for planting and irrigation systems. Moreover, a concrete water storage reservoir was constructed on the site.

A first shipment of plants consisting of 5,598 specimens of 23 species was delivered to NPC on 18 March. Soil samples from the

NPC products, enhanced through biosaline agriculture, are marketed throughout the world.

demonstration site were collected, analyzed at ICBA and reported to NPC in April.

A large number of mangrove seeds and seedlings were collected from the barrier island. The seedlings were hardened according to guidelines provided by ICBA, gradually increasing irrigation water salinity to 57 dS/m (equivalent to seawater).

Water storage reservoir at the NPC demonstration site.

NPC's shadehouse.

First plant consignment from ICBA.

The irrigation system was completed, including procurement of pumps and other materials, construction of pumping stations, layout of main and lateral irrigation lines and installation of drip systems.

In October, an NPC engineer visited ICBA for training in the management of salt-tolerant grasses and shrubs.

Inspecting an infected mangrove seedling.

Second plant consignment prepared at ICBA for shipping to NPC.


Mangrove seedlings prepared and maintained at NPC.

Plans for 2006

ICBA technical staff will visit NPC to provide technical assistance in irrigation system maintenance and nurturing of halophytes and other plants supplied to NPC. A coordination meeting at NPC will be held to evaluate achievements and adjust the project timetable. Other matters for discussion include a plan for transferring plants to the demonstration plots and the establishment of a windbreak.


Mangroves are hardy plants, but susceptible to jellyfish.

The drainage canal to the sea.

Soil Survey for the Emirate of Abu Dhabi (PMS36)

DURATION: 2005-09
COLLABORATOR: Environment Agency-Abu Dhabi (EAD)
RESOURCES: EAD and Core

SIGNIFICANCE OF THE PROJECT

The survey is a multi-purpose, science-based inventory of soil resources, something that has not previously existed in the Emirate of Abu Dhabi. Realizing its importance, the Executive Council of Abu Dhabi, responding to a request from EAD – formerly the Environmental Research and Wildlife Development Agency (ERWDA) – approved funding for the project. EAD and ICBA signed a Memorandum of Agreement on 11 April for joint implementation of project activities. The partners jointly prepared a comprehensive soil survey action plan for the next three and a half years and presented it to potential stakeholders.

The soil survey will be conducted in two phases, providing digital information to assist Abu Dhabi officials in land use planning and agricultural expansion. The survey will be conducted by GRM Incorporated, an Australian firm.

KEY POINTS

- This is the first soil survey of the Emirate of Abu Dhabi ever taken.
- The capacity of UAE nationals to manage such surveys will be enhanced through the project.

OBJECTIVES

- Conduct a survey of the entire Emirate on a scale of 1:100,000.
- Conduct a survey of an area of 400,000 ha for agriculture expansion on a scale of 1:25,000.
- Publish soil, thematic, salinity and current land use maps at different scales.
- Develop a Soil Database Management System within a GIS environment.
- Build capacity of UAE nationals.

PLANS FOR 2006

- ICBA will manage project activities.
- Two soil training workshops will be conducted at ICBA headquarters.
- ICBA will host the contractor at its Abu Dhabi office.

Brainstorming session at Abu Dhabi.

Field and Forage Crops

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

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

Significance of the project

Long-term field studies on the economic feasibility and sustainability of forage production systems based on the use of non-conventional salt-tolerant grasses and highly saline water are very limited internationally and unavailable regionally. In order to assess such forage production systems, two highly salt-tolerant grasses, *Sporobolus virginicus* and *Distichlis spicata*, were selected for research and demonstration at ICBA headquarters. The species were selected based on previous evaluation of salinity tolerance, nutritional value, suitability for mechanical harvesting and handling for economical large-scale production.

Key points

- Mean annual dry biomass production over all salinity levels reached nearly 33 t/ha in *Distichlis* and 28.5 t/ha in *Sporobolus.*
- Maximum yields were achieved at high fertility levels.
- The two species responded in different ways to increased levels of irrigation. *Distichlis* yield increased significantly, while *Sporobolus* yield declined at irrigation levels equivalent to twice ET_0.

The grasses were established in 2001 on a 0.6-ha field in collaboration with UAEU at Al Ain. Different combinations of management inputs were applied to determine optimum production packages. These included:

- 3 salinity levels
  - 10 dS/m
  - 20 dS/m
  - 30 dS/m
- 3 irrigation levels
  - 1.0 X ET_0
  - 1.5 X ET_0
  - 2.0 X ET_0
- 4 fertilizer levels
  - F1 = 0 fertilizer added
  - F2 = NPK at 20-10-10 units
  - F3 = NPK at 40-20-20 units
  - F4 = NPK at 60-30-30 units

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 level that minimizes salt accumulation in the soil.
- Determine appropriate fertilizer regimes for maximum production.
- Assess the nutritional value of the two species in response to the different salinity, irrigation and fertilizer levels.

ACHIEVEMENTS IN 2005

The cutting program was adjusted in 2005 to three cuts instead of the four practiced in previous seasons. This was done to minimize the variations among cuts and increase the efficiency of field operations. In addition, chemical and nutritional analyses of plant samples from one harvest were achieved in 2005 in collaboration with UAEU. Irrigation, fertility and salinity treatments were applied throughout the year and their impact on yield and quality was taken into consideration. A real-time salinity monitoring system with 12 sensors was also installed in the field to continuously monitor salinity levels in selected treatments.

RESULTS

Highlights of production and chemical analysis are presented in the following figures.

A. Large-scale field yield

Total yield at each harvest (over all treatments) ranged from 12 to 13 t/ha for *Sporobolus virginicus* and from 12 to 15 t/ha for *Distichlis spicata*. Total annual field dry matter production reached 38,500 kg/ha in *S. virginicus* and 39,750 kg/ha in *D. spicata*. Seasonal variations in yield were lower than previous years. Adjustment of the cutting program reduced the variations. Highest yields were obtained during November harvest (Figure 2).

Yields under each salinity level were similar to the average yields mentioned above. Higher yields of *D. spicata* were attained at the high salinity level, while those of *S. virginicus* were at the medium level.

Figure 2: Mean annual field dry matter yield (kg/ha) in *Distichlis spicata* and *Sporobolus virginicus* at 3 harvests

(Values are means of 3 cuts over different combinations of irrigation and fertility levels)

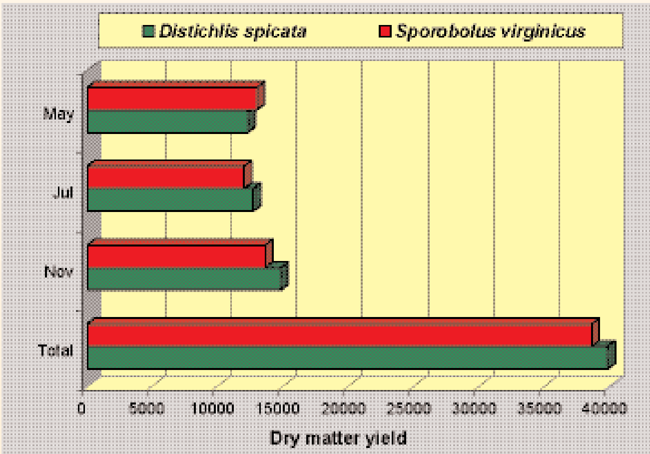
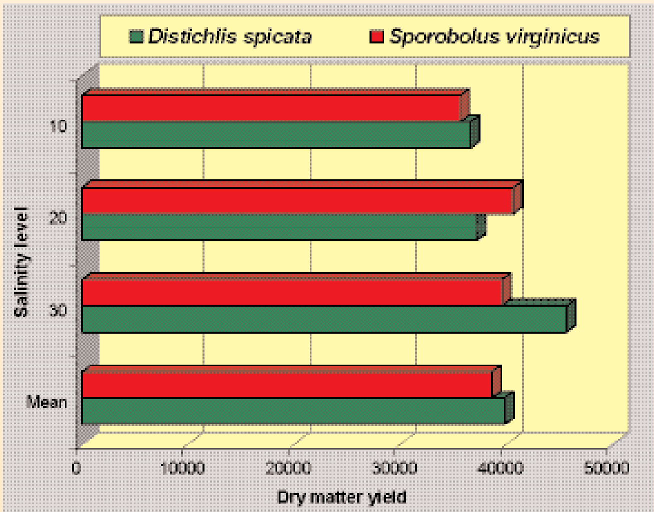


Figure 3: Total annual field dry matter yield (kg/ha) in *D. spicata* and *S. virginicus* under 3 salinity levels (dS/m)

Levels are means of 3 cuts over different combinations of irrigation and fertility levels)



Maximum production was 45,571 kg/ha in *D. spicata* and 40,559 kg/ha in *S. virginicus* (Figure 3).

These numbers are very significant because they represent grasses grown at the high salinity level of 30 dS/m. It is clear from these results that management inputs (irrigation, fertility levels and cutting management) can lead to large improvements in yield.

B. Dry matter production under different levels of fertility, irrigation and salinity

Yields of *S. virginicus* and *D. spicata* responded positively to increased fertility levels. However, the impact was minimal at low salinity and significant at high salinity (Figures 4 and 5). At medium salinity, *S. virginicus* yield increased by 5 t/ha between the lowest fertility level (F1) and the highest level (F4). In *D. spicata*, the impact was highest at high salinity, which exhibited a yield increase of nearly 4 t/ha.

The influence of different irrigation levels was less significant in comparison with nutrient levels (Figures 6 and 7). *S. virginicus* yields were higher at the low and medium irrigation levels (ET_0 and 1.5 ET_0) compared to the high level (2 x ET_0). Meanwhile, *D. spicata* yields were higher at the medium and high irrigation

Figure 4: Dry matter yield (kg/ha) in *S. virginicus* under different combinations of salinity (dS/m) and fertility levels
(Values are means of 3 irrigation levels)

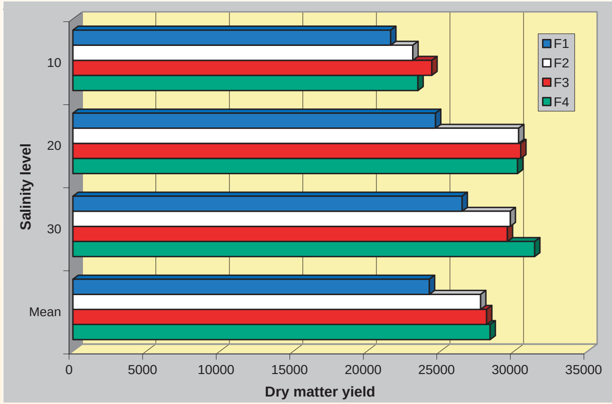


Figure 5: Dry matter yield (kg/ha) in *D. spicata* under different combinations of salinity (dS/m) and fertility levels
(Values are means of 3 irrigation levels)

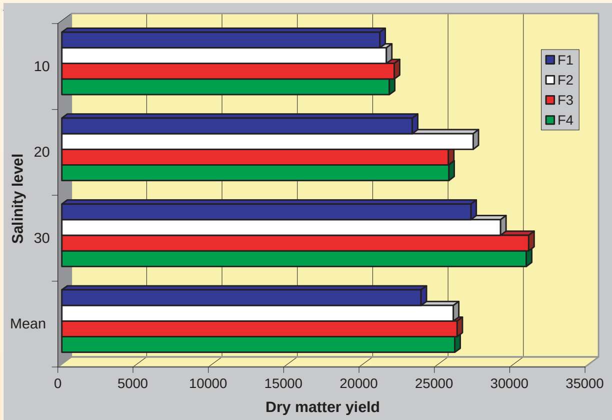


Figure 6: Effects of irrigation level (ET_0) and salinity levels on dry matter yield (kg/ha) in *S. virginicus*
(Values are means over 4 fertility levels)

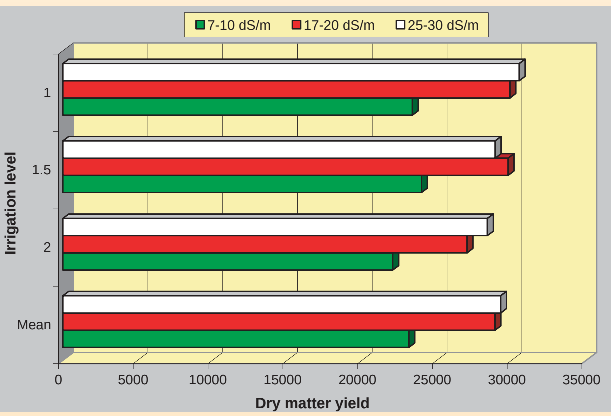
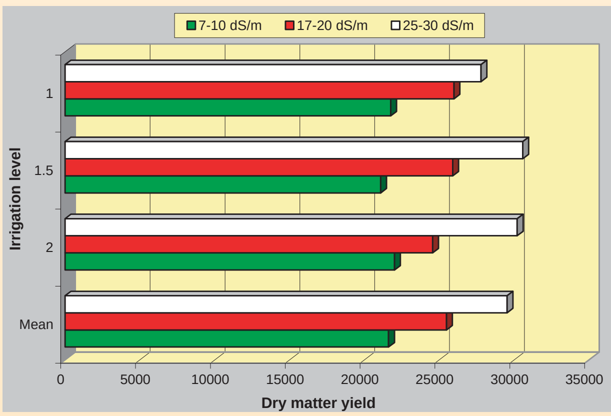


Figure 7: Effects of irrigation level (ET_0) and salinity levels on dry matter yield (kg/ha) in *D. spicata*
(Values are means over 4 fertility levels)



levels. It can therefore be concluded that for *S. virginicus,* medium fertility and irrigation levels are optimal for yield under all salinity levels, while in *D. spicata* the optimal combination for higher yields is high irrigation and fertility, particularly at high salinity levels.

C. Forage quality analysis

Analysis of basic forage quality traits in both species included crude protein percentage, ash content, neutral detergent fiber (NDF) and acid detergent fiber (ADF). Crude protein percentage increased with the increase in fertility up to the third level – F3 in both *Distichlis* and *Sporobolus* – and reached 8% (Figure 8). Ash percentage also increased significantly with fertilizer application, although it remained

Figure 8: Effects of different levels of fertility on crude protein percentage in *S. virginicus* and *D. spicata*
(Values are means over 3 salinity levels)

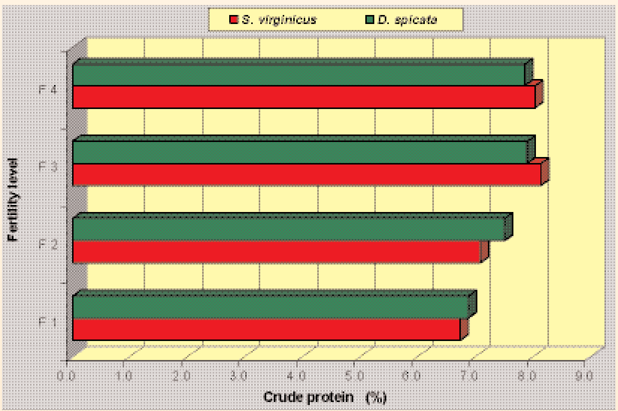


Figure 9: Effects of different levels of fertility on ash percentage in *S. virginicus* and *D. spicata*
(Values are means over 3 salinity levels)

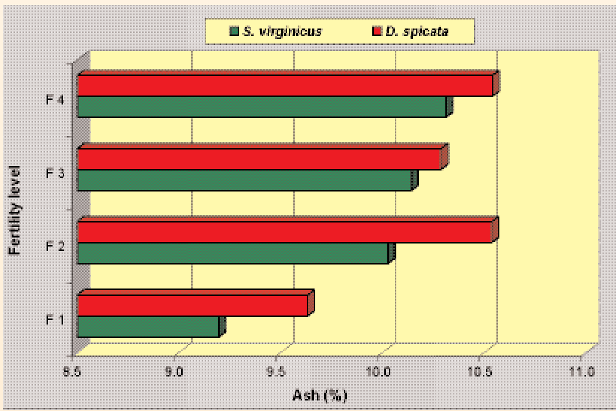


Figure 10: Effects of different levels of salinity (dS/m) on crude protein percentage in *S. virginicus* and *D. spicata*
(Values are means over 3 salinity levels)

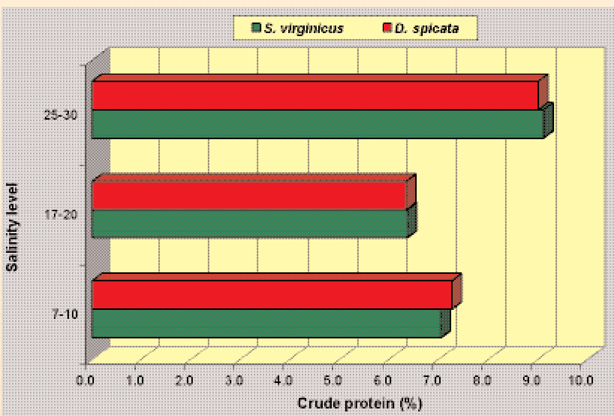
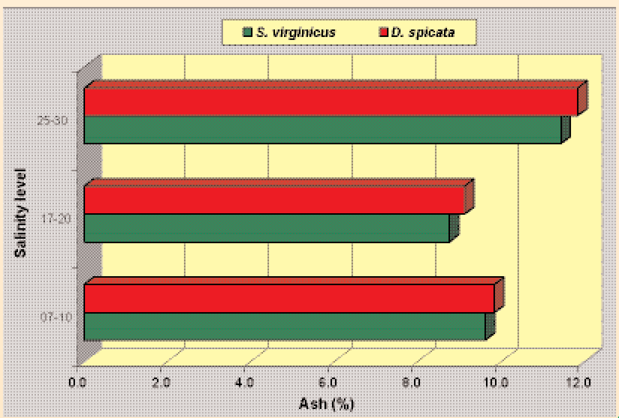


Figure 11: Effects of different levels of salinity (dS/m) on ash percentage in *S. virginicus* and *D. spicata*
(Values are means over 3 salinity levels)



within the modest level of 10%. Such values are comparable with conventional crops grown under normal conditions (Figure 9).

As in previous seasons, an increase in salinity from moderate (17-20 dS/m) to high (25-30 dS/m) led to an increase in both protein and ash content in both species (Figures 10 and 11). Both species had similar values. The maximum level of protein reached 9% and that of ash content nearly 12% percent. Both had similar values of protein content at each salinity level.

In conclusion, both species showed consistent yield potential and forage quality after 4 years of growth under high levels of salinity – levels at which few other species can retain economic productivity. The unique character of these species is their ability to keep the mineral content of the tissue low even at high salinity levels. Moreover, in feeding trials conducted in collaboration with UAEU, livestock consumed both grasses as readily as conventional crops. In 2005, both species were exhibited in on-farm demonstrations in the UAE, Oman and Saudi Arabia. The two species are very promising in converting marginal lands and water resources into productive land, particularly for forage production.

Sporobolus *(above) and* Distichlis *(below) field growth in fall 2005. Despite high production of heads of both grasses, neither produced seeds.*

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

Significance of the project

Atriplex is well known for its salt tolerance and its value as a high-protein feed for animals. However, because animals do not thrive if fed solely on a diet of *Atriplex* because of its high concentration of mineral salts, a mix of salt-tolerant grasses and shrubs is recommended to provide a balanced diet.

This project, like the grass project (PMS03), assesses the potential production, feasibility and long-term sustainability of forage production systems based on salt-tolerant forage shrubs.

Key points

- Total biomass production is higher in *A. lentiformis* than *A. nummularia* and *A. halimus* at all salinity levels.
- Different fertility levels had minor effects on total yields of the three species at all salinity levels.
- Irrigation levels did affect yield at low and medium salinity, but negatively affected yield at high salinity (30 dS/m).

Objectives

- Determine yield potential when *Atriplex* is grown under high salinity levels, and the level to which the productivity remains economical.
- Determine the optimum irrigation level for maximum production and minimum salt accumulation in the soil.

Atriplex *trials at ICBA.*

- Determine the optimum plant density for maximum production under all salinity levels.
- Determine the appropriate fertilizer regime for maximum production.
- Assess the nutritional value in response to different salinity, irrigation and fertilizer levels.

Achievements in 2005

To provide a constant supply of *Atriplex* green matter for sheep and goat feeding trials, plants were cut throughout the year. However, individual plants were cut only once. Annual fresh biomass production was similar to that of previous seasons. *A. lentiformis*, for example, had significantly higher yields than *A. nummularia* and *A. halimus* under all combinations of salinity, density and fertility levels. Biomass increased with density level. Total annual biomass production reached nearly 23 t/ha in *A. lentiformis* at the high-density level (5,000 plant/ha), while *A. nummularia* produced only 13.6 t/ha and *A. halimus* just 13 t/ha (Figure 12). The experiment, now in its fourth year, showed that consistently higher yields can be obtained under irrigation with saline water when the crop is planted under high density at 2x1m plant spacing.

Figure 12: Fresh biomass production in 3 *Atriplex* species under 3 density levels (D1, D2 and D3)
(Values are means over 3 salinity levels)

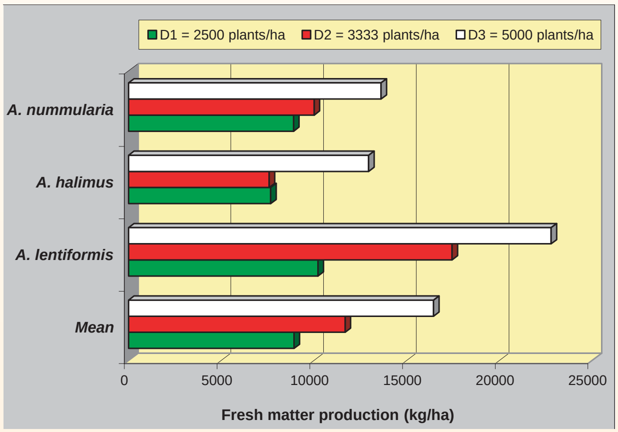
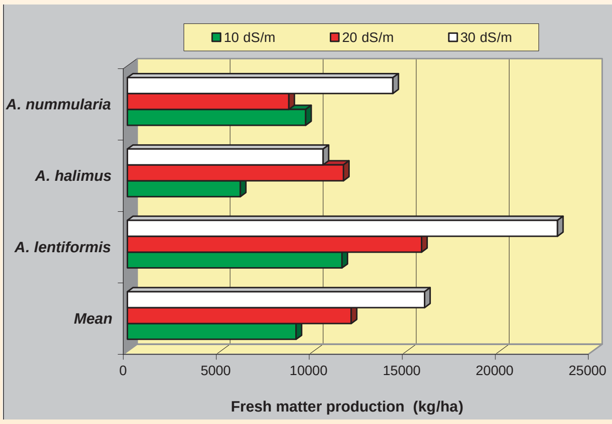


Figure 13: Fresh biomass production in 3 *Atriplex* species under 3 salinity levels
(Values are means over 3 density levels)



Biomass production was higher under high salinity in *A. lentiformis* and *A. nummularia*, while *A. halimus* yield was highest under medium salinity (Figure 13). Death of several *A. nummularia* and *A. halimus* individuals occurred under high salinity. Replacement of dead individuals is required in both species to maintain the stand.

Plans for 2006

Forage quality analysis is under way and will be reported during the second half of 2006. Monitoring and evaluation of the performance of the three species under the management practices of salinity, fertility, irrigation and density will continue. The ultimate goal is to reach a solid conclusion about the sustainability of the system and its economic value.

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

Duration: 2003-06
Collaborator: Ministry of Agiculture and Fisheries (MAF)
Resources: Core

Key points

- A demonstration farm was established on a salt-affected, abandoned farm in R'as al-Khaimah.
- Various conventional and non-conventional forage production systems were successfully established in 2004.
- The farm is already drawing considerable attention of officials, professionals and farmers in the region.

Significance of the project

Although irrigated agriculture in the UAE has increased dramatically over the past 30 years, few farmers are trained in the special skills and techniques in the handling of irrigation water. This project demonstrates the sustainability and profitability of plant production through the implementation of appropriate biosaline agricultural techniques. Through the collaboration of MAF, farmers learn what is possible when dealing with moderate to high levels of salinity. The demonstration farm is 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 3-year period.
- Involve local farmers and technicians in the evaluation of the project and organize field days.

Achievements in 2005

MAF and ICBA developed a plan for demonstrating biosaline agriculture on 0.5 ha at R'as al-Khaimah in 2004, including appropriate irrigation and drainage methods and cropping systems. The farm selected had been abandoned due to high salinity damage. Salinity of irrigation water is 23 dS/m. Highly salt-tolerant winter crops such as barley, fodder beet and perennials were planted.

Barley growth under high salinity (23 dS/m).

RESULTS

The three *Atriplex* species were planted on 27 March. Drip irrigation lines were employed with a total area of 480m^2. One *Acacia* species (*ampliceps*) was also planted on a drip line during the first week of April. Mother plots of four highly salt-tolerant grasses (*Sporobolus virginicus*, *Distichlis spicata*, *Paspalum* and Kallar grass) were also planted in April. In November, the four species were transplanted to large production plots, each 250m^2. A micro-sprinkler system was used for irrigation. First production cuts are planned for spring 2006.

Twenty-four barley genotypes selected at ICBA were planted in December 2004 in three replications under drip irrigation. The genotypes showed high yield variations. Dry matter production ranged from 5 to 13 t/ha and seed yield from 1.5 to 3.5 t/ha. The top five performing genotypes will be distributed to farmers in the region in 2006.

Fodder beet varieties Adagio, Dana and Turbo were evaluated under high salinity, and their performance was acceptable considering the high salinity level. Total tuber production ranged from 17 to 24 t/ha.

Fodder beet (above) and buffel grass (below) under high salinity (23 dS/m).

Also in 2005, 40 accessions of *Cenchrus ciliaris*, both local and exotic, as well as commercial varieties, were established on the demonstration farm. Establishment and initial growth in all accessions was good. Production harvest will begin in 2006.

Monitoring of soil salinity under annual and perennial grasses and shrubs showed high accumulation of salt in the upper layers. In some instances, salinity reached 25 dS/m. Periodic leaching was performed to bring down soil salinity to levels below irrigation water salinity.

Growth of Atriplex *and* Sporobolus *grass under high salinity (23 dS/m).*

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

Duration: 2003-06
Collaborator: ICRISAT
Resources: OPEC Fund for International Development (OPEC Fund), Core

Significance of the project

PMS15 is the second phase of PMS02 (*Evaluation of salinity tolerance, growth, yield potential and forage quality in selected cultivars/accessions of pearl millet and sorghum under field conditions*), which took place from 2002 to 2003.

Salinity of both soil and irrigation water has emerged as a major crop production problem worldwide. It is estimated that over 2 million ha of agricultural lands are lost to salinization annually. Several engineering and agronomic options have been used in managing salt-affected soils, but these are not practical everywhere because of prohibitive costs, agroclimatic conditions, or both. Also, these options provide location-specific solutions and have annual recurring costs. The development and adoption of salt-tolerant varieties is a cost-effective option in the management of salt-affected lands. The goal of this project is to improve agricultural productivity in salt-affected arid and semi-arid environments of the Near East and Asia through the development of pearl millet and sorghum genotypes with high grain and fodder yields and improved salt tolerance.

Key points

- Salt-tolerant nurseries of pearl millet and sorghum were developed and evaluated at several national stations and farmers' fields in the UAE and Oman.
- Yields of top-performing genotypes ranged from 13 to 23.3 t/ha of dry matter at 15 dS/m.
- Salinity tolerance assessment will assist the pearl millet improvement activities at ICRISAT.
- 40-50 new salt-tolerant genotypes of pearl millet and sorghum were selected for further field evaluation.

Objectives

- Select pearl millet and sorghum genotypes with improved salinity tolerance suitable for either forage or dual-purpose forage and grain production.
- Based on selections done at both ICBA and ICRISAT, develop nurseries consisting of 15-25 salt-tolerant genotypes of each species, and evaluate them on-farm at R'as al-Khaimah, as well as in India, Iran, Oman, Sudan and Yemen.
- 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 2005

The second annual progress report, which covered activities and achievements from July 2004 to July 2005, was submitted jointly by ICRISAT and ICBA to the OPEC Fund. A second installment of USD 70,000 was received in October 2005 and shared equally between the two institutions. A third coordination meeting between the project teams took place in December at ICRISAT's headquarters at Hyderabad, India. Research progress during 2004/05 was reviewed, and a detailed work plan for 2006 and a schedule of activities were developed by the project team.

More than 300 genotypes of each crop were screened for salinity tolerance for two cycles at 10 dS/m under controlled conditions. Field evaluation under three salinity levels (5, 10 and 15 dS/m) of previously selected genotypes (30 pearl millet and 25 sorghum) was completed in 2005. The same genotypes were also evaluated in farmers' fields in Oman.

Research results

1. Development of nurseries

Nurseries for salt-tolerant pearl millet and sorghum were established during 2004/05 in Egypt (1 site), India (3 sites), Iran (2 sites), Oman (2 sites) and the UAE (1 site), as well as at both ICRISAT and ICBA (total of 11 sites) (Table 3).

Table 3. Salinity-tolerant sorghum and pearl millet nurseries supplied to locations in Egypt, India, Iran and Oman (2004/05)

Locations	Nursery size (ha)
Sorghum	
Suez Canal University, Ismailia, Egypt	25
Central Rice Research Institute, Cuttack, India	10
Marathwada Agricultural University, Parbhani, India	44
Agricultural Research Center of Isfahan, Isfahan, Iran	44
Seed and Plant Improvement Institute, Karadj, Iran	19
Agriculture Research Center, Oman	25
Pearl Millet	
Central Rice Research Institute, Cuttack, India	10
Seed and Plant Improvement Institute, Karadj, Iran	10
Agriculture Research Center, Oman	30

Sorghum and pearl millet trials on the ICBA campus.

2. Field evaluation

At ICBA, 30 genotypes of pearl millet and 26 of sorghum were evaluated under field conditions at three salinity levels: 5, 10 and 15 dS/m. Yields of the top-performing genotypes at the high salinity level ranged from 13 to 23 t/ha of dry matter. Distribution of mean dry matter production over the three salinity levels followed a pattern similar to that of the previous season. Dry yields of more than half of the genotypes were in the 8-12 t/ha range (Figure 14). The top 10 genotypes yielded between 10 and 17 t/ha (Figure15). Eight of the 10 genotypes were also among the top 10 in dry matter production during the previous season.

The 30 genotypes included forage, seed and dual-purpose types. Seed yield in the top 10

Figure 14: Dry matter yield (kg/ha) in 30 pearl millet genotypes
(Values are means of 3 salinity levels)

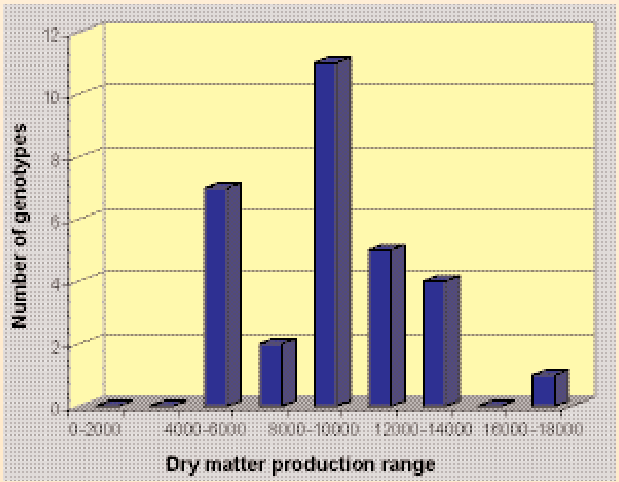
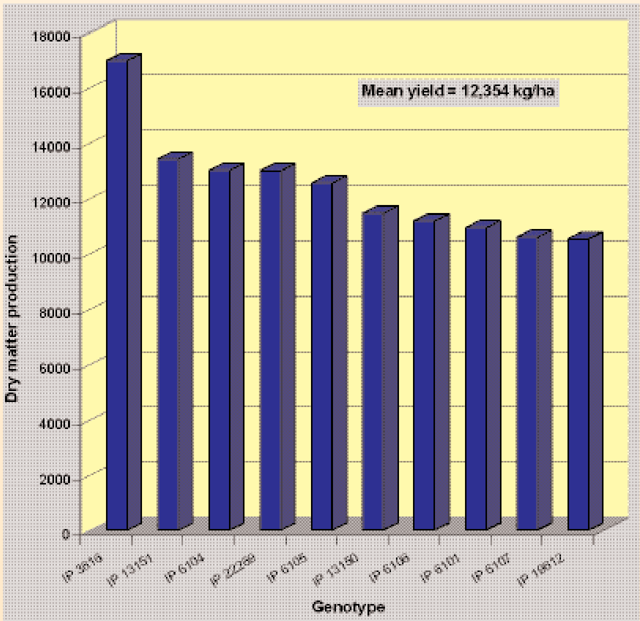


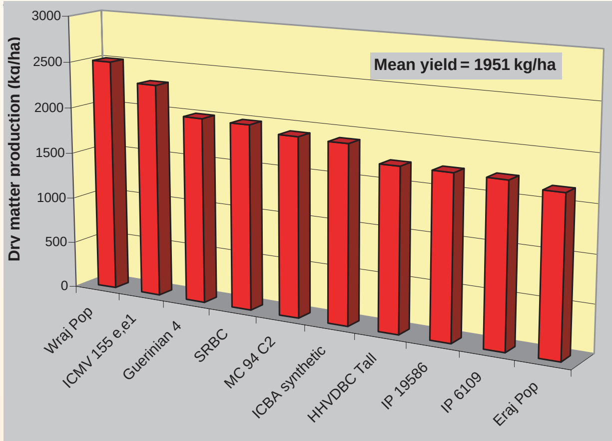
Figure 15: Dry matter yield (kg/ha) in top 10 pearl millet genotypes
(Values are means of 3 salinity levels)



genotypes ranged from 1.7 to 2.5 t/ha (Figure 16) with an average of 1,951 kg/ha. However, it is worth noting that seed yield is usually low during summer planting under the hot environmental conditions prevailing in the UAE. Previously, demonstrations showed that late summer planting in such environments is more suitable for seed production.

Figure 16: Seed production in top 10 sorghum genotypes

(Values are means of 3 salinity levels)



In Oman, under farmers' field conditions, dry matter production in top-yielding sorghum genotypes reached more than 14 t/ha and green fodder production in a single cut reached more 77 t/ha; while pearl millet dry matter reached 13 t/ha and green fodder production more than 85 t/ha (Figures 17 and 18).

At ICRISAT, on-station field trials of sorghum led to the identification of varieties and a hybrid that exhibited high grain yield under both saline and non-saline field conditions.

Similarly, a pearl millet population was identified that exhibited grain yield similar to that of a commercial variety under saline field conditions, but with 35% more dry fodder yield. Pearl millet germplasm accessions exhibiting 40-85% more dry fodder yield than the commercial variety were also identified. A pearl millet hybrid based on salt-tolerant parents gave 11% more grain yield and 38% more fodder yield than the most widely cultivated dual-purpose commercial hybrids.

Figure 17: Dry matter production in top 10 pearl millet genotypes grown under field conditions in Oman

(Salinity level 8-10 dS/m)

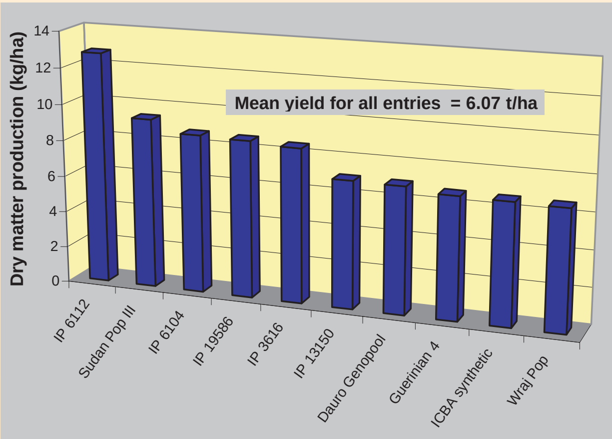
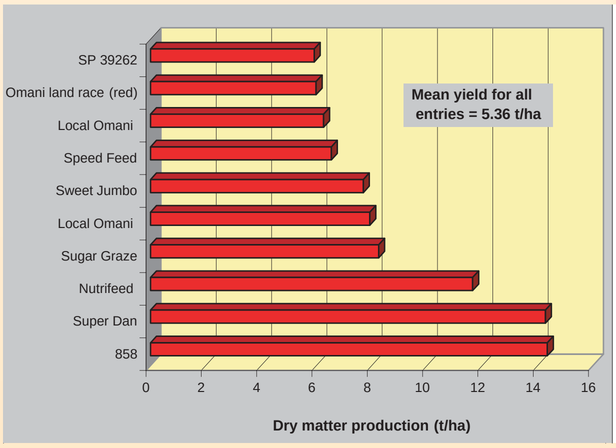


Figure 18: Dry matter production in top 10 sorghum genotypes grown under field conditions in Oman

(Salinity levels 8-10 dS/m)



Planting in a farmer's field in Oman.

Soil sampling procedures.

3. Screening of pearl millet and sorghum genotypes

More than 300 genotypes of both sorghum and pearl millet were screened for salinity tolerance for two cycles at 10 dS/m under controlled conditions. Pearl millet included 128 elite and landrace varieties. Mean dry biomass for this group was 31.2 grams per plant (g/plant) (Figure 19), less than the values during the previous season. However, the mean yield of the top 10 genotypes was nearly 80 g/plant and several genotypes exceeded 100 g/plant of dry matter. The second pearl millet group consisted of 90 elite B lines. The average yield of this group was 22.2 g/plant and the top 10 genotypes averaged 43.1 g/plant (Figure 20). The third group of 80

Figure 19: Dry matter production range in 128 elite and landrace pearl millet varieties grown at 10 dS/m

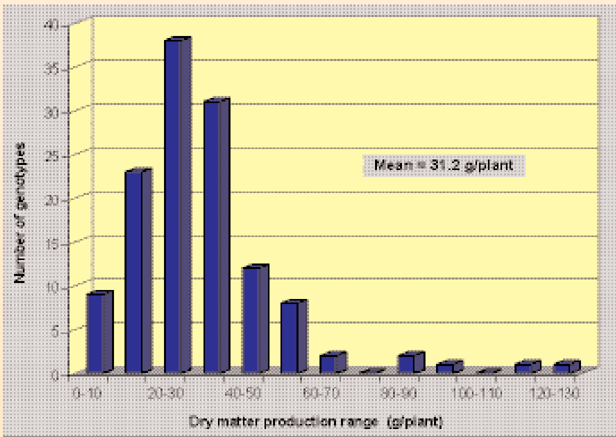


Figure 20: Dry matter production range in 90 pearl millet elite B-lines grown at 10 dS/m

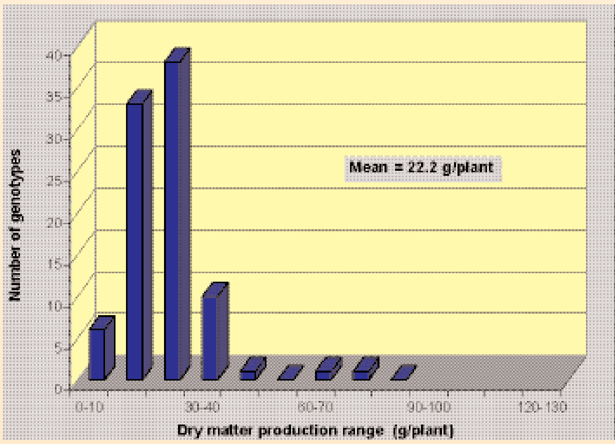


Figure 21: Dry matter production range in 80 pearl millet hybrid lines from mapping populations grown at 10 dS/m

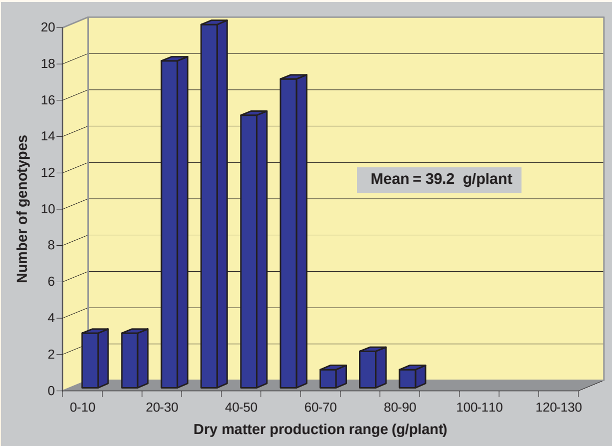
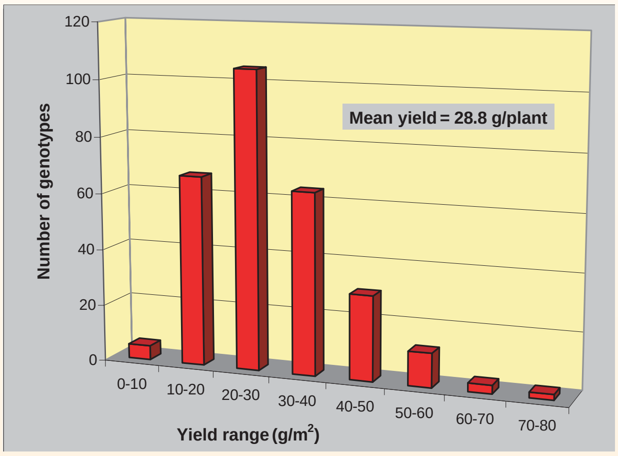


Figure 22: Total field above-ground dry matter production in 288 sorghum genotypes grown at 10 dS/m



hybrids of mapping population developed by ICRISAT averaged yields of 39.2 g/plant. The top 10 genotypes had an average yield of 64.6 g/plant (Figure 21).

Sorghum collection included high-yielding B lines, landraces and elite varieties. Overall mean dry yield was 28.8 g/plant, while the top 10 genotypes yielded 61 g/plant (Figure 22). From the top performing genotypes, 40-50 new genotypes of pearl millet and sorghum will be added to field evaluation in 2005/06.

Tissue analysis of Na accumulation indicated that Na exclusion from leaves might be a principal mechanism of salinity tolerance in sorghum, whereas both Na exclusion and Na compartmentalization mechanisms might be operating in pearl millet.

4. Dissemination of outputs 2005

Two publications were produced on the basis of preliminary trials and the second year's work.

- Variability for salinity tolerance in sorghum (for *Plant and Soil*)
- Variability for salinity tolerance in pearl millet (for *Euphytica*)

5. Field days

Several field days for technical staff and farmers were held in India, Oman and the UAE, in addition to large number of visitors to research field plots at both ICRISAT and ICBA headquarters.

Plans for 2006

The selected pearl millet and sorghum nurseries (30 genotypes each) will be evaluated in seven countries in the WANA region. Seeds have already distributed to the targeted countries.

Trials related to the development of optimal production practices will be initiated at ICBA during 2006. Various management practices will be applied to a selected group of salt-tolerant genotypes of pearl millet and sorghum. During 2005/06, ICRISAT will also develop mapping populations for future use in identifying molecular markers of QTLs associated with salinity tolerance. Chemical and nutritional analysis will be also performed on selected genotypes during 2006.

Participants of traveling workshop and farmers during field visits to the demonstration site in UAE.

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

DURATION: 2003-06
COLLABORATOR: United Arab Emirates University (UAEU)
RESOURCES: UAEU, Core

SIGNIFICANCE OF THE PROJECT

PMS16 aims to improve 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). The animals are fed exclusively with salt-tolerant forages, and their productive and reproductive performance, as well as their feed intake, are measured. Also, adaptive and genetic potential of the species and breeds is evaluated.

The results of this project will lead to significant reduction of feeding costs in sheep and goat production systems. Also, the results will help determine the productive and adaptive capabilities of indigenous breeds, which will contribute to sustainable agriculture in low-input production systems.

KEY POINTS

- Nutrition of local sheep and goats fed a diet of 100% *Sporobolus* hay compared favorably with conventional forages.
- Replacing traditional hay with *Sporobolus* and *Distichlis* in lamb feeding in the UAE has no negative impact on animal performance.

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.

Achievements in 2005

PMS16 was jointly funded by UAEU and ICBA for three years from January 2003. For ICBA, this project is a continuation of PMS03 and PMS04. The first component, which deals with the production of salt-tolerant grasses and shrubs, is already in progress. Forages produced at ICBA are delivered to the UAEU farm for use in the feeding trials and for nutritional analysis. The second component, which deals with *Sporobolus* feeding trials, was completed in 2004. *Distichlis* feeding trials are under way, while *Atriplex* feeding started in early 2005.

Feeding trials with *Sporobolus virginicus* were completed, and the effects of the hay on (a) growth, (b) feed and water intake, and (c) body composition in indigenous lambs were evaluated. Initial assessment of the results showed that daily feed intake was significantly higher for animals fed a diet of 100% *Sporobolus* hay than those animals fed a diet of either 0.0% or 33.4% *Sporobolus*. Water consumption was higher for lambs fed different levels of *Sporobolus* hay in comparison to those in the control. Average daily gain was not affected by treatment diet, while the carcass and non-carcass components were unaffected.

It is initially concluded that replacing traditional hay with *Sporobolus* in indigenous lamb feeding is feasible without negative impact on the animals. Similar trends in feeding trials of Awassi sheep were observed with 70% *Sporobolus* hay in diets leading to higher weight gain in comparison with traditional hay such as Rhodes grass. Further details of these feeding trails will be available in subsequent reports.

Plans for 2006

In 2006, plant production trials and optimization of production of salt-tolerant forage grasses and shrubs will be well established and generate information about the productive potential of these species under salinity and their value in animal feeding. Chemical analyses will be also performed extensively on plant materials produced under various salinity levels. Assessment of optimum management practices will also be available by the end of 2006.

Goats thrive on Sporobolus *hay.*

Evaluation of salinity tolerance and yield in 25 barley varieties and accessions (PMS17)

Duration: 2003-06
Collaborator: International Center for Agricultural Research in the Dry Areas (ICARDA)
Resources: ICARDA, Core

Significance of the project

Barley is a robust and useful crop. In addition to its adaptation to a wide range of environmental conditions, as well as its high productivity and nutritional value, barley is also characterized by its high tolerance for salinity. Wide genetic diversity within the species makes it possible to further improve salinity tolerance through breeding and selection.

Key points

- 25 salt-tolerant genotypes were developed and distributed for evaluation in national research stations and farmers' fields in the UAE and Oman.
- Top-performing genotypes maintained total yield levels of 10-12 t/ha and seed yields of 3-4 t/ha.

Barley constitutes a stable source of animal feed in dryland agro-ecosystems. Improving its productivity in these environments, where salinity is increasingly constraining irrigated systems, is therefore a strategically important objective. ICBA, in collaboration with ICARDA, is targeting the improvement of salinity tolerance in barley. A large number of improved barley genotypes and accessions from Oman are being evaluated for salinity tolerance under mild winter conditions in the UAE.

Barley field trials.

Objectives

- Evaluate salinity tolerance among a selected group of 25 top-performing genotypes of improved and landrace barley from a group of 280 evaluated in previous seasons.
- Select salt-tolerant genotypes for large-scale field evaluation.
- Provide national programs in the region with sufficient seeds of genotypes with improved salinity tolerance for field evaluation.
- Provide collaborating institutes with information about salinity tolerance among their barley accessions for further use in breeding.

ACHIEVEMENTS 2005

The 25 genotypes selected, which included elite germplasm from ICARDA's barley breeding program as well as accessions from local Omani landraces, were evaluated in 2004/05 for salinity tolerance under field conditions at three salinity levels: 5, 10 and 15 dS/m. The same genotypes were also evaluated under farmers' field conditions in the UAE and Oman. Initial assessment of data showed wide ranges in growth and yield potential of both biomass and seed among the 25 genotypes.

RESULTS

Total dry matter production under low salinity reached high levels comparable to other low-stressed environments. Even at high salinity levels, some genotypes maintained yield levels of 8-12 t/ha (Figure 23). Seed production was similarly high under medium and low salinity, several genotypes producing up to 2.5 t/ha under high salinity (15 dS/m) (Figure 24). This is still within the range of economic returns to barley cultivation. Biomass production

Figure 23: Dry matter frequency in 25 barley genotypes grown at low and high salinity levels

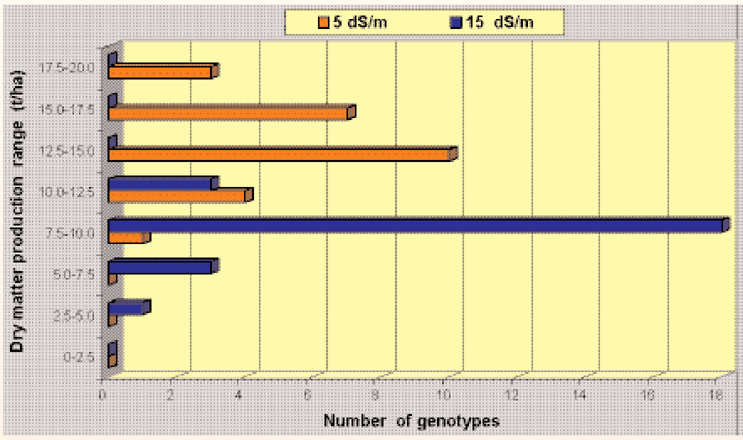


Figure 24: Seed production frequency in 25 barley genotypes grown at low and high salinity levels

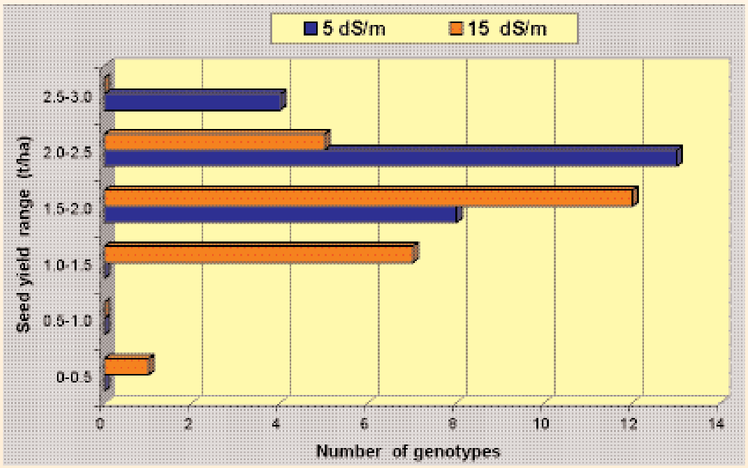


Figure 25: Field dry matter yield (t/ha) in top 10 barley genotypes under high and low salinity levels

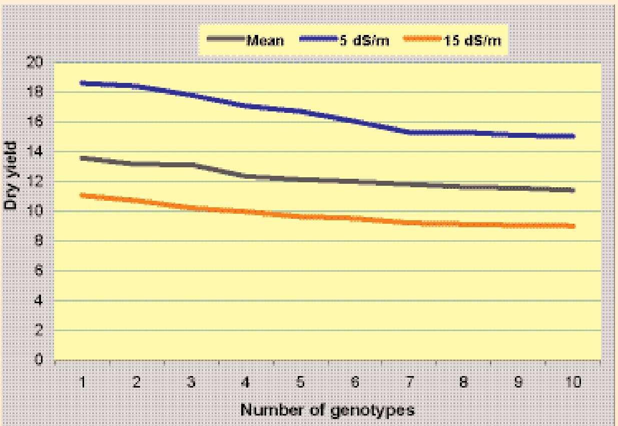
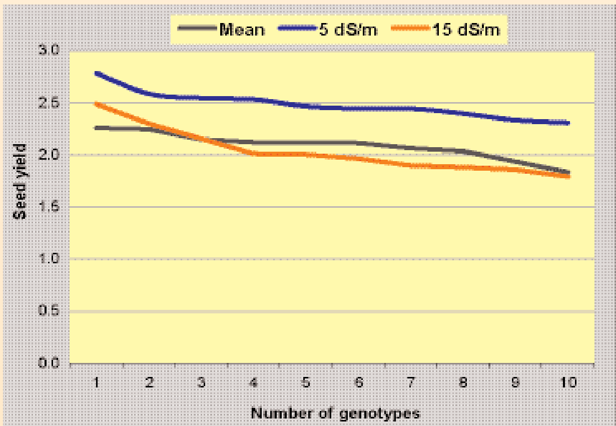


Figure 26: Seed yield (t/ha) in top 10 barley genotypes under high and low salinity levels



among the 10 top-performing genotypes under low salinity ranged from 15 to 18.6 t/ha, and under high salinity from 9 to 11 t/ha. Meanwhile, seed production ranged from 2.3 to 2.8 t/ha under low salinity and from 1.8 to 2.5 t/ha at high salinity (Figures 25 and 26). Further improvement through management will also lead to improvement of seed and biomass production.

Plans for 2006

Based on biomass production and seed yield, a group of five to eight genotypes will be identified and planted at ICBA and at selected national program sites in the UAE and Oman. These trials will include evaluation under the same three salinity levels and assessment of yield and nutritional value among the selected genotypes. Similarly, sufficient seeds of the best-performing genotypes will be produced and made available to interested national programs for in-country field evaluation and selection within the West Asia and North Africa (WANA) region. Additional barley materials acquired from various sources will be further evaluated for salinity tolerance.

Collecting data on barley field trials.

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

DURATION: 2003-06
RESOURCES: Core

SIGNIFICANCE OF THE PROJECT

The Production and Management Systems Program at ICBA focuses on developing appropriate forage and crop production systems for salt-affected environments. Emphasis is placed on species that can be grown for forage or for industrial use as in the case of safflower. Each year, ICBA's Plant Genetic Resources Program introduces and evaluates many potentially salt-tolerant species. Genotypes with moderate to high genetic diversity are targeted for selection and evaluation under salinity, with the ultimate objective of improving the productivity of such species under high salinity levels.

KEY POINTS

- 40 salt-tolerant buffel grass genotypes were selected for field evaluation at ICBA, national program stations and farmers' fields in the region.
- High-yielding genotypes were identified for salinity ranges up to 25 dS/m.

OBJECTIVES

- Assess the performance of 160 accessions of *Cenchrus ciliaris*, including 8 local landraces.
- Select promising genotypes for further evaluation at a large scale under field conditions and various salinity levels.

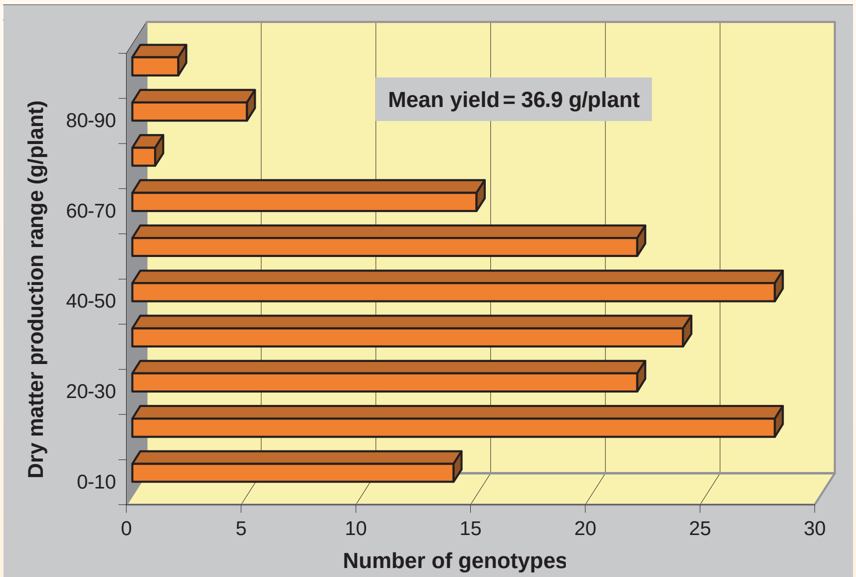
ACHIEVEMENTS IN 2005

A total of 161 *Cenchrus ciliaris* genotypes were evaluated over a period of 20 months under increasing salinity levels ranging from 10 to 25 dS/m (Figure 27). In 2005, three harvests under 25 dS/m were completed and the selection procedure was terminated with the selection of a group of 40 genotypes for further field evaluation. Variations in response among the 161 accessions were very wide, particularly under the high

Cenchrus ciliaris field trials.

salinity level, in comparison with the previous lower salinity levels. Mean dry matter production for all accessions was 37 g/plant. The top-performing 40 genotypes with average yields around 50-60 g/plant were selected for evaluation under field conditions with a salinity range from 7 to 30 dS/m.

Figure 27: Dry matter frequency in 161 *Cenchrus ciliaris* (buffel grass) genotypes grown at 25 dS/m
(Values are means of 3 harvests)



Plans for 2006

The selected group of genotypes was distributed to seven national agricultural research systems (NARS) in the WANA region. They will be planted in 2006 at various sites for further selection in each targeted environment within the region. At ICBA, the 40 genotypes will be evaluated for field production and forage quality.

Saving fresh water resources with salt-tolerant forage production in marginal areas of the West Asia and North Africa region – an opportunity to raise the income of the rural poor (PMS 27)

Duration: 2004-07
Collaborators: Jordan, Oman, Pakistan, Palestine, Syria, Tunisia and the UAE
Resources: IFAD, Arab Fund for Economic and Social Development, OPEC Fund for International Development, the NARS of the seven countries, Core

Significance of the project

Key points

- **The project will improve livelihoods in dry mixed-farming areas of WANA.**
- **The project fosters collaboration among the seven NARS.**
- **The project addresses four Millenium Development Goals.**

The goal of the project is to improve livelihoods and increase incomes for resource-poor rural men and women in degraded and marginal lands in the WANA region. PMS27 contributes to four of the 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 project, by far the largest yet undertaken by ICBA, is guided by three overarching principles.

1. Increase feed availability for livestock through sustainable use of under-utilized saline water resources.
2. Integrate the use of saline water into an overall strategy of sustainable semi-arid and arid farm system management.
3. Develop the capacity of the NARS of the target countries.

Developing salt-tolerant forages in the WANA region.

Objectives

- Establish a full demonstration site at each NARS to introduce salt-tolerant forages and management practices.
- Introduce salt-tolerant forages and management packages to one or more selected farmers in each country.
- Collect data and monitor fields.

Achievements in 2005

The first major events in the execution of the project were the first Technical and Steering Committee meetings of the full project, which were held back-to-back in February. Members of the two committees, each of which were comprised of representatives of the seven participating countries, developed and approved individual Technical Cooperation Agreements. Following the approval of the work plans in six countries, agreement on the budget allocation for the first year was reached with IFAD, the primary donor. The activities in the seventh country, the UAE, are supported by the Arab Fund and the OPEC Fund.

Progress by agreed outputs

Output 1: *Productive salt-tolerant forage grasses, legumes and shrubs identified and distributed to national programs for irrigated cultivation under saline conditions*

ICBA staff visited all selected locations during the year to monitor progress. While the project progressed very well in some countries, activities in other target countries progressed more slowly.

Jordan. Four perennial crops and seven annual crops were identified for the project. The availability and requirement of the desired varieties were also determined.

Oman. NARS staff tested salt-tolerant sorghum and pearl millet varieties and ensured that the identified materials were planted in farmers' fields. Other trees, shrubs and grasses tested were *Cenchrus ciliaris*, *Atriplex* spp., *Acacia ampliceps*, *Sporobolus* spp., *Distichlis* spp., *Leptochloa fusca* and *Paspalum vaginatum*.

During winter 2004/05, barley trials conducted with irrigation water of 10.5-13.5 dS/m produced promising results. Among the entries were eight that produced higher green matter yield (13.07-19.16 t/ha) than the mean performance of local check varieties (11.7 t/ha). ICBA 13 (19.2 t/ha) and ICBA 2 (18 t/ha) were numerically superior to the rest of the entries.

A field day was held during early June 2005 involving Batinah farmers and agriculture extension officers to expose them to the performance of pearl millet and sorghum entries in the on-farm trials, as well as to the performance of forage shrubs, trees and grass species.

Pakistan. One of the partner organizations in Pakistan chose to work on fodder beets, sorghum, pearl millet, oats, alfalfa, *Atriplex*, *Acacia*, ipil ipil, Zizyphus, Mott grass, Bermuda grass, *Cenchrus ciliaris* and Kallar grass. Another partner organization chose to work on Kallar grass, sorghum, *Sporobolus*, *Kochia indica*, and Para grass.

Palestine. The materials chosen by Palestinian partners were varieties of barley, fodder beet and alfalfa. Local materials added to these were wheat, vetch, clover and alfalfa.

Syria. The Syrian NARS chose to work on sorghum, proso millet and pearl millet.

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

Guidelines on measuring and assessing soil salinity were distributed to the Technical Committee members of the project by ICBA staff during the Oman/UAE traveling workshop. During this workshop, clear guidelines on irrigation methods and development of drainage systems were also provided.

Jordan. Soil profile analyses of three locations chosen for demonstrations were taken and the irrigation water analyzed. Screening nurseries were established at Alkhlediah Research Station and selected farms.

Pakistan. A survey of soil and water salinity survey was conducted in Tehsil Pind Dadan Khan. Data on the water quality, infiltration rate and tubewell discharge was also collected.

Above: traveling workshop participants visiting demonstration farm in Rumais, Sultanate of Oman.
Below: participants visiting ARC facilities at Rumais.

Palestine. The chemical and physical properties of the soil at the demonstration sites were identified, and the irrigation network design and installation were completed.

Oman. The project was developed at the Agriculture Research Center of the Ministry of Agriculture and Fisheries at Rumais from August 2004 to March 2005 with required irrigation systems for different experiments. An automatic control panel for irrigation was provided that featured three 5,000-gallon water tanks.

Underground drainage channels were constructed to collect excess water in a sump tank. The water supply is sufficient for one drip irrigation system suitable for field crops and another for forage shrub species (*Atriplex lentiformis*, *A. halimus*, *A. nummularia*), tree species (*Acacia ampliceps*) and grass species (*Cenchrus ciliaris*). Sprinkler and spray irrigation systems were also installed to provide for demonstration plots of selected grass species (*Sporobolus virginicus*, *Distichlis spicata*, *Leptochloa fusca*, *Paspalum vaginatum*).

Syria. Several irrigation levels were used at four sorghum demonstration sites, combining Euphrates river water with agricultural drainage water of different salinity levels. The treatments were replicated three to four times using complete block design. Similarly, proso millet was grown at three different demonstration sites at three salinity level combinations.

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

The 2-day Expert Consultation Workshop on *Socio-economic aspects of introducing salt-tolerant forage cultivation in WANA* arrived at a consensus on the following activities.

- 2005: a benchmark survey to analyze the current situation
- 2006: an analysis of the experimental results at the NARS locations where salt-tolerant varieties/species and soil and water management techniques will be tried
- 2007: an analysis of demonstrations in farmers' fields
- 2007: a repeat survey to study the response and early adoption of the new technologies by farmers, the economic impact of these technologies, and the prediction of their long-term impact

ICBA staff distributed guidelines for socio-economic studies to the seven partner countries. The guidelines were adopted as an outcome of the deliberations.

Jordan. On 1 November, the national program identified a leader for the team that would collect baseline economic data of the current situation and develop a questionnaire.

Pakistan. Farmers at Shorkot were introduced to the forage species being sown in their area and briefed on the role these species can play in their economic upliftment. Feedback from the farmers and extension staff helped in the planning of future research on saline soils. Specific problems identified by the participants for attention included non-availability of seed of improved fodder crop varieties, diseases/insect pests of fodder crops and lack of awareness among farmers.

Palestine. A socio-economic questionnaire was designed following the guidelines provided by ICBA with some modifications. This will be distributed and the responses analyzed.

Oman. The 6 June Farmer's Day is described above. The farmers were impressed by the elite salt-tolerant genotypes of pearl millet and sorghum. Some have come forward to initiate farm trials with selected genotypes and have indicated their willingness to assist in extension.

Syria. A field day conducted on 15 September attracted about 100 engineers, farmers and field workers. The farmers showed interest in growing the fodder crops using different water qualities. Some farmers who lived near the research station prepared themselves to plant the same forage summer crops to produce animal feed on their farms.

Output 4: *Capacity development of research and development staff*

Activities organized by ICBA

- A traveling workshop on *Capacity development in project implementation* was organized in Oman and the UAE, 23-27 April. The course began at Muscat, Oman, with in-depth exposure to the potential and the methodology of growing forages. The tour then moved to R'as al-Khaimah and Dubai in the UAE. Participants interacted with ICBA technical staff, officials from the Ministries of Agriculture and Fisheries of both countries, as well as farmers.
- An expert consultation workshop on *Socio-economic aspects of introducing salt-tolerant forage cultivation in WANA* was held at ICBA headquarters, 28-29 June. The consultation brought together young economists and social scientists from Jordan, Pakistan, Syria, Tunisia and the UAE. A senior agricultural economist from ICRISAT provided guidance to the group as they shared their experiences and standardized a data collection protocol for the project.
- Training course in biometrics and statistical analysis at ICARDA on *Design and analysis of field experiments*

Activities organized in-country by NARS

Jordan. A 5-day training course on *Using saline water resources in agriculture* was held for 15 participants from 4 to 8 December.

Pakistan. A training workshop on *Fodder crop production* was organized for 40 extension staff and farmers at Government Boys High School, Kaslian, on 27 September.

Palestine

- A 5-day training course on *Soil, water and plant relationship under saline conditions* was held at Tulkaram Training Center, 20-24 November.

- A course on *Irrigation management under saline conditions* was held for five participants from the Project Management Unit, 26-29 December.
- Two team members also participated in the Jordan workshop.

Syria

- A week-long course on *Determination of pH, EC, concentration of cations and anions in different soil-water extracts* was organized for 17 trainees from 28 August to 3 September.
- Another week-long course was held for 14 trainees on *Field measurements of soil and plant parameters*, 16-23 October.
- A discussion of the results of the first summer-season experiments was organized for 14 engineers from Deir-Alzoor at Damascus on 6 December. Several senior scientists joined the discussion.

Tunisia. Two training workshops were held during the year.

Impact

Throughout the year, ICBA staff visited partner country project locations, providing the seeds required for the initial planting and advising in the use of technologies. Nearly 140 accessions of 11 forage species were delivered by ICBA to the seven countries.

Some Syrian farmers who lived near the station where the project was implemented planted salt-tolerant forage crops on their farms. Farmers are already growing salt-tolerant forages in Oman and the UAE. In Pakistan, four farmers who sowed top-performing sorghum and pearl millet forage crops under a salinity level of 15 dS/m reported the effects of salinity on nutrition to be negligible.

Expert consultation in session at ICBA headquarters.

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: Consultative Group on International Agricultural Research (CGIAR) Challenge Program on Food and Water (through IRRI)

SIGNIFICANCE OF THE PROJECT

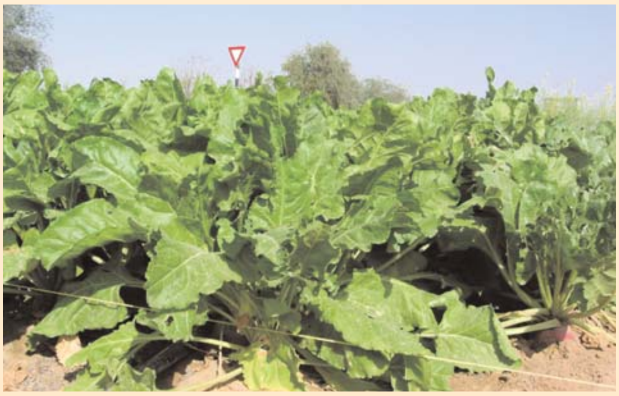
ICBA contributed to a project proposal submitted by the IRRI that was approved for funding under the CGIAR Challenge Program on Food and Water, which is coordinated by the International Water Management Institute (IWMI). A letter of agreement with IRRI was signed in September 2004 to cover ICBA's inputs into the project. ICBA's role centers on identification of possible crops and cultivation methods to fit into rice-based cropping systems, particularly those suited to off-season crops following rice in the Nile Delta of Egypt, the Caspian Sea Basin of Iran and in coastal areas of Bangladesh.

KEY POINTS

- ICBA participation in a collaboration with IRRI funded through the CGIAR Challenge Program on Food and Water.
- ICBA's role is to help identify crops that fit into rice-based cropping systems in salt-affected areas, particularly for Bangladesh, Egypt and Iran.
- Initial focus on forage beet and forage rape.

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 for validation in target areas.



Selecting the best fodder beet accessions.

Achievements in 2005

ICBA acquired samples of fodder beet and fodder rape for testing. These crops were selected because canola is already being grown after rice in Iran and sugar beet in Egypt. Identifying more salinity-tolerant cultivars of these crops will permit earlier sowing and a longer growing season. Testing of the salinity tolerance of the cultivars was undertaken in the field, in pots and in hydroponic-based tests.

Plans for 2006

Screening of forage beet and *Brassica* varieties will continue during the first part of the year. Selected varieties or lines will be made available for field testing in Egypt and Iran together with samples of other species identified in ICBA's core salinity screening activities with crops such as safflower, pigeonpea and forage legumes. Activities undertaken in PMS09 (*Demonstration of biosaline agriculture in salt-affected areas of Bangladesh*) also contribute to this project.

HALOPHYTE PRODUCTION

Water use and salt balance of halophytic species (PMS12)

DURATION: Ongoing
RESOURCES: Core

SIGNIFICANCE OF THE PROJECT

Plants are subjected to a number of environmental and edaphic factors that affect plant growth. Lysimeter studies simulate field conditions in a restricted environment where these factors can be studied in greater detail. Of particular importance are the movement and translocation of salts when plants are irrigated with saline water. Because leaching requirements vary among different soil types, the information obtained from these experiments is important in economic studies of efficient water use. Recent work has featured the use of significantly saline drainage water for growing plants with high salt tolerance. A model study was initiated to evaluate the prospects of using such methodology.

KEY POINTS

- A three-step lysimeter study demonstrated that re-use of drainage water can increase productivity at difficult sites.
- Volume of saline drainage water was reduced by 75%, thus reducing cost of disposal in fields.
- Productivity per unit area increased.

OBJECTIVES

- Study the effects of water quality/quantity, harvest period and frequency, and their nutritional aspects for optimizing productivity.
- Simulate studies related to re-use of drainage water for efficient water utilization and minimum drainage disposal.
- Maximize productivity for increasing salt-tolerant plants and halophytes.

ACHIEVEMENTS IN 2005

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

Biomass production of grasses from three cuts per annum showed maximum biomass for *Sporobolus virginicus* (4.4 kg/m^2) and minimum for *S. arabicus* (1.8

Figure 28: Fresh weight (FW) and ash-free dry weight (AFDW) of different grass species irrigated with water of 10 dS/m salinity

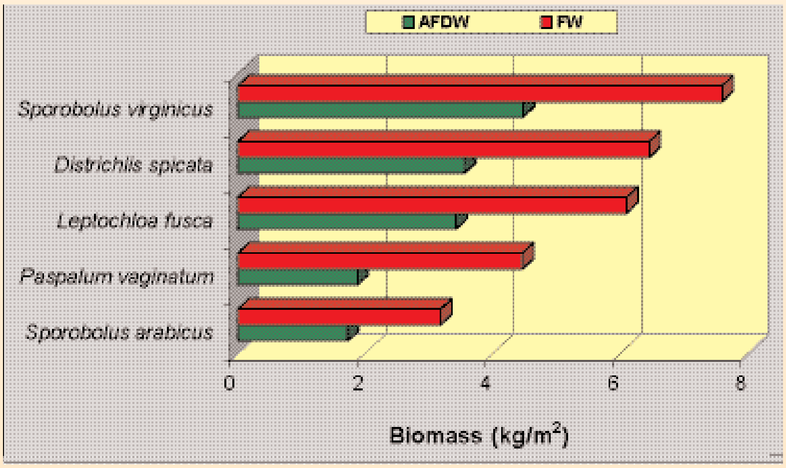
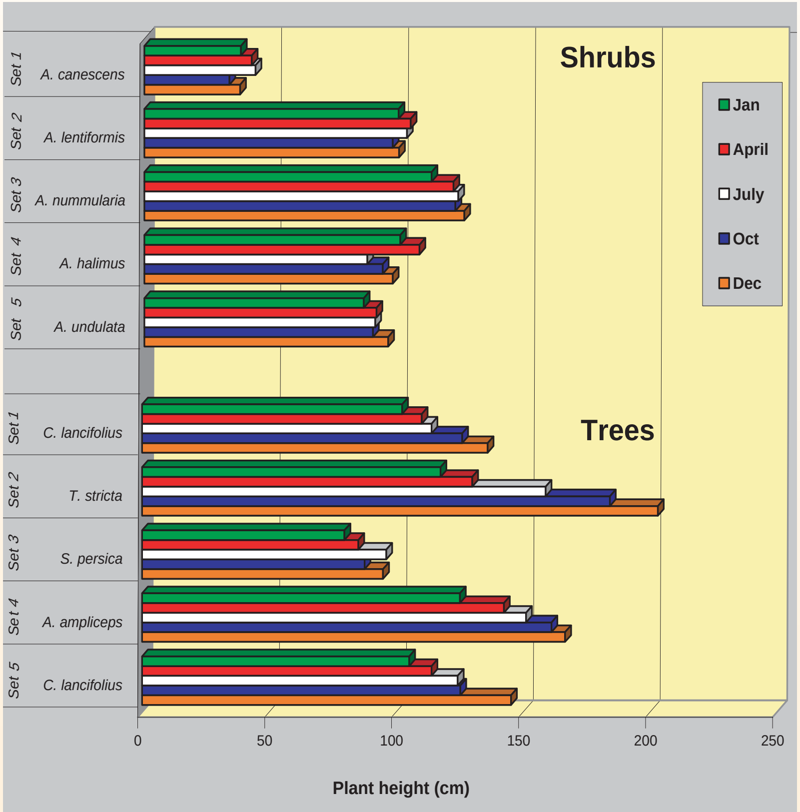


Figure 29: Plant height as affected by salinity of drainage water in tree species and halophytes



kg/m2) (Figure 28). However, the latter species needs to be cut frequently for optimum production.

Plant height did not exhibit significant variations, except *Tamarix stricta* (among trees) and *Atriplex canescens* (among shrubs) (Figure 29). The tree species were irrigated with drainage water ranging from 16 to 23 dS/m. The salinity of the water used to irrigate halophytes ranged from 22 to 32 dS/m. The volume of water at the last lysimeter was reduced by 75% after being used serially for growing trees and halophytes.

Soil salinity ($EC_{1:5}$) among grasses did not exhibit significant differences, whereas lysimeters in which the halophytes were grown showed higher soil salinity. *Atriplex* spp. showed higher values at lower soil depth (30-60 cm), whereas other species showed different responses to soil depth salinities (Figure 30). Figure 31 shows the salinity of drainage water used in the five sets of plants by quarter years.

Plans for 2006

Simulation studies using a three-step lysimeter will continue to elicit more information about salt and water movement in the soil and test plant species for appropriate salinity and amount of irrigation water under field conditions.

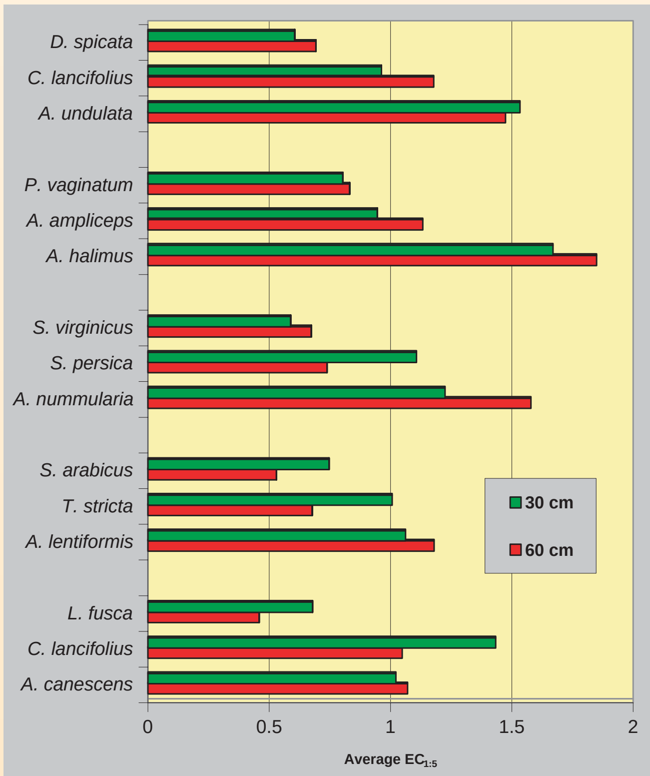
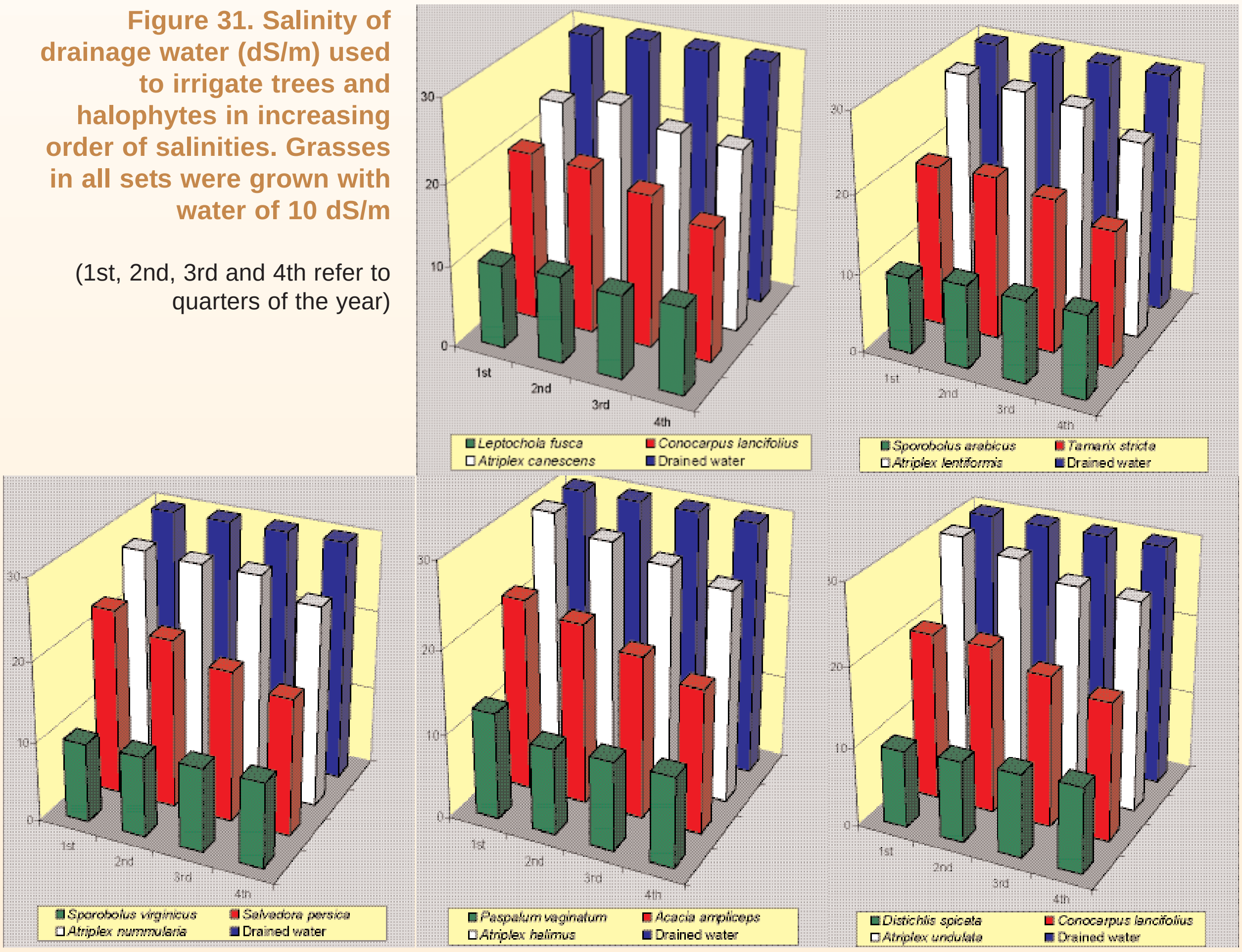


Figure 30: Soil salinities ($EC_{1:5}$) as affected by growth of different species irrigated with drainage water at 30 cm and 60 cm soil depths

Figure 31. Salinity of drainage water (dS/m) used to irrigate trees and halophytes in increasing order of salinities. Grasses in all sets were grown with water of 10 dS/m

(1st, 2nd, 3rd and 4th refer to quarters of the year)



Level 1: Grasses

Level 2: Shrubs

Lysimeter at the ICBA campus.

Level 3: Trees

Level 4: Brine

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

DURATION: 2003-05
COLLABORATOR: Pakistan Agricultural Research Council (PARC)
RESOURCES: PARC, Core

SIGNIFICANCE OF THE PROJECT

With the increasing demand for food and feed brought about by population pressure, aggravated by an escalating shortage of arable land and water, Pakistan faces enormous challenges. The shortfall of water supplies over the past 3 years through the Indus Basin irrigation system has reached 40%. Meanwhile, the country's population has increased fivefold over the past 50 years, with a consequent fall in per capita water availability. This situation necessitates the use of marginal quality water for agriculture.

Moreover, 6.8 million hectares of the total cultivated land are salt-affected. The economic and social implications, especially for smallholder farmers, are profound. The lack of adequate arable land for cultivating conventional food crops has resulted in significant reductions in crop yields. Clearly, marginal land and water resources must be utilized more efficiently.

PMS21, which was initiated in January 2003, addresses the problem directly. The project is implemented by PARC in collaboration with ICBA.

KEY POINTS

- Agronomic methods ameliorated saline-sodic soils for establishment of economically important plants.
- Biosaline agriculture was demonstrated to farmers on highly degraded lands.

OBJECTIVES

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

Farmers Field Day at Bhalwal.

Achievements in 2005

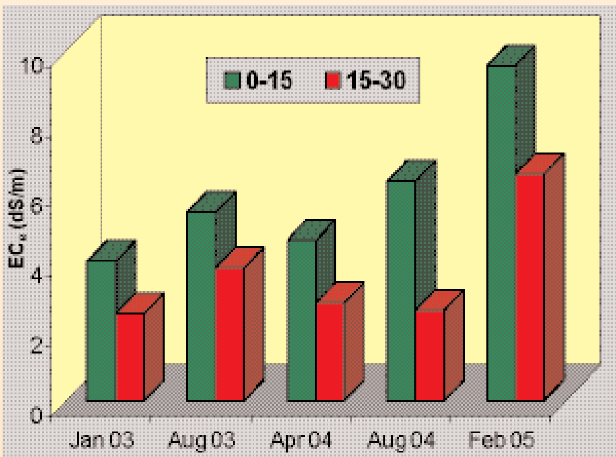
Investigations at three saline sites represent different ecological regions of Pakistan (Figure 32). The work consists of evaluating the effectiveness of different water management strategies for silvo-horticultural systems in salt-affected soils.

What the sites have in common is that all three are formerly productive agricultural lands abandoned by farmers because of salinity (Figure 33) and sodicity (Figure 34). The focus was to select crops with economic importance and to grow them on these lands. Since the soil was highly sodic (SAR ranging 10 to 25), initial establishment was very poor and the plants had to be replanted after gypsum application and growing *Sesbania sesban* for one season.

One significant outcome of the project was the rehabilitation of wastelands abandoned by the local community over the past 45 years. The current project work in Bhalwal, which was initiated in an area of only 3 ha, has now been extended to 13 ha by the local community.

Project activities also included a final project meeting/seminar plus a Farmers Field Day. The meeting highlighted the progress of the work done over the past 3 years and its impact on the local community. An additional Farmers Day, organized by PARC as part of the project activity, was attended by about 60 farmers and village elders.

Figure 33: Seasonal variation in soil salinity (dS/m) at Bhalwal station



Reclaiming abandoned land with trees and crops.

Figure 32: Plant survival rate at different periods at three locations

(Seasonal attempts = growing periods from mid 2003 to first quarter 2004 when the plants established properly)

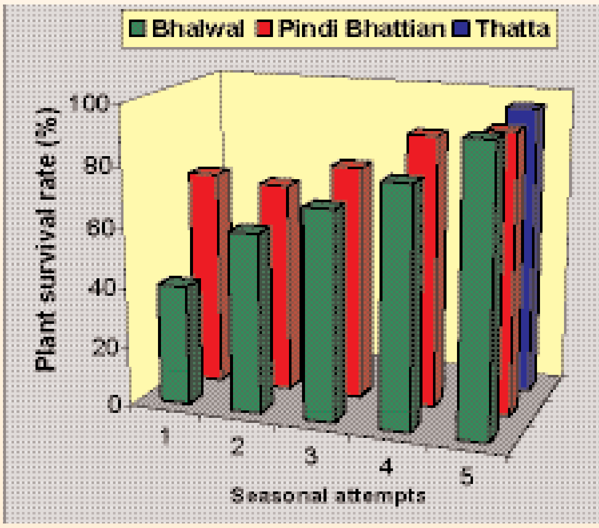
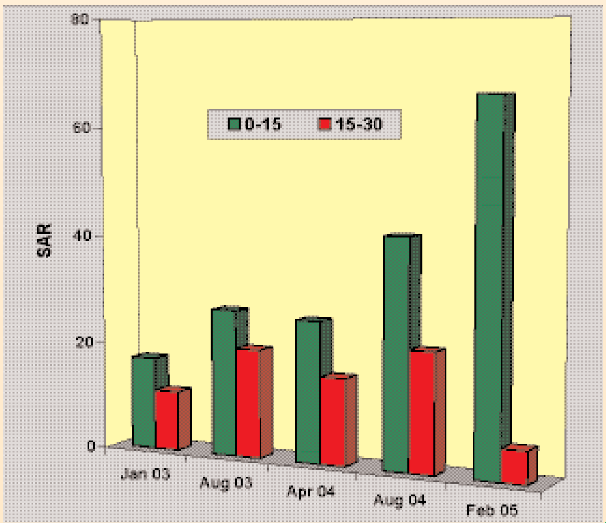


Figure 34: Seasonal variation in sodium adsorption ratio (SAR) at Bhalwal station



Production of halophytes in Iran (PMS22)

DURATION: 2003-05
COLLABORATOR: National Salinity Research Center (NSRC), Iran
RESOURCES: NSRC, Core

SIGNIFICANCE OF THE PROJECT

Approximately 27 million ha of Iran's soils are significantly affected by salinity. Reclamation of these lands is undertaken using different combinations of leaching and drainage. These processes are expensive. Worse, both require large quantities of fresh water, leading to such additional problems as the removal of drainage water and various environmental issues. An alternative strategy for Iran, a country typified by a rich diversity of rangeland plants and halophytes, is biological reclamation.

KEY POINTS

- *Atriplex canescens* produced maximum forage yield, whereas *A. lentiformis* showed minimum yield.
- These two species do not require P, but N at the level of 50 kg/ha increased the yield.
- The highest water use efficiency was obtained with drip irrigation.

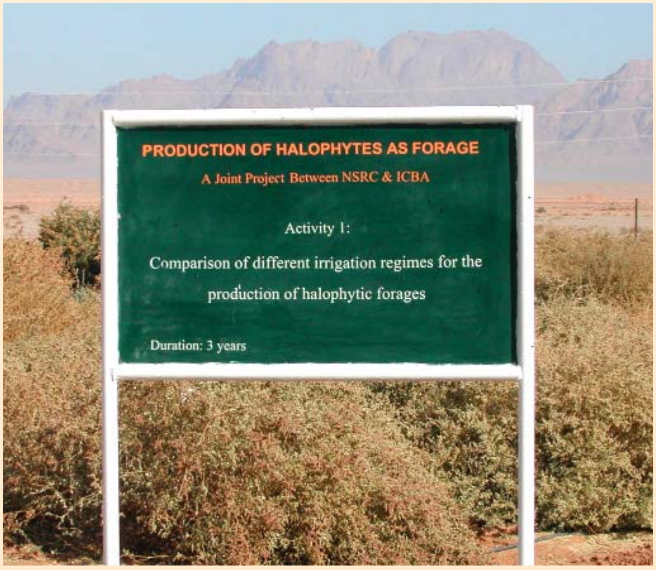
To address this challenge, ICBA initiated a collaborative project with NSRC at Yazd in 2003. Earlier studies in Yazd funded by IAEA had demonstrated the successful establishment of some shrub and tree halophytes, and the feasibility of the production of halophytic forage species. PMS22 aimed to build on those results and initiate work on evaluating agronomic techniques for economical production of some halophytic species under farm conditions.

OBJECTIVES

- Evaluate the nutrient requirements of some halophytic forages under irrigation with saline water.
- Compare different irrigation systems for the production of halophytic forages, and their effect on soil salinity.

ACHIEVEMENTS IN 2005

Studies were conducted in pots in open conditions at NSRC headquarters in Yazd, using *Atriplex lentiformis*, *A. nummularia*, *A. halimus*, *A. canescens* and *Kochia indica*. Simultaneously, the same species were planted under field conditions at Sadooq Salinity Research Farms. In the pot studies, plants were irrigated with saline water of 14 dS/m, while in the field studies were conducted using water of 10 dS/m. Species were tested



Irrigation studies at Yazd, Iran.

for salinity, fertilizer applications (N and P at 0, 25 and 50 kg/ha) and three irrigation methods (furrow, bubbler and drip).

Results of the work in lysimeters showed that *A. canescens* produced both maximum shoot fresh weight (23 t/ha/y) and total dry weight (9 t/ha/y). *A. canescens* was followed by *Kochia indica*, *A. halimus*, *A. nummularia* and *A. lentiformis*. Yield of different halophytes significantly increased when the amount of applied N was increased, with little response to different P applications. Trials relating to different irrigation systems showed that furrow and bubbler significantly affected forage production in comparison to drip. *A. canescens* had the highest forage yield followed by *A. halimus*.

Table 4: N and P requirements for optimum productivities of test species

Halophyte	Maximum shoot fresh weight (t/ha/y)	Fertilizer requirement (kg/ha/y)	
		N	P
Atriplex canescens	22.45	50	0
Kochia indica	18.07	50	50
Atriplex halimus	7.32	50	50
Atriplex nummularia	6.24	50	50
Atriplex lentiformis	4.10	50	0

The studies also demonstrated the optimum requirements of N and P for different species. *A. canescens* showed maximum productivity even without any addition of P. *A. lentiformis*, *A. nummularia* and *K. indica* required both N and P for maximum biomass.

The effects of salinity and fertilizer treatments on forage quality of different species showed that fertilizer treatments did not have significant effects – with the exception of protein content, which increased with N application. Differences were exhibited in ash, fiber and protein content of test species, with maximum protein content in woody species (*A. lentiformis* and *A. nummularia*) and minimum in *A. halimus*. *K. indica* showed minimum ash content (23.07%), whereas *A. lentiformis, A. halimus* and *A. nummulatria* showed higher fiber percentage.

Studies related to the efficiency of irrigation systems on biomass production and forage quality tested under field conditions showed that

Halophyte studies in pots at NSRC headquarters, Yazd.

bubbler irrigation produced similar biomass to furrow irrigation, whereas the volume of water applied was significantly lower in bubbler irrigation than in furrow irrigation. Drip irrigation produced lower biomass for all the species tested, probably because of the lower amount of water used.

The different irrigation systems were also evaluated for water use efficiency (WUE) of the test species. Maximum WUE was obtained from *A. halimus* (2.26 kg/m³) under bubbler irrigation, whereas the lowest was for *K. indica* (0.07 kg/m³) under furrow irrigation.

Table 5: Effects of N application rates on forage quality

Species	Forage quality		
	Ash (%)	Fiber (%)	Protein (%)
Atriplex canescens	24.85c	10.41b	10.47bc
Atriplex halimus	33.66b	6.99c	9.66c
Atriplex nummularia	36.74a	7.50c	13.20a
Atriplex lentiformis	33.81b	7.20c	14.02a
Kochia indica	23.07c	12.45a	11.12b
N application rate (kg/ha/y)			
0	32.27a	9.06b	10.12b
25	31.80a	9.80a	11.05a
50	31.30a	9.61ab	11.31a

Numbers followed by the different letter within a column are significantly different at $P < 0.05$.

Table 6: Water use efficiency (WUE) of different test species against different irrigation systems in kg/m³

Plant species	Irrigation System		
	Furrow	*Bubbler*	*Drip*
Atriplex canescens	0.21	1.09	0.68
Atriplex halimus	0.52	2.26	1.68
Atriplex lentiformis	0.30	1.25	1.08
Atriplex nummularia	0.27	1.15	0.98
Kochia indica	0.07	0.27	0.23

Seminar participants at NSRC.

Propagation and development of NyPa forage in arid environments (PMS29)

Duration: Ongoing from 2004
Collaborator: NyPa International
Resources: NyPa International, Core

Key points

- NyPa forage has been irrigated successfully at 40 dS/m.
- Air-dried biomass showed no significant variation between 25 and 40 dS/m.
- Sodium sulfate treatment at 6 mM increased the air-dried biomass.

Significance of the project

Decreasing availability of fresh water has prompted scientists to examine seawater-based agriculture. Though the potential is appealing, very few plant species have been successfully cultivated with seawater irrigation. This project uses the germplasm and technology developed by NyPa International, a private company, to cultivate NyPa forage (*Distichlis spicata* var. Yensen 4a) with seawater irrigation. The long-term aim of the work is to use seawater to grow this grass along coastal regions.

Objectives

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

Achievements in 2005

Two trials were initiated during 2005:

- Using three different salinity regimes of water (10, 25 and 40 dS/m)
- Evaluating the application of different doses (2, 6 and 12 mM) of sodium sulfate on biomass productivity

Annual productivity measured over three cuttings during 2005 showed an increase from that of 2004. Air-dried biomass at 40 dS/m at ET_0 x 1.5 was 30.18 t/ha compared to 16.9 t/ha in 2004. Maximum air-dried biomass of 34.98 t/ha was observed at 25 dS/m (ET_0 x 1.5) (Figure 35). Similarly, application of sodium sulfate at 6 mM (EC 25 dS/m and ET_0 x 1.25) showed an increase in air-dried biomass from 28.24 t/ha in 2004 to 37.36 t/ha in 2005 (Figure 36).

Chlorophyll absorbance measured by spad meter did not show any significant differences to salinity treatments, water application rates or sodium sulfate treatments. Without any addition of N:P:K fertilizers, the grass retained its green color and chlorophyll

Figure 35: Effects of salinity and irrigation rates on air-dried biomass of NyPa forage
(Data represent the total of 3 cuttings/year)

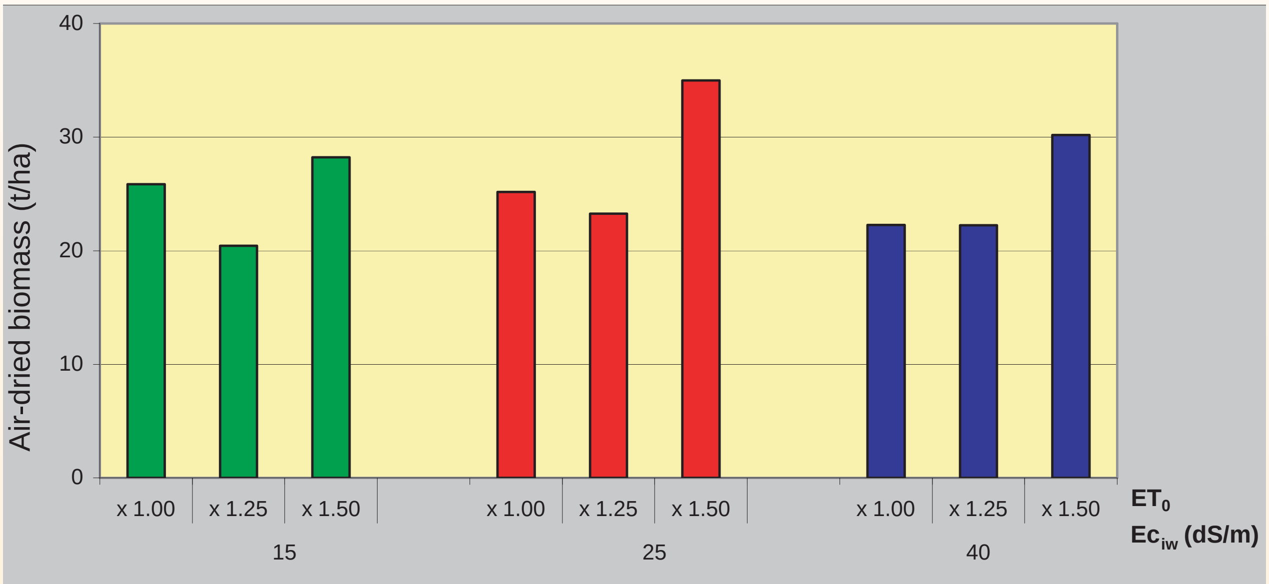


Figure 36: Effects of sodium sulfate treatments on air-dried biomass of NyPa forage
(Data represent the total of 3 cuttings/year grown at 25 dS/m salinity and ET_0 x 1.25)

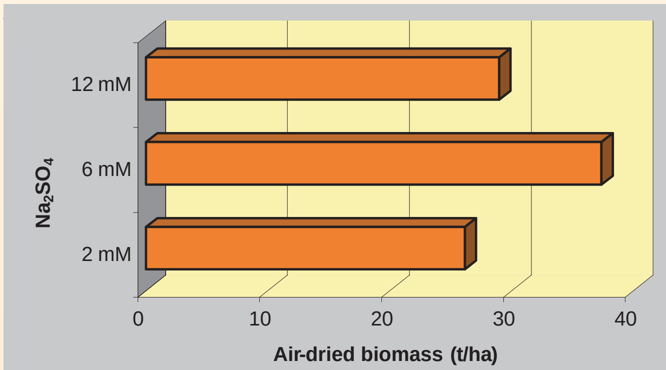
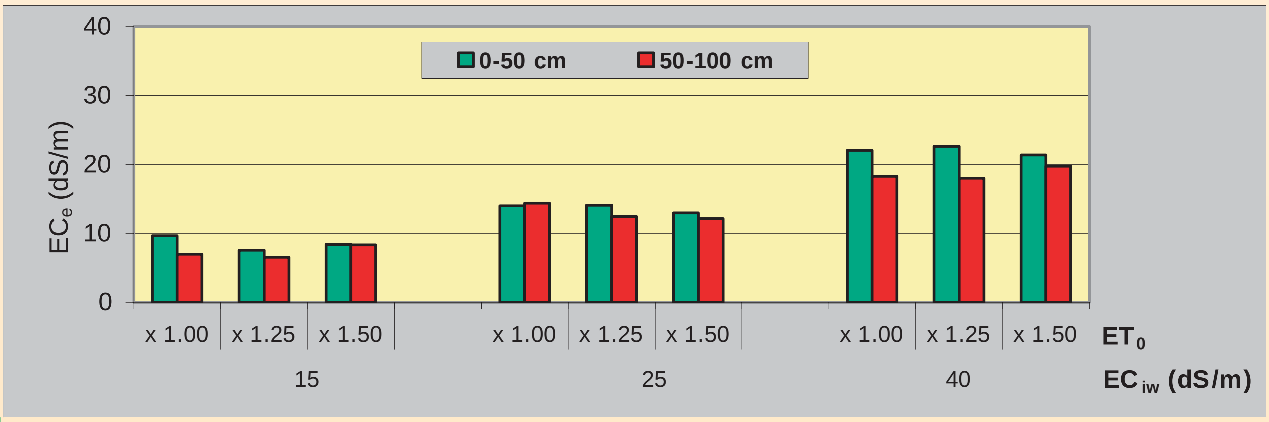


Figure 37: Effects of different salinity treatments and irrigation rates on soil salinity measured at two soil depths
(Data represent average soil salinity measured during different periods of growth during the year)

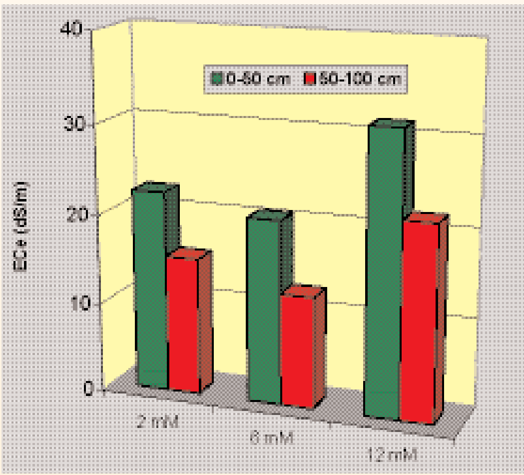


content, indicating higher biomass productivity and regrowth after harvest. Slight variations were observed only during different months of the year. Ash content varied from 9.5 to 11.5% for different types of treatments.

Average soil salinity in plots irrigated with water of 40 dS/m varied between 21.36 and 22.65 dS/m for different irrigation rate treatments. It can therefore be concluded that with proper management, soil salinity can be maintained at levels equal to or less than that of irrigation water while increasing grass productivity (Figure 37). Plots irrigated with 25 dS/m salinity with sodium sulfate treatments showed slightly higher soil salinity values (Figure 38).

Figure 38: Effects of different sodium sulfate treatments on soil salinity of NyPa forage measured at two soil depths

(Data represent average soil salinity measured in plots irrigated with water of 25 dS/m salinity and ET_0 x 1.25)



Plans for 2006

Plots will be harvested more frequently to evaluate the regrowth of the grasses. Analyses of foliar material will also be undertaken to determine the nutritional quality of the grass.

The NyPa Scale

Salinity can be measured by weight, electrical conductivity, pressure, number of molecules, density or specific gravity. In the interest of clarity, NyPa has developed this convenient scale, which the company has generously agreed to allow ICBA to print in this publication (Appendix 6, page 120).

Response of two prominent grasses – indigenous Dhai (*Lasiurus scindicus*) and African variety *Cenchrus ciliaris* – to water salinity (PMS30)

DURATION: 2004-06
COLLABORATOR: Ministry of Agriculture and Fisheries (MAF)
RESOURCES: Core

SIGNIFICANCE OF THE PROJECT

Groundwater, the main source of water for agriculture in the UAE, is becoming more and more saline. The use of such water without proper management has resulted in the abandonment of many farms. Though several exotic grass species have been tested, their adaptability and productivity remain an issue. Indigenous wild species and other species re-introduced to the region have much better chances for sustainable production.

KEY POINTS

- Groundwater is becoming more saline in the UAE.
- This project is unique in that it mixes an indigenous grass with an exotic one.

PMS30 focuses on assessing the responses of *Lasiurus scindicus* and *Cenchrus ciliaris* to different levels of saline irrigation water. These species, reportedly capable of being cultivated in soils with low levels of fertility and under saline conditions, are evaluated. Growth, productivity and forage quality are assessed over different growth periods.


Cenchrus ciliaris *ready for harvest.*

OBJECTIVES

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

ACHIEVEMENTS 2005

Seedlings established through plastic bags failed to establish in the field due to environmental and soil factors. After repeated establishment failures at the site, a new trial site was prepared where new seedlings were grown and later transplanted in the field. Since the seedlings were raised from seeds, it took about 4 months before the plants were properly established. Salinity treatments were therefore postponed to 2006.

PLANS FOR 2006

Growth and productivity of the test species will be evaluated under different salinity levels and their nutritional value studied at different growth periods of the year.

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

Duration: 2004-06
Resources: Core

Significance of the project

Arid and semi-arid areas not only face the problem of high temperatures and water scarcity, but also lower quantities of essential minerals in the soils. Fertilizer inputs on marginal and unproductive lands increase the establishment costs of agricultural production. Furthermore, multi-cropping systems have largely replaced traditional mono-cropping systems throughout the world because of their increased productivity per unit area. Agroforestry systems, which integrate tree species with other crops and livestock, is a good example. Such multi-cropping systems not only increase production, they enrich and regulate soil minerals as well.

Key point

- Two grass and one tree species were established at salinities of up to 30 dS/m.
- Multi-cropping systems are rapidly replacing mono-cropping.

Earlier studies conducted by ICBA both at its research farm in Dubai and in various partner countries have shown the enormous potential of *S. arabicus, P. vaginatum* and *A. ampliceps*. Integrated production systems utilizing these species are expected to fix N with *Acacia* and provide N to the grass species by lateral movements. However, the

P. vaginatum *(foreground) and* S. arabicus *(background) trials at the ICBA research farm.*

issues of fixing and moving N require further investigation, particularly under different salinity conditions. PMS31 undertakes to address these issues and to evaluate the production of grasses under both fertilized and unfertilized conditions.

Objectives

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

Achievements in 2005

Growth and productivity of the test species were evaluated under three salinity levels: 10, 20 and 30 dS/m. Each species was further tested at each of the three salinity levels with N:P:K (20:20:20) fertilizer treatment at 45 kg/ha and also without any fertilizer. Importantly, none of the species was significantly affected by the fertilizer treatments, a clear indication of the efficacy of the N-fixing ability of *A. ampliceps*. The trial was commissioned in 2004 and the grasses were harvested in 2005.

Although a slight increase in plant height of *A. ampliceps* was evidenced with the addition of fertilizer, the increase was never more than 20% at the different salinity levels used, indicating that the plant can grow under poor mineral conditions (Figure 39). Similar effects were also evident for biomass production in *S. arabicus*. *P. vaginatum*, on the other hand, showed no significant effect with or without fertilizer. For both grasses, dry biomass decreased at the highest salinity level (30 dS/m) (Figure 40).

Soil salinity ($EC_{1:5}$) increased with increase in salinity of irrigation water and was higher at lower soil depth (75-150 cm) for *S. arabicus*. Plots with fertilizer application showed

Figure 39: Height (cm) of *Acacia ampliceps* as affected by salinity and fertilizer treatments after 18 months of growth

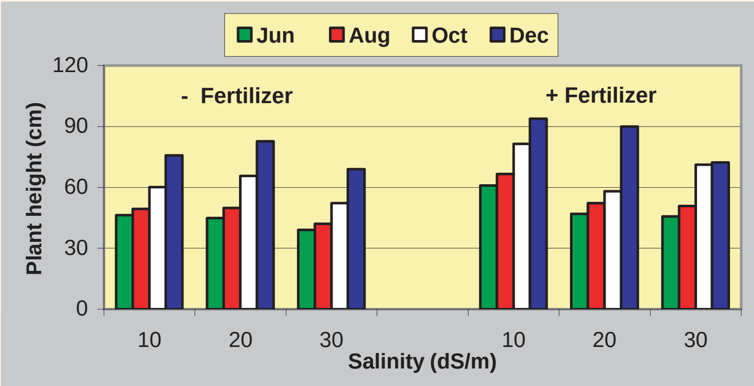
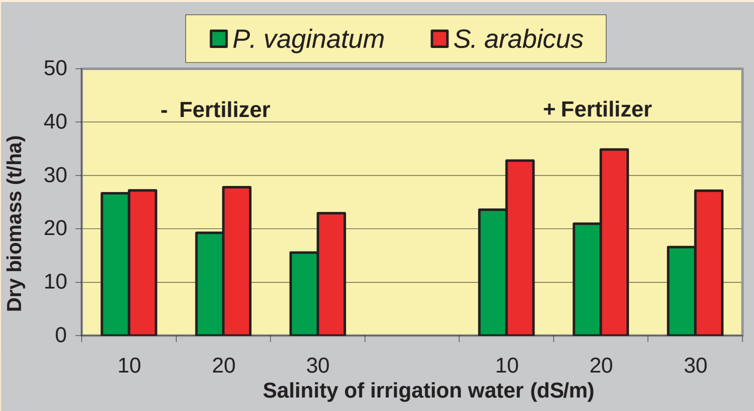


Figure 40: Annual dry biomass (t/ha) of *S. arabicus* and *P. vaginatum* grown at different salinity levels and fertilizer treatments (Data present the total of three cuttings/year)

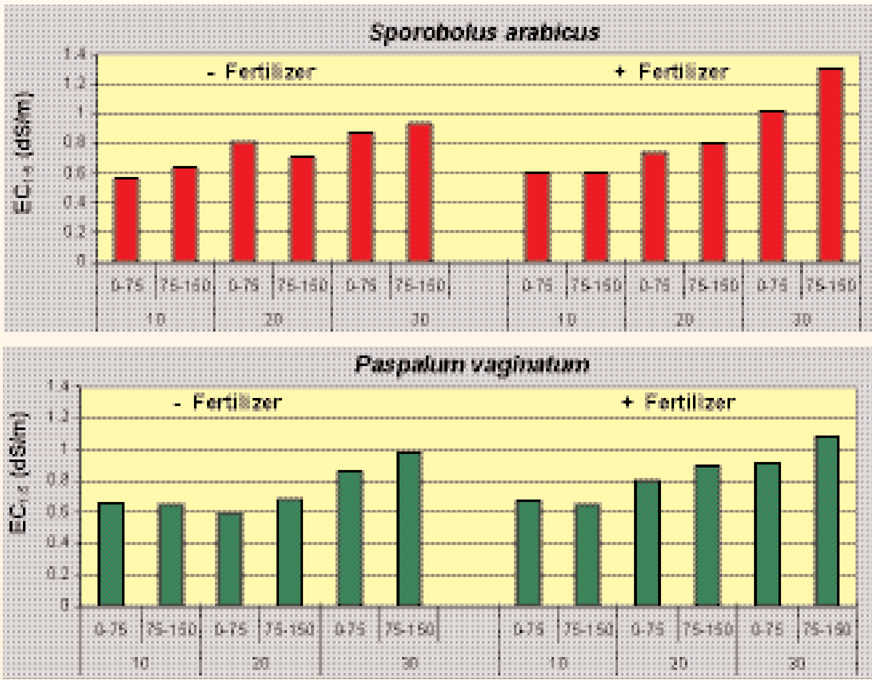


relatively higher soil salinity values. *P. vaginatum* did not exhibit any significant differences between the two fertilizer treatments (Figure 41).

PLANS FOR 2006

Growth and productivity of the different species will be monitored. In addition, studies will be initiated on fixed soil nitrogen content by *A. ampliceps* and its lateral movement in neighboring plots at different salinity levels. The nutritional values of these grasses will also be studied at different growth periods of the year.

Figure 41: Soil salinity (dS/m) measured at two different soil depths, with and without fertilizer treatment



A. ampliceps *shows excellent promise as a component of integrated forage systems*.

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 and ICBA
RESOURCES: Asian Development Bank (ADB)

SIGNIFICANCE OF THE PROJECT

Over the years, various R&D organizations have demonstrated that appropriate water management techniques and soil conservation practices can significantly increase agricultural productivity and income generation. Based on these experiences, two CGIAR centers, ICARDA and IWMI, entered into a partnership with ICBA to prepare a proposal for efficient use of degraded lands in Central Asian countries (CAC). Supported by the ADB, PMS35 aims to develop innovative income-generating strategies that make use of problematic water and soils.

KEY POINTS

- This multi-faceted project is ICBA's first with the Asian Development Bank.
- ICBA has opened an office in Tashkent and hired a full-time scientist to look after the project.

OBJECTIVES

- Alleviate poverty in the region.
- Improve food security at the household level.
- Improve environmental security.
- Promote and adopt strategies that enhance productivity.

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

ACHIEVEMENTS IN 2005

Project activities started in May 2005 at three experimental stations:

- Makhtaral (South Kazakhstan)
- Dashauz province (Turkmenistan)
- Gulistan State University (Uzbekistan)

ICBA provided seeds of 50 different species/cultivars/lines of salt-tolerant crops, shrubs and trees. In addition, 300 vegetative cuttings were sent for propagation in trials. During 2005, only locally available germplasm was planted. The varieties that established best were maize, sorghum, pearl

The genebank at the Uzbekistan Plant Research Institute, Tashkent.

millet and sunflower. Sorghum varieties were especially robust, producing up to 42 t/ha of fresh biomass.

ICBA also organized a training course on *Screening of salt-tolerant material and multiplication methods* in December at Tashkent, Uzbekistan. The course was attended by 16 participants from Karakul Research Station, the Uzbekistan Plant Research Institute and various cotton research institutes in the region. Lectures were given by eminent researchers from Uzbekistan as well as the ICBA Course Coordinator. A trip was organized to the Uzbekistan Plant Research Institute where participants were briefed about germplasm collections both *in situ* and in the genebank. Germplasm sent by ICBA for the project activities and kept in quarantine at the institute was exhibited to the participants.

Scientists checking soil salinity.

Plans for 2006

Existing trials will be continued and new sites will be identified in all three countries for additional trials. These new trials will involve local germplasm tested in 2005 and found to be productive on degraded lands. In addition, ICBA germplasm, when released from quarantine, will be used in fall planting in 2006.

Forage crops show great promise for poverty alleviation.

Horticulture Crop Production

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

Duration: 2001-06
Collaborator: Ministry of Agriculture and Fisheries (MAF)
Resources: Core

Significance of the project

Sustainability of the date palm agro-ecosystem requires continual adjustment in structure and management strategy to keep pace with changes in the production environments. The problems of salinity (and other biotic and abiotic constraints) necessitate the development of varieties and management techniques that enable the system to function properly and to survive the changing environment. Fortunately, the Arabian Peninsula is home to a vast genetic diversity of date palms.

This long-term experiment was planned to run for 5-6 years to provide valuable information on the salinity tolerance of elite UAE date palm varieties. In collaboration with MAF, ICBA selected 10 of the most preferred date palm varieties for investigation – Abu Ma'an, Barhi, Fardh, Jabri, Khalas, Khisab, Khnizi, Lulu, Naghal and Shahlah. These varieties were planted in 2001 in a replicated field experiment at three salinity levels with five replications of each variety, totaling 150 trees. Few studies have examined the long-term effects of salinity on date palm growth and productivity from establishment to maturity. In November 2002, 8 new varieties from Saudi Arabia were planted in the same field under the same salinity treatments along with 4 varieties of olive. The 18 elite varieties will provide a sound database for the evaluation of salinity impact on date palm production in the region.

Key points

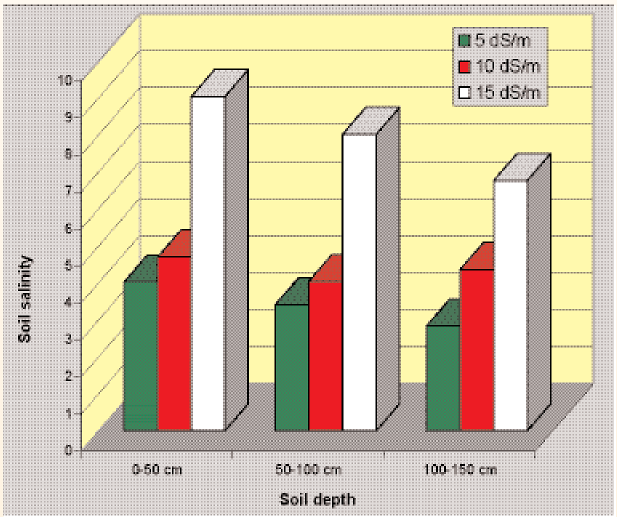
- After two years of salinity treatments, marked effects on growth and development of 10 date palm varieties are evident.
- Abu Ma'an, Jabri, Khinizi and Lulu are the best-performing varieties at salinities up to 15 dS/m.

Date palm trials at ICBA.

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 different salinity levels on date palm fruit quality.

Figure 42: Average soil salinity (EC_e in dS/m) in 10 date palm varieties under 3 salinity levels
(40 months after planting)



ACHIEVEMENTS IN 2005

Three salinity levels (5, 10 and 15 dS/m) were applied in late 2002. The growth and development of each plant was monitored by recording basic traits: height, trunk circumference, number of leaves and phenology. Three measurements were completed on each variety. Salinity treatments were applied in late 2003 on the additional 8 varieties. Soil salinity monitoring was practiced routinely at various depths, along with chemical analysis of vegetative parts.

RESULTS

The average irrigation rate per tree was 115 liters per day ($42m^3/y$). Average soil salinity build-up under each treatment reached 4, 4.7 and 9 dS/m under 5, 10 and 15 dS/m irrigation salinity levels (Figure 42). Growth parameters, like tree trunk height and diameter, varied significantly among varieties. Abu Ma'an, Barhi, Khisab, Khnizi, and were the best-performing varieties at the salinity ranges used (Figures 43 and 44). Other parameters like number of leaves and offshoots did not exhibit any correlation with salinity tolerance.

Figure 43: Average trunk circumference in 10 date palm varieties under 3 salinity levels
(Data are means of 5 plants, 40 months after planting)

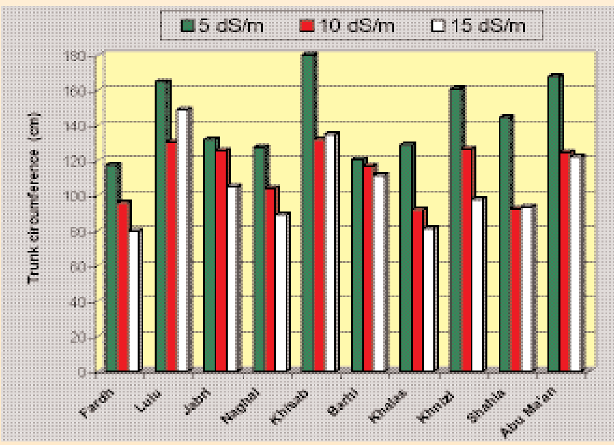
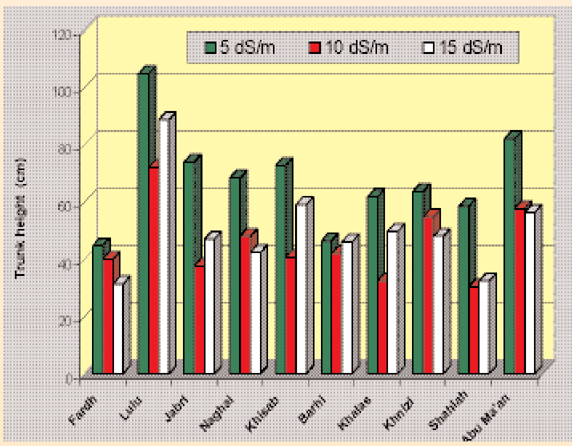


Figure 44: Average trunk height in 10 date palm varieties under 3 salinity levels
(Data are means of 5 plants, 40 months after planting)



Expanding date palm cultivation under saline conditions in Jordan (PMS23)

Duration: 2003 onward
Collaborator: National Center for Agricultural Research and Technology Transfer (NCARTT), Jordan
Resources: NCARTT, Core

Key points

- 18 varieties of date palm at two locations in Jordan Valley tested.
- The potential for expanding date palm cultivation from its present limited level is significant.

Significance of the project

Approximately 11,400 ha in the main irrigated areas of Jordan Valley are saline. This represents approximately 15% of available irrigated land. In Jordan, date palm is a high-value crop in great demand. The plant is known to be salt-tolerant. The project will test 18 varieties of date palm at two locations in Jordan Valley where optimal agronomic practices for establishing date gardens on saline soils will be investigated. The trials will serve as demonstrations for farmers, extension staff and researchers. The outcomes of the project will include recommendations of varieties adapted to saline areas of Jordan Valley and appropriate irrigation management systems.

Objectives

- Explore the potential of expanding the area of date palm in Jordan.
- Identify salt-tolerant date palm varieties suitable for the environmental conditions of Jordan.

Achievements in 2005

The following 15 date palm varieties were successfully established on two sites, Al-Karamah and Ghor Safi, in Jordan Valley in 2004. All are female varieties except Farad and Ghanname, which are male.

Ahmar Talal	Dairy	Khadrawe
Barhii	Farad	Medjool
Benoot Saif	Ghanname	Nboot Sultan
Braim	Hawayez	Sukari
Dahhan	Hayani	Zuhdi

In 2005, growth and application of appropriate agronomic practices were monitored regularly. Soil samples from both sites at different depths (0, 20, 20-40 and 40-60cm) were collected regularly for site characterization. Irrigation water was tested for salinity and other traits at both sites.

Plans for 2006

Monitoring of growth, plant measurement and soil and irrigation water analysis will continue on a regular basis as outlined in the project document. Field days for farmers, officials and technical staff will be conducted at least once annually.

Climatic data will be collected and water requirements estimated for the various date palm varieties under Jordan Valley conditions.

Successful establishment of date palm varieties in Jordan Valley.

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.
- Prepare and distribute information about biosalinity and maintain a network of communication with individuals and agencies with an interest in biosalinity.

Communication

Memoranda of Understanding

Five Memoranda of Understanding (MoUs) were signed in 2005. 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. Tashkent Office

On 2 February, ICBA signed an MoU with the Program Facilitation Unit (PFU) of the CGIAR Program for CAC. The PFU is hosted by ICARDA at its regional office in Tashkent, Uzbekistan. The agreement recognizes ICBA as an Associate Member in the Consortium for CAC, which includes nine CGIAR Centers and eight countries in the region: Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan.

2. Ocean Desert Enterprises

An MoU was signed between ICBA and Netherlands-based Ocean Desert Enterprises on 24 March. The agreement designates various areas for collaboration, including biosaline foods, utilization of waste water, biomass for renewable energy, landscaping and habitat restoration.

3. NyPa Arabia License Agreement

ICBA signed an agreement with NyPa International, a private company based in Tucson, Arizona, USA, and with its Dubai-

Mr Rob McFarlane, Director of Turfarm (left), and Dr Mohammad Al-Attar, ICBA's DG (right), after signing the agreement.

based partner Robert McFarlane Associates, which trades as Turfarm, on 5 April. The agreement provides for collaboration on cultivating, improving and disseminating NyPa-patented salt-tolerant grasses at the ICBA research farm.

4. Environment Agency Abu Dhabi

An agreement with ERWDA – now known as EAD – for ICBA to manage a soil survey project for Abu Dhabi Emirate was signed on 11 April. In addition, ICBA and EAD renewed their 2000 MoU for another four years on 14 April.

5. Institut National de la Recherche Agronomique

On 6 June, ICBA signed an MOU with Morocco's Institut National de la Recherche Agronomique (INRA) to collaborate on an array of activities relevant to biosaline agriculture, including training.

Bilateral Projects

ICBA has ongoing joint projects in Bangladesh, Egypt, Iran, Jordan and Pakistan.

Table 7. Joint projects 2005

Organization	Project	Location	Duration
Bangladesh			
BARI	Demonstration of biosaline agriculture in salt-affected areas (PMS09)	Bangladesh	2003-06
Iran			
NSRC	Production of halophytes (PMS22)	Iran	2003-05
Jordan			
NCARTT	Expanding date palm cultivation under saline conditions (PMS23)	Jordan	2003-06
Pakistan			
PARC	Use of low quality water for productive use of desert and salt-affected areas (PMS21)	Pakistan	2003-05
UAE			
MAF	Investigation of elite date palm and olive varieties for salt tolerance (PMS06)	ICBA	2001-06
MAF	Application of biosaline agriculture in a demonstration farm in the northern Emirates (PMS05)	UAE	2004-05
MAF	Feasibility study for biosaline agriculture in the UAE (PMS32)	ICBA	2004-06
UAEU	Optimizing management practices for maximum production of two salt-tolerant grasses: *Sporobolus virginicus* and *Distichlis spicata* (PMS03)	ICBA	2002-06
UAEU	Optimizing management practices for maximum production of three Atriplex species under high salinity levels (PMS04)	ICBA	2002-06
UAEU	Development of sustainable salt-tolerant forages for sheep and goat production (PMS16)	UAEU	2003-06

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 new members join the network, their 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 2006.

Because GBN is not facilitated, no statistics for hits and downloads are at present available from the website hosting service. Evaluation of the impact of GBN therefore remains unavailable, although plans to improve this situation are under study for implementation in 2006.

Table 8. 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	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**

GBN members (Table 8) 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. 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. To obtain the AGRIS and AGRICOLA, or to request a search on CAB Abstracts, members can email ICBA at library@biosaline.org.ae.

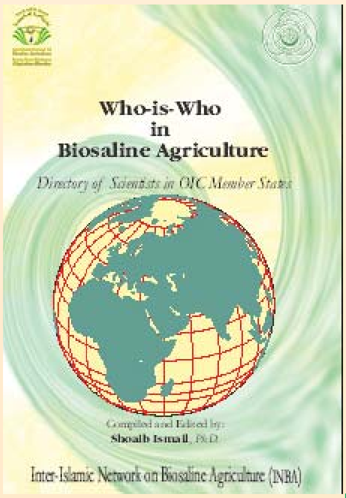
INTER-ISLAMIC NETWORK FOR BIOSALINE AGRICULTURE

INBA was established during the 10th General Assembly Meeting of the Standing Committee on OIC member Scientific and Technological Cooperation (COMSTECH) in Islamabad, Pakistan, in 2002. Since then, the network has provided a forum for mutual collaboration and cooperation among the members of the Organisation of Islamic Countries (OIC) in the field of biosaline agriculture.

Activities in 2005

Publications

INBA prepared a publication entitled *Who-is-Who in Biosaline Agriculture*, a database of scientists involved in different aspects of biosaline agriculture. The directory was made available both as a CD-ROM and as a 46-page booklet, both of which were distributed to various R&D organizations. The information used in the database was collected from national, regional and international institutions in both developing and developed countries. A database form was sent to acquire personal and professional information about each scientist, including field of specialization, qualifications and peer-reviewed scientific publications.



Library services

The ICBA library periodically prepares a list of recent publications on different aspects of biosaline agriculture called *What's new in the library*. The list is circulated among INBA-member countries. In addition, INBA provides the following information services to its members.

- Reference requests for specific articles or book chapters, subject to clearance of copying declarations.
- Information/literature search requests from three bibliographic databases (AGRIS, AGRICOLA and CAB Abstracts), or from the ICBA library catalog.

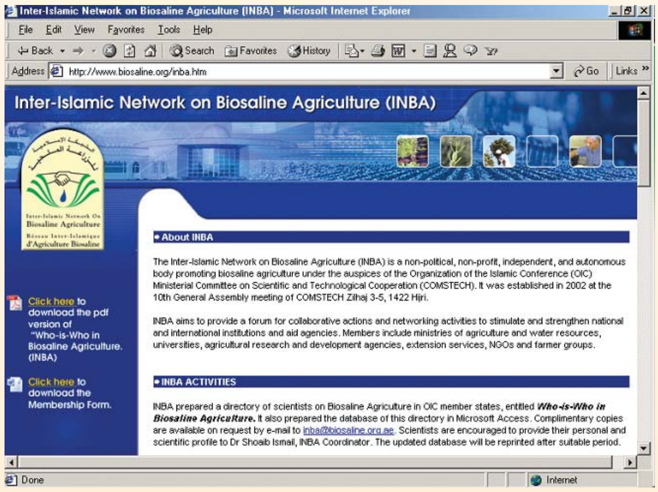
Workshops and seminars

INBA participated in the following seminars/workshops during 2005.

- 9-15 January. International seminar on Biosaline agriculture and high salinity tolerance, Mugla, Turkey.
- 6-11 September. INBA co-sponsored a session on Food security and unconventional water resources during an international seminar on Water, land and food security in arid and semi-arid regions, Bari, Italy.
- INBA also sponsored Mr Saud Al Farsi from Oman's Ministry of Agriculture and Fisheries who presented a country paper entitled *Food security and use of non-conventional water resources in Sultanate of Oman* during the Bari seminar.

Website

INBA put up its own web page on the ICBA website to provide details of its mission, objectives and activities. The URL is www.biosaline.org/inba.



Plans for 2006

- INBA submitted a proposal to COMSTECH and the IDB on *Apprenticeship for human capacity building on biosaline agriculture in Islamic countries*. Four potential apprentices from Bangladesh, Burkina Faso, Indonesia and Senegal will spend four weeks in the UAE undertaking studies on different aspects of biosaline agriculture (soils, water or plants).
- Work on the research database will continue.
- INBA will organize seminars and undertake consultancy studies on biosaline agriculture.

Information management

Activities in 2005

The main tool to inform staff and partners of newly available library materials, *What's New in the Library*, was made more comprehensive by including journal contents pages. In late 2005, *What's New* was posted on the ICBA website in an effort to promote the Center's library resources more widely to its partners and networks (Table 9).

To facilitate use of the ICBA Library by members of the INBA, an information sheet about library services, including literature search requests and references, was prepared and distributed.

Client database

A key tool for dissemination of information is a comprehensive and well-maintained stakeholder database. In early 2000, a contact database was developed and made accessible to all staff on the ICBA network. By the end of September 2005, the database held contact details of 2619 individuals. The database is used for targeted distribution of annual reports, newsletters and other ICBA communication activities.

Table 9. Summary of ICBA library services

	2003	2004	2005
Additions to database			
Books	337	89	177
Reprints	66	67	13
Periodicals	-	26	289
Purchase requests	52	47	21
Library services to ICBA staff			
Information/document/search requests	83	110	166
Library materials checked out	-	-	183
Document scans	-	-	60
Library services to non-ICBA staff			
Use of public computer	-	-	24
Visitors	-	-	80

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. The main issues discussed during these visits are added to the database for subsequent reference.

Image database

The image database, which contains over 18,600 images relating to ICBA projects and activities, cataloged by topic and year, provide a useful resource for reports, publications and presentations.

Plans for 2006

- Acquire information resources to support the needs of ICBA and its client base.
- Catalogue and classify information resources to ensure accessibility to all.
- Provide information as required to meet the specialized needs of ICBA.
- Promote ICBA's library resources.
- Compile library procedures manual.
- Renew access to specialized subject databases and journals.
- Installation and implementation of Integrated Library Management System software.

Publications

ICBA Annual Report 2004 (English and Arabic)
Biosalinity News Vol 6 No 1 (English and Arabic)
Biosalinity News Vol 6 No 2 (English and Arabic)
Biosalinity News Vol 6 No 3 (English and Arabic)
Who is Who in Biosaline Agriculture (English)
Unique center with a unique mandate (English and Arabic)

Table 10. Distribution of ICBA annual reports and newsletters, 2000-05

	English		Arabic		French		Total
	Recipients	Countries	Recipients	Countries	Recipients	Countries	
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

Media

Media coverage of ICBA is generated primarily by distribution of newsletters, annual reports and news releases to a media list, followed up by direct contact. The local Arabic press covers ICBA regularly, the English press to a lesser extent.

In addition to wide publicity in the UAE, ICBA also receives requests for articles and features for a variety of regional and international newsletters and magazines. Articles submitted have been published in the IDB journal *Manar, COMSTECH News, Qabas* (a Kuwaiti daily) and others.

Visitors

During 2005, ICBA hosted many important visitors, including ministers of agriculture, donor agency officials, private sector managers, and representatives of international, regional and national organizations (Table 11). Among the luminaries to visit the Center during 2005 was Dr Ahmed Mohamed Ali, President of the IDB.

Table 11. ICBA visitors, 2000-05

	2000	2001	2002	2003	2004	2005	Total
Ministers	-	3	7	2	2	2	16
Diplomats	1	6	7	8	3	4	29
Regional/internat'l organizations	15	17	25	26	25	20	128
IDB	2	4	9	4	4	13	36
UAE	20	29	31	26	34	33	173
Others	22	50	58	119	65	68	382
Total	**60**	**109**	**137**	**185**	**133**	**140**	**764**

Papers, presentations and exhibitions

Papers

Jaradat AA, Shahid M and **Al-Maskri AY.** 2005. Biomass production potential in barley landrace from Oman. Journal of Food, Agriculture & Environment. 3(2): 381-385

Omar S, Bhat NR, Shahid SA and **Assem A.** 2005. Land and vegetation degradation in war-affected areas in the Sabah Al-Ahmad Nature Reserve of Kuwait: A case study of Umm Ar Rimam. Journal of Arid Environments 66:475-490.

Shahid SA and **Hasbini BA.** 2005. Optimization of modern irrigation for biosaline agriculture. Proceedings of the WSTA Seventh Gulf Water Conference Water in GCC – Towards an Integrated Management. Vol II: pp735-746.

Taha F, Ismail S and **Dakheel A.** 2005. Biosaline agriculture: An international perspective within a regional context of the Middle East and North Africa (MENA). Keynote Paper on Food Security and Use of Non-Conventional Water Resources, International Conference on Water, Land and Food Security in Arid and Semi-Arid Regions, Bari, Italy, 6-11 Sep 2005, pp 255-270.

Hasbini BA, Al-Lawati YM and **Ismail S.** 2005. Biological treatment of oil process water and use in biosaline agriculture. *In*: Water in the GCC – Towards an integrated management. WSTA 7th Gulf Water Conference, Kuwait, 19-23 Nov 19-23, 2005. Vol II, pp 833-838.

Ismail S. 2005. Who-is-Who in Biosaline Agriculture: Directory of scientists in OIC member states. Inter-Islamic Network for Biosaline Agriculture. 44 pp.

Papers accepted for publication

Omar SAS, Cook S, Grealish G and **Shahid SA**. 2005. Statistical assessment of variations in soil properties within and between map units generated by GIS. Kuwait Journal of Science and Engineering.

Book chapters accepted for publication

Shahid SA. 2005. Physical Geography – Soils. *In* Sector Paper on Physical Geography. Abu Dhabi Global Environment Data Initiatives, Environment Agency-Abu Dhabi.

Shahid SA and **Abdelfattah MA**. 2005. Soils of Abu Dhabi Emirate. In Desert Ecology of United Arab Emirates. Environment Agency-Abu Dhabi.

Presentations

Shahid SA and **Hasbini BA**. Utilization of saline water for sustainable plant production. International Conference on Biosaline Agriculture and High Salinity Tolerance, Mugla, Turkey. 9-15 January 2005.

Chlild S and **Al Jabri G**. Role of ICBA in the IDB-member countries. First International Conference for the Women Advisory Panel of the Islamic Development Bank. Sharjah, UAE. 23-24 March 2005.

Taha FK, Ismail S and Dakheel A. Biosaline Agriculture: an international perspective within a regional context of the Middle East and North Africa. International Seminar, 5-12 September, Bari, Italy.

Meetings

9-14 January. Strategies for Forage Production in Salt-Affected Environments in Arid Regions. International Conference on Biosaline Agriculture and High Salinity Tolerance. Mugla, Turkey.

4-5 March. Inception and Planning Workshop, Ashgabat, Turkmenistan.

31 March to 1 April. FAO Regional Workshop on Salt-affected Soils from Seawater Intrusion: Strategies for Rehabilitation and Management. FAO Regional Headquarters for Asia and the Pacific, Bangkok, Thailand.

11-16 April. Manzanar project and Salicornia plantation at Massawa and Hargigo, Eritrea.

22-25 April. IFAD project meeting. Muscat, Oman.

11-13 May. National Planning Workshop for ADB Reta-9, Bright Spot Project. Tashkent, Uzbekistan. Visit field sites in Kazakhstan.

4 June. Brainstorming Workshop on Soil Survey for the Emirate of Abu Dhabi. Abu Dhabi.

28 September to 2 October. ADB project meeting and field trials set-up. Kazakhstan and Uzbekistan.

23-28 November. ICBA collaborative project meetings with PARC, ABAD and NIAB. Islamabad, Pakistan.

30 November to 1 December. ICBA-NSRC Bilateral Project Meeting and Field Day. Yazd, Iran.

11-18 December. ADB project Training Course. Tashkent, Uzbekistan.

Exhibitions

30 Jan to 1 Feb	Environment Exhibition, Abu Dhabi
1-3 Feb	WETEX 2005, Dubai
23-24 Mar	IDB Women Advisory Panel Meeting, Sharjah
18-25 Jun	IDB Annual Governors Meeting, Putrajaya, Malaysia
4-8 Dec	CGIAR Annual General Meeting, Marrakech, Morocco

Dr Ahmad Mohammad Ali, President of IDB (center) listening to Dr Mohammad Al-Attar, ICBA's DG (left).

Training, Workshops and Extension Program

OBJECTIVES

- 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

Integrated management of saline water resources and environments for forage production in the North Africa region

DURATION: 13-18 June

COLLABORATORS: INRA, ICBA

RESOURCES: OPEC Fund for International Development

The inaugural session of this training workshop in Rabat, Morocco, was attended by officials of INRA, the IDB regional office for North Africa, ICBA, and 26 participants from Algeria, Egypt, Mauritania, Morocco and Tunisia.

The presentations of experts from the region covering various aspects of salinity-related problems were delivered in both English and French. The course comprised a total of 16 lectures and two field practical sessions. Country sessions gave each represented nation the opportunity to share its experiences in biosaline agriculture.

The opening session of the workshop in Morocco. Left to right: IDB Representative for North Africa, DG of INRA, DG of ICBA.

RECOMMENDATIONS

- Biosaline plant production systems should be evaluated not only on a biological basis but on their economical and environmental suitability.
- Demonstration sites for biosaline plant production systems need to be established in each country.
- National programs in North Africa should work closely with ICBA to develop bilateral and regional projects.
- An early warning system for salinity hazards should be applied in areas where saline water and/or soils are used through systematic monitoring programs.
- When drainage water is used for agriculture, sustainability and long-term environmental impact must be considered.
- Soil and groundwater salinity levels should be mapped at both country and regional levels.

A Moroccan scientist briefs participants about the salinity problems of his country.

Workshop participants learn about salinity problems from a Moroccan farmer.

Workshop visit to Tadla agricultural area .

ADB Project Training Course

Duration: 12-16 December

Collaborators: ICARDA, IWMI, Uzbekistan Plant Research Institute

Resources: ADB

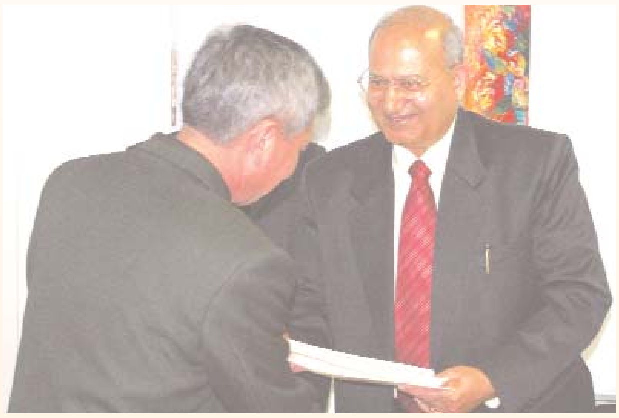
ICBA organized a 5-day training course in collaboration with ICARDA and IWMI at Tashkent, Uzbekistan. The course was part of the project *Enabling communities in the Aral Sea Basin to combat land and water resource degradation through the creation of 'bright spots'*. The project, classified as PMS35 by ICBA and funded by the ADB as Regional Technical Assistance (RETA) 6208, is being undertaken in Kazakhstan, Turkmenistan and Uzbekistan.

The course was attended by 16 participants from regional cotton research institutes, Karakul Research Station and the Uzbekistan Plant Research Institute. Lectures were given by researchers from Uzbekistan and ICBA.

The Inaugural Session, which was attended by representatives of ADB, ICARDA and IWMI, stressed the importance of biosaline agriculture in this region where increasing salinity problems have obliged researchers and policymakers to seek alternatives to cotton.

The course content was divided into eight sessions covering germplasm evaluation, multiplication and data collection of salt-

Visit to Plant Research Institute, Tashkent.



On the last day of the course, certificates were awarded to the participants by Dr Raj Paroda, ICARDA Regional Coordinator (right), and Dr Herath Manthrihilake, IWMI's Central Asia Region representative.

tolerant plants and halophytes. Opportunities for discussion and hands-on training were made available the participants.

A trip was organized to the Uzbekistan Plant Research Institute, where participants were briefed about germplasm collections both *in situ* and in the genebank, where more than 47,000 accessions of different species are stored. Germplasm sent by ICBA for the project activities and presently held in quarantine was also shown to the participants.

Table 12. Capacity building 2005

Title	Venue	Organizer	Dates	Participants		Funding
				From	No	
Management of salt-affected ecosystems	ICBA	ICBA	5-9 Feb	UAE	12	Ministry of Presidential Affairs, MAF, IDB, Global Scan Technologies
Traveling workshop for capacity development in project implementation	Oman and UAE	ICBA	23-27 Apr	Jordan, Oman, Pakistan, Palestine, Syria, Tunisia, UAE	36	IFAD, Arab Fund, OPEC Fund
Integrated management of saline water resources and environments for forage production in the North Africa region	Rabat, Morocco	INRA and ICBA	13-18 Jun	Algeria, Egypt, Tunisia, Mauritania, Morocco	31	OPEC Fund
Socio-economic aspects of introducing salt-tolerant forage cultivation in WANA	ICBA	ICBA, ICRISAT	28-29 Jun	Jordan, Pakistan, Syria, Tunisia, UAE	11	IFAD, Arab Fund, OPEC Fund
Design and analysis of field experiments	ICARDA	ICARDA, ICBA	11-22 Sep	Oman, Palestine, Syria, ICBA	4	ICBA
Screening of salt-tolerant material and multiplication methods	Tashkent, Uzbekistan	ICARDA, IWMI, ICBA	12-16 Dec	Uzbekistan, Kazakhstan	16	ADB

SEMINARS

Non-conventional water resources: practices and management: Bari, Italy

ICBA sponsored a session during an international conference on *Water, land and food security in arid and semi-arid regions* in Bari, Italy, 6-11 September. The session on *Non-conventional water resources: practices and management* included sub-sessions on saline water and wastewater. Prof Dr Faisal Taha presented the keynote address on *Biosaline agriculture: an international perspective within a regional context of the Middle East and North Africa*, co-authored with Drs Shoaib Ismail and Abdullah Dakheel. INBA sponsored the participation of Engineer Saud Al Farsi of Oman's Ministry of Agriculture and Fisheries who presented a paper on *Food security and use of non-conventional water resources*.

ICBA also submitted two posters for the conference:

- *Management strategies for using high salinity water for growing economical cash crops*
- *Optimization of modern irrigation for biosaline agriculture*

Seminar on ICBA's activities: Putrajaya, Malaysia

ICBA organized a seminar on the Center's activities on 20 June 2005 in cooperation with IDB and the Malaysian Agriculture Research and Development Institute (MARDI) which was held in conjunction with IDB's 30th Annual Governors meeting at Putrajaya, Malaysia. The seminar, which was chaired by Dr Amadou Boubacar Cisse, IDB's Vice President Operations, was attended by senior managers and scientists from both ICBA and MARDI.

Dr Abd Shukor Abd Rahman, MARDI's Deputy Director General for Research (left), Dr Amadou Boubacar Cisse, IDB's Vice President Operations (center) and Dr Mohammad Al-Attar, ICBA DG (right) during the session on ICBA's activities in Putrajaya, Malaysia.

Administration and Finance

Administration and Finance Services

Administration and Finance Services effectively conducted its activities and provided support to the Technical Division of the Center. Highlights of Administration and Finance Services activities are summarized below.

Insurance

ICBA staff continued to be insured for life and medical throughout 2005. ICBA Buildings and facilties were also insured throughout the year. Life and medical insurance was provided by ALICO and property insurance by Norwich Union.

Capital assets

No significant changes in capital assets occurred during 2005. However, the Board-approved budget for 2006 includes major purchases. These will be reported in full in Annual Report 2006.

Government Relations Office, Abu Dhabi

The Emirate of Abu Dhabi comprises about 86% of the land area of the UAE, including most government and diplomatic offices. Established in 2002, ICBA's Liaison Office in Abu Dhabi plays an important role by promoting the Center's interaction with UAE authorities. The relationships nurtured through the Center's Liaison Office have led to several key projects.

- PMS08 (2002-04) investigated waterlogging on agricultural lands in collaboration with Abu Dhabi Municipality.
- The Ministry of Presidential Affairs contributed to ICBA's 2004 budget with a grant of USD 450,000 and with USD 25,000 to support capacity building in CAC.
- PMS24 (2003-04). ICBA provided a consultancy to the Abu Dhabi Public Works Department to establish the farm of Qareen el-Eish.
- The largest cooperative venture between Abu Dhabi and ICBA to date is PMS36 (page 37), the Soil Survey of Abu Dhabi. In late 2005, ICBA decided to relocate its Liaison Office to a much larger facility to accommodate this project.

In addition to participating in the above projects, Liaison Office staff represents ICBA at conferences and exhibitions both in the UAE and abroad, facilitates visits, and promotes media relations.

Staffing

New staff

Ms Carla Mellor, Librarian, May

Ms Loubna Baya, Administrative Assistant, INBA, June

Dr Mahmoud Ali Abdelfattah, Soil Scientist on Secondment, April

Mr Khurshid Ahmad Mufti, Soil Technician, October

Mr Eric McGaw, Communications Specialist, October

Mr Zaynal Younis, Director, Administration and Finance Services (Acting), November

Ms Irene Galang, General Accountant, December

Departing staff

Ms Randa Koleilat, Librarian, May

Dr Bassam Hasbini, Irrigation Management Scientist, July

Dr John Stenhouse, Plant Genetic Resources Scientist, July

Dr Sandra Child, Communications Specialist, July

Mr Ghassan Sarris, Administration and Finance Officer, October

Mr Sami Barakey, General Accountant, December

Information technology

The IT department continued providing its ongoing services to all other departments while ensuring the proper functionality of the ongoing systems and the underlying IT infrastructure. Planning for upgrading infrastructure, servers and workstations was prepared in anticipation of the expected budget increase in 2006.

Resource Mobilization

IDB/COMSTECH Niger project grant approved

The farmers of Niger, one of the poorest countries in the world, are experiencing the onslaught of salinity in their fields due to improper irrigation methods, As a result, many are abandoning their fields. Because the limited experience with salinity problems of Niger's national research system, a Technical Assistance Grant Agreement was formulated by ICBA and the Institut National de Recherches Agronomiques du Niger (INRAN) to provide an umbrella for joint technology exchange. The project, which is funded by the IDB, will strengthen INRAN's capacity to deal with salinity in three stages.

- A training course conducted by ICBA in Niger.
- An internship at ICBA for the best participants of the course.
- Involvement of the interns in managing a pilot field training and demonstration project in Niger.

IDB/COMSTECH project proposal from INBA

In several OIC countries, the human capacity for managing saline land and water resources is inadequate. Unless proper management techniques are applied quickly and effectively in these countries, the health of their ecosystems is at risk. The best way to address this problem is to provide exposure to biosaline agriculture technologies to a few middle-level scientists, who can then provide appropriate

Table 13. Donor contributions 2000-05 (USD)

	2000	2001	2002	2003	2004	2005
IDB	3,000,000	3,249,375	1,999,946	2,040,000	2,215,000	2,000,000
Arab Fund		43,874	900,000	20,000	169,000	
OPEC Fund	250,000		140,000	130,000	70,000	160,000
IAEA			18,612	139	40,000	
PDO (Oman)		18,489	31,409	106,000	18,000	
Abu Dhabi Municipality (UAE)			27,734		67,337	12,850
BEHAR (Saudi Arabia)		22,500				
IFAD			9,600	28,700	3,300	477,000
USAID/ICARDA				78,350		
COMSTECH				4,969		7,975
HH President of UAE				20,000	450,000	
DFID (UK)				3,000		
NWICDP (Somaliland)					4,000	
Bank Keshavarzi (Iran)					16,720	
CGIAR--CA (IWMI)					45,000	30,000
National Prawn Co. (Saudi Arabia)					31,000	95,977
Abu Dhabi Public Works Dept					59,380	
Nakheel					10,000	
Dubai Islamic Bank					6,793	
AAAID					5,978	
CGIAR--CP (IRRI)					5,000	10,000
EAD (formerly ERWDA)						185,462
ADB						12,546
Total	**3,250,000**	**3,334,238**	**3,127,301**	**2,431,158**	**3,216,508**	**2,991,810**

training to junior scientists and technicians in each national program.

To initiate this cost-effective method of technology transfer, INBA submitted a proposal to COMSTECH and IDB to invite four junior scientists from Bangladesh, Burkina Faso, Indonesia and Senegal to participate in a 4-week hands-on apprenticeship at INBA headquarters in Dubai. Such an initiative would enhance the international visibility of COMSTECH-IDB activities while providing INBA/ICBA with a model for improved service to IDB-member countries.

ADB grant for Central Asia

Three International agricultural research centers, ICARDA, ICBA and IWMI, jointly submitted a proposal to the ADB entitled *Enabling communities in the Aral Sea Basin to combat land and water resource degradation through the creation of 'bright spots'*. The ADB agreed to fund the proposal with a budget of $700,000.

Figure 45: Donor contributions 2000-05

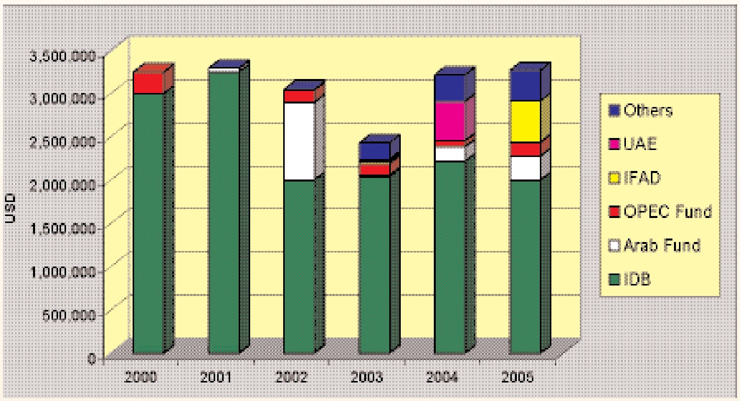
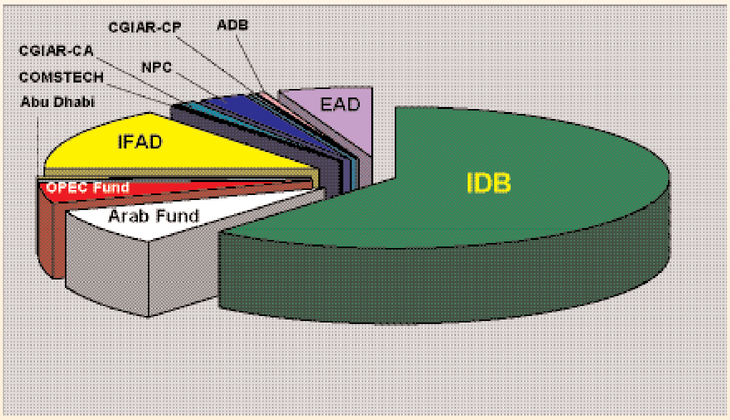


Figure 46: Funding 2005



ICBA's largest-ever UAE project

ICBA negotiated a 4-year (2005-09) soil survey project with ERWDA (now EAD). The project agreement, which was signed in April, provides ICBA with AED 4.55 million over 5 years.

The soil survey is a multi-purpose, science-based inventory of soil resources, something that had never been done in Abu Dhabi. In order to safeguard the sustainable use of the emirate's soil resources, a complete soil inventory was deemed essential. A sound knowledge of the soils is also an essential part for the development of wildlife and land use management plans. Training of UAE nationals is a priority in the soil survey program.

OPEC Fund grant disbursed

The first installment of a grant signed between ICBA and the OPEC Fund in 2004 was readied for disbursement late in the year. These funds partially supported the Oman-UAE traveling workshop, the Morocco forage training workshop, and the forage socio-economic workshop at ICBA.

Preparation of the ICBA Strategic Plan 2007-11

Considerable efforts were made to develop a 5-year Strategic Plan. A proposal seeking USD 175,000 for the exercise was submitted to the IDB in 2004, but the funds had not been disbursed before the end of 2005. Notwithstanding, ICBA Management and staff took the initiative of hiring a consultant to develop a Partner Survey, a structured questionnaire designed to obtain feedback from ICBA stakeholders as to what they feel our priorities should be during the Strategic Plan period. By the end of the year 57 responses had been received.

Increased financial support from IDB

The IDB has always been the main core donor for ICBA. In recent years, the Bank's support to ICBA was fixed at USD 2 million while cost of living in Dubai and cost of living were spiraling upwards. ICBA management and staff wrote to the IDB President voicing their concerns. The President sent individual letters to all staff indicating that the Bank would review its annual support. Subsequent developments indicate that the Bank will increase its support to ICBA in 2006.

Proposal for Eritrea

ICBA is developing a project proposal jointly with Dr Gordon Sato (Rolex Awardee) and the Eritrean Ministry of Fisheries to produce fodder for the livestock of low-income villagers using seawater. The project, designed to improve the economic well being of the villagers, essentially scales up the success of Dr Sato's work in the Manzanar project centered on mangrove forests.

Plans for 2006

- ICBA will work towards developing documents such as the Strategic Plan to help in core resource mobilization.
- ICBA will sensitize the GCC countries (especially the UAE) to provide annual core support to ICBA.
- ICBA will submit a proposal to the OPEC Fund in collaboration with ICRISAT early in 2006 for the next phase of the salt-tolerant sorghum and pearl millet forage and grain project.
- ICBA will build on the Forage Project (PMS27) and develop activities that link up with the success stories that will become apparent at the annual Technical Committee and Steering Committee meetings of the forage project to be held early in 2006.
- Armed with the new Strategic Plan 2006-09, the ICBA Board of Directors, Management and the Donor Relations Specialist will make fresh attempts to procure financial support from the World Bank, the Australian Center for International Agricultural Research and Iran.
- Efforts to procure funds for ICBA from sources within the GCC will be sustained. The new Chairman of the Board is well known in the GCC region and throughout the global donor community. These are indicators of likely success with new donors for ICBA in 2006.

Appendixes

Appendix 1

Summary of genebank holdings (December 2005)

	Genus	Family	Number of accessions	Number of species	Type of crop
1	*Acacia*	Poaceae	1	1	Forage
2	*Agropyron*	Poaceae	1	1	Forage
3	*Arachis*	Fabaceae	32	1	Oilseed/forage
4	*Asphodelus*	Liliaceae	2	1	Forage
5	*Astragalus*	Fabaceae	70	23	Forage
6	*Atriplex*	Chenopodiaceae	43	9	Forage
7	*Avena*	Poaceae	2	1	Forage/grain
8	*Beta*	Chenopodiaceae	57	1	Forage
9	*Botrichloa*	Poaceae	1	1	Forage
10	*Brassica*	Brassicaceae	4	1	Forage
11	*Cajanus*	Fabaceae	71	1	Forage
12	*Calligonum*	Polygonaceae	3	2	Forage
13	*Carthamus*	Asteraceae	643	2	Oilseed
14	*Cassia*	Caesalpiniaceae	1	1	Forage
15	*Cenchrus*	Poaceae	872	3	Forage
16	*Centrosema*	Fabaceae	1	1	Forage
17	*Chamaecrista*	Fabaceae	1	1	Forage
18	*Chenopodium*	Chenopodiaceae	121	1	Forage
19	*Chloris*	Poaceae	117	1	Forage
20	*Clitoria*	Fabaceae	1	1	Forage
21	*Coelachyrum*	Poaceae	2	1	Forage
22	*Convolvulus*	Convolvulaceae	1	1	Forage/medicinal
23	*Crotalaria*	Fabaceae	5	1	Forage
24	*Cyperus*	Cyperaceae	2	1	Forage
25	*Dichanthium*	Poaceae	11	1	Forage
26	*Digitaria*	Poaceae	1	1	Forage
27	*Dipterygium*	Capparidaceae	8	1	Forage
28	*Echinochloa*	Poaceae	145	9	Forage
29	*Farsetia*	Brassicaceae	2	1	Forage
30	*Haloxylon*	Chenopodiaceae	1	1	Forage
31	*Hedysarum*	Fabaceae	16	5	Forage
32	*Heliotropium*	Boraginaceae	3	1	Forage
33	*Hordeum*	Poaceae	946	1	Forage/grain
34	*Hymenocarpos*	Fabaceae	2	1	Forage
35	*Indigofera*	Fabaceae	5	2	Forage
36	*Jaubertia*	Rubiaceae	2	1	Forage
37	*Lablab*	Fabaceae	44	1	Forage
38	*Lasiurus*	Poaceae	9	1	Forage
39	*Lathyrus*	Fabaceae	269	3	Forage
40	*Lavandula*	Lamiaceae	1	1	Aromatic/medicinal
41	*Leptochloa*	Poaceae	3	1	Forage
42	*Leucaena*	Mimosaceae	237	1	Forage
43	*Lotus*	Fabaceae	446	21	Forage
44	*Lupinus*	Fabaceae	264	18	Forage

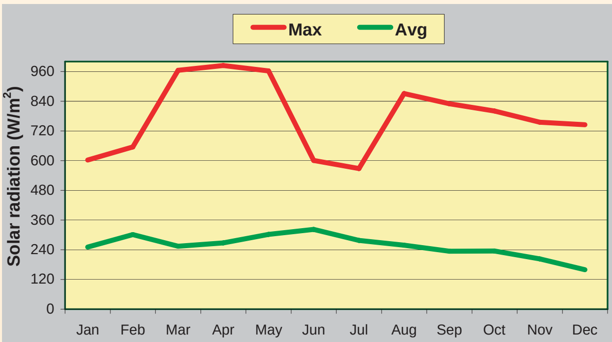
	Genus	Family	Number of accessions	Number of species	Type of crop
45	*Lycium*	Solanaceae	1	1	Forage
46	*Macroptilium*	Fabaceae	1	1	Forage
47	*Maireana*	Chenopodiaceae	1	1	Forage
48	*Medicago*	Fabaceae	513	41	Forage
49	*Melilotus*	Fabaceae	481	2	Forage
50	*Moringa*	Moringaceae	1	1	Browse tree
51	*Ochradenus*	Resedaceae	5	2	Forage
52	*Oryzopsis*	Poaceae	1	1	Forage
53	*Panicum*	Poaceae	28	2	Forage
54	*Paspalum*	Poaceae	5	4	Forage
55	*Pennisetum*	Poaceae	315	5	Forage
56	*Phalaris*	Poaceae	1	1	Forage
57	*Prosopis*	Mimosaceae	3	2	Forage
58	*Puccinellia*	Poaceae	1	1	Forage
59	*Rhanterium*	Asteraceae	2	1	Forage
60	*Scorpiurus*	Fabaceae	19	1	Forage
61	*Sesbania*	fabaceae	1	1	Forage
62	*Simmondsia*	Simmondsiaceae	29	1	Oilseed
63	*Sorghum*	Poaceae	709	4	Forage/grain
64	*Sphaerocoma*	Illecebraceae	2	1	Forage
65	*Sporobolus*	Poaceae	77	18	Forage
66	*Stipagrostis*	Poaceae	22	2	Forage
67	*Stylosanthes*	Fabaceae	2	2	Forage
68	*Taverniera*	Fabaceae	1	1	Forage
69	*Tephrosia*	Fabaceae	1	1	Forage
70	*Thinopyrum*	Poaceae	1	1	Forage
71	*Tricholaena*	Poaceae	1	1	Forage
72	*Trifolium*	Fabaceae	156	17	Forage
73	*Trigonella*	Fabaceae	13	1	Forage
74	*Triticum*	Poaceae	211	1	Forage/grain
75	*Urochloa*	Poaceae	1	1	Forage
76	*Vicia*	Fabaceae	56	2	Forage
77	*Vigna*	Fabaceae	408	1	Forage/grain
78	*X Triticosecale*	Poaceae	936	1	Forage/grain
79	*Ziziphus*	Rhamnaceae	3	1	Forage
		Total	**8,478**	**255**	

APPENDIX 2

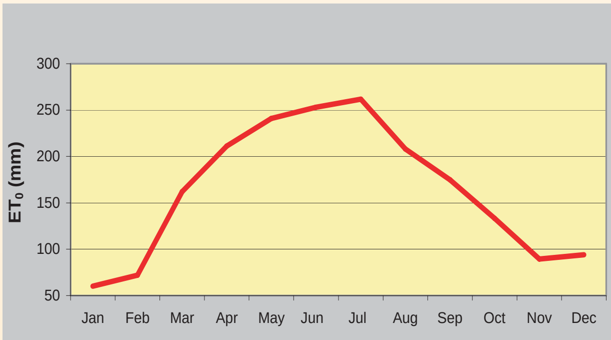
SUMMARY OF WEATHER DATA, ICBA STATION 2005

	Temperature (°C)				Relative humidity (%)				Sun	Solar radiation (W/m²)				Windspeed (kph)				Rainfall (mm)		ET_0 (mm)	
	Min	Max	Avg	Med	Min	Max	Avg	Med	Hrs	Min	Max	Avg	Med	Min	Max	Avg	Med	Total	Total to date	Monthly	Total to date
Jan	13.7	23.5	18.6	18.6	41.0	83.2	65.4	62.1	8.2	0	602.0	251.0	426.5	6.2	21.3	15.0	13.8	2.6	2.6	60.2	60.2
Feb	16.5	25.9	21.2	21.2	35.2	82.1	61.8	58.7	9.0	0	655.0	301.0	478.0	7.8	28.9	15.2	18.4	6.9	9.5	72.1	132.3
Mar	19.2	29.6	24.4	24.4	21.3	81.4	69.4	51.4	9.4	0	965.0	254.0	609.5	8.1	30.4	8.6	19.3	15.8	37.7	162.0	294.3
Apr	14.6	31.1	22.9	22.9	19.8	72.1	61.3	46.0	10.2	0	984.0	268.0	626.0	9.5	30.4	9.7	20.0	6.4	42.8	211.2	505.5
May	19.2	41.2	30.2	30.2	12.4	69.8	58.9	41.1	11.5	0	962.0	302.0	632.0	10.5	44.8	10.8	27.7	10.4	54.7	241.0	746.5
Jun	27.5	43.3	35.4	35.4	23.4	75.8	52.9	49.6	11.6	0	601.0	322.0	461.5	8.1	23.6	16.4	15.9	1.5	54.7	253.1	999.6
Jul	30.4	42.7	36.5	36.6	30.1	72.6	55.8	51.4	11.2	0	568.0	278.0	423.0	7.9	22.5	14.8	15.2	0.0	54.7	261.8	1261.4
Aug	28.9	44.5	36.7	36.7	22.4	74.6	61.8	48.5	11.0	0	871.0	258.0	564.5	8.8	30.4	6.6	19.6	0.0	56.7	208.0	1469.4
Sep	25.6	31.2	28.4	28.4	20.0	80.0	70.0	50.0	10.3	0	830.0	234.0	532.0	6.5	23.5	5.9	15.0	1.0	59.7	175.0	1644.4
Oct	23.1	28.6	25.9	25.9	21.1	88.1	78.6	54.6	9.6	0	800.0	235.0	517.5	6.1	22.8	5.7	14.5	2.1	62.5	133.2	1777.6
Nov	22.8	24.7	23.7	23.8	32.4	90.4	80.7	61.4	9.1	0	755.0	203.0	479.0	6.9	26.9	7.0	16.9	5.9	71.4	89.5	1867.1
Dec	20.5	22.6	21.5	21.6	41.7	91.4	81.4	66.6	8.2	0	745.0	159.0	452.0	7.5	30.8	7.5	19.2	24.7	100.6	94.1	1961.2
Avg	**21.8**	**32.4**	**27.1**	**27.1**	**26.7**	**80.1**	**66.5**	**53.4**	**9.9**	0	**778.2**	**255.4**	**516.8**	**7.8**	**28.0**	**10.3**	**17.9**				

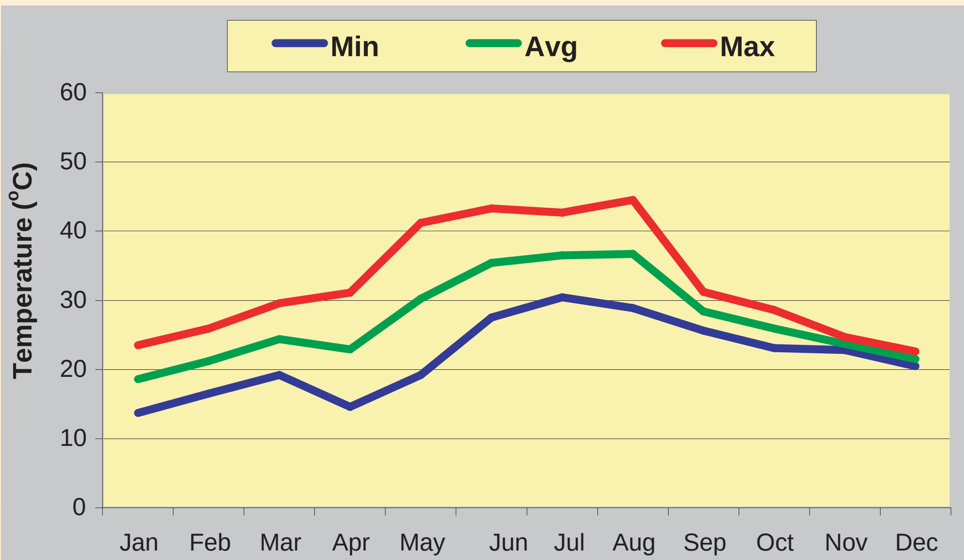
Solar radiation



Evaporation



Temperature



APPENDIX 3

CORE STAFF (AS OF 31 DECEMBER 2005)

Office of the Director General		
Dr Mohammad Al Attar	Kuwait	Director General
Mr Ibrahim Bin Taher	UAE	Government Liaison Officer
Mr Jugu Abraham	India	Donor Relations Specialist
Ms Abeer Abu Alzuluf	Jordan	Executive Secretary
Ms Ayat Abed Rasheed	Jordan	Office Assistant, Abu Dhabi
Mr Akhtar Ali	India	Administrative Support
Technical Programs		
Prof Dr Faisal Taha	USA	Director, Technical Programs
Dr Abdullah Dakheel	Syria	Field and Forage Crops Scientist
Dr Shoaib Ismail	Pakistan	Halophyte Agronomist
Dr Shabbir Shahid	Pakistan	Salinity Management Scientist
Mr Eric McGaw	USA	Communications Specialist
Dr Mahmoud Ali Abdelfattah	Egypt	Soil Scientist on Secondment
Mr Ghazi Abu Rumman	Jordan	Agronomy Laboratory Technician
Mr Basel Al Aaraj	Jordan	Irrigation Technician
Mr Wameed Yousif	Iraq	Field Technician
Mr Ghazi Al Jabri	Syria	Administrative Assistant, Communications
Ms Loubna Baya	Morocco	Administrative Assistant, INBA
Ms Diane Giessen	South Africa	Administrative Assistant
Ms Carla Mellor	Australia	Librarian
Mr Khurshid Mufti	Pakistan	Salinity Technician
Mr Khalil ur-Rehman	Pakistan	Halophyte Laboratory Technician
Mr Mohammad Shahid	Pakistan	Plant Genetic Laboratory Technician
Mr Saiful Islam Gul	Pakistan	Technical Support
Mr B Santhanakrishan	India	Technical Support
Mr Mohammad Shah	Pakistan	Technical Support
Administration and Finance		
Mr Zaynal T Younis	USA	Director, Administration & Finance (Acting)
Mr Bilal Al Salem	Jordan	Administrator/Government Relations
Mr Ghassan El Eid	Lebanon	IT and Computer Supervisor
Ms Souhad El Zahed	Lebanon	Administrative Services Supervisor
Ms Irene Galang	Philippines	General Accountant
Mr Jamal Telmesani	Saudi Arabia	Facilities Supervisor

Appendix 4

Audited financial statements

Statement of activities year ended 31 December 2005			
		2005	*2004*
Revenues	Grants - unrestricted	2,311,612	2,687,659
	Grants - restricted	-	41,742
	Contribution for training courses and research	1,281,262	394,036
	Contribution from outreach projects	53,271	95,670
	Other income	14,895	26,429
	Total revenues	**3,661,040**	**3,245,536**
Expenses	Salaries	978,877	1,134,479
	Benefits	556,575	747,694
	Supplies	108,655	98,581
	Board expenses	24,211	23,197
	Contract services	49,909	87,856
	Travel	98,161	89,131
	Utilities	117,504	112,334
	Maintenance	117,251	116,095
	Water expense for irrigation	-	-
	Depreciation	275,364	304,721
	Expenses related to grants restricted	-	41,742
	Expenses against training courses and research	1,281,262	394,036
	Expenses related to outreach projects	53,271	95,670
	Total expenses	**3,661,040**	**3,245,536**
Excess of revenues over expenses		-	-

Statement of financial position as of 31 December 2005			
		2005	*2004*
ASSETS			
Current assets	Bank balances and cash	1,135,744	1,184,881
	Receivable from donors	-	46,017
	Accounts receivable - other	-	63,773
	Receivables from staff	14,692	47
	Prepaid expenses	4,628	39,998
		1,155,064	**1,334,716**
Non-current assets	Property, plant and equipment	6,368,641	6,669,569
		6,368,641	**6,669,569**
TOTAL ASSETS		**7,523,705**	**8,004,285**
LIABILITIES AND NET ASSETS			
Current liabilities	Accounts payable	57,867	101,335
	Accrued expenses and other payables	26,501	104,997
		84,368	**206,332**
Non-current liabilities	Employees’ end of service benefits	69,904	46,109
		69,904	**46,109**
Net assets	Unrestricted - unappropriated	6,368,641	6,669,569
	Unrestricted - appropriated	429,889	442,981
	Temporarily restricted	570,903	639,294
	Total net assets	**7,369,433**	**7,751,844**
TOTAL LIABILITIES AND NET ASSETS		**7,523,705**	**8,004,285**

APPENDIX 5

ACRONYMS AND ABBREVIATIONS

AAAID	Arab Authority for Agricultural Investment and Development
ADB	Asian Development Bank
ADF	acid detergent fiber
AFESD	Arab Fund for Economic and Social Development
BARI	Bangladesh Agricultural Research Institute
CAC	Central Asia and the Caucasus
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Center
COMSTECH	Standing Committee on Scientific and Technological Cooperation (of the Organization of the Islamic Conference)
EAD	Environment Agency-Abu Dhabi (formerly ERWDA)
ERWDA	Environmental Research and Wildlife Development Agency
GBN	Global Biosaline Network
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
INRA	Institut National de la Recherche Agronomique (Morocco)
INRAN	Institut National de Recherches Agronomiques du Niger
IRRI	International Rice Research Institute
IWMI	International Water Management Institute
MARDI	Malaysian Agriculture Research and Development Institute
MAF	Ministry of Agriculture and Fisheries (UAE)
MDG	Millennium Development Goal
MoU	Memorandum of understanding
NARS	national agricultural research system
NCARTT	National Center for Agricultural Research and Technology Transfer (Jordan)
NDF	neutral detergent fiber
NIAB	Nuclear Institute for Agriculture and Biology (Pakistan)
NPC	National Prawn Company (Saudi Arabia)
NSRC	National Salinity Research Council (Iran)
NWICDP	Northwestern Integrated Community Development Program (Somaliland)
OIC	Organization of the Islamic Conference
OPEC	Organization of Petroleum Exporting Countries
PARC	Pakistan Agricultural Research Council
PFU	Project Facilitation Unit (Uzbekistan)
PDO	Petroleum Development Oman
QTL	quantitative trait locus
UAE	United Arab Emirates
UAEU	United Arab Emirates University
WANA	West Asia and North Africa
WUE	water use efficiency

Appendix 6

A description of ICBA's working relationship with NyPa (PMS29) appears on page 77.