Consultation Meeting on Saline Agriculture

ICBA: Sustainable, Climate-smart Agriculture in Marginal Environments

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Overview

- Steady growth of global population and changes in living standards
- Growing freshwater scarcity
- Accelerating climate change
- Loss of biodiversity

All these factors will have impact on agriculture and food security, economic development, etc.
Salinization is a global concern

- About 11% of the world’s irrigated areas are already affected by some degree of salinization (FAO, 2012)
- Globally 1 billion hectares of lands are salt-affected
- Estimated loss of land due to soil salinization annually could reach 0.5 million hectares

As a consequence thousands of farmers go out of business annually
Global salinity map

Central Asia
50% of the irrigated area is salinized

Pakistan
3-6 Mha

Bangladesh
1 Mha of salinized land

India
7 Mha

Australia
2 Mha salinized & 820,000 ha of unsuitable land

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Impact of increasing salinity

Crop Yield t/ha

Water Salinity (ds/m)

Tomato
Lettuce
Alfalfa

Farmers annual profit (US$)

Fresh 2,830
Low Salinity 2,085
Medium Salinity 1,215
High Salinity 1,120

Return to water used

US$/m³

Dates 0.33
Fodder 0.64
Vegetables 3.15

Twice the value
Five times the value
Climate & topography in most Arab countries

Subtropical-arid to hot with little rainfall

Desert lands

- Underutilized, abandoned lands
- Depletion of natural resources
- Sea water intrusion
- Salinization of farms
Water scarcity & effect of climate change in marginal environments

• By 2080, 43-50% of the global population will be living in water-scarce countries

• Marginal water resources have potential to supplement fresh water resources and reduce expected future fresh water gap

• By 2050, MENA region
  – Hotter and drier
  – Drought will be increasing

Increase of Water Demand by 50%
Decrease of Water Supply by 12%

Water Gap will increase
Why biosaline agriculture?

• It releases pressure from good quality water and land resources
• Utilizes wastelands and poor quality water resources
• High potential to bring back salinized farms to agricultural production
• It provides new sources of food, fodder, fuelwood, fiber
• It creates CO$_2$ sinks
• It can sustain local communities
Good progress in biosaline agriculture *but not enough*

- ICBA succeeded in introducing climate-resilient crops: Quinoa, Sorghum, Pearl Millet, Barley
Alternative salt-tolerant forages

- Farm status: Abandoned due to high salinity of irrigation water, which ranged between 15-18 dS/m
- Four salt-tolerant perennial grasses were planted:
  - Distichlis spicata,
  - Sporobolus virginicus
  - Sporobolus arabicus
  - Paspalum vaginatum
- Fresh biomass yields determined for the four grasses after one year of growth ranged between 75-150 t/ha/year, which is 66% more compared to Rhodes grass (low salinity 2 ds/m)
- Saved 44% of water use compared to traditional forages
Forage yield t/ha (15-20 dS/m)

**Fresh Biomass Yield t/ha (15-20 dS/m)**

- Distichlis spicata: 59 t/ha
- Sporobolus arabicus: 58 t/ha
- Atriplex lentiformis: 51 t/ha
- Sporobolus arnicola: 48 t/ha
- Paspalum...: 46 t/ha
- Quinoa Biomass...: 40 t/ha
- Atriplex halimus: 35 t/ha
- Buffel grass: 30 t/ha
- Barley: 28 t/ha
- Sesbenea: 28 t/ha
- Mustard: 23 t/ha
- Fodder beet: 16 t/ha
- Safflower: 12 t/ha
-...: 8 t/ha
- Alfalfa: 2 t/ha

**Dry Biomass Yield t/ha (15-20 dS/m)**

- Distichlis spicata: 36 t/ha
- Paspalum vaginatum: 27 t/ha
- Sporobolus virgicus: 24 t/ha
- Sporobolus arabicus: 17 t/ha
- Barley: 16 t/ha
- Buffel grass: 12 t/ha
- Quinoa (Seed): 8 t/ha
- Mustard: 7 t/ha
- Quinoa Biomass yield: 7 t/ha
- Sesbenea: 6 t/ha
- Mustard (Seed): 5 t/ha
Date palm trees

Effect of salinity on fruit yield in 2015

Fruit yield (KG/head)
Breeding salt-tolerant barley

- Crosses between elite barley cultivars adapted to Arabian Peninsula environments and highly salt-tolerant genotypes of wild barley (*Hordeum spontaneum*) have been selected for planned crosses.

Supply of salt-tolerant barley seed to the farmers of salt-effected agricultural lands and the areas where only saline water is available for irrigation.
Salinity tolerance study on tomato

- *Solanum pimpinellifolium*, a wild relative of cultivated tomato, offers a wealth of breeding potential for salt tolerance.
- At ICBA, 389 lines of 4 species of tomato were grown at low (0.3 dS/m) and high (17 dS/m) salinity levels to study the salt-tolerant mechanism at molecular levels in tomato.
Inland modular farm

**Uses**
- Cows
- Sheep
- Chicks

**Halophytes**
- Halophytic Forages
- Salicornia
- Other Halophytes (mustard, quinoa)

**Inland Modular Farm (ICBA)**
- Aquabrine (Salinity 25 ppt)
- Fish Farming
- Rejected Brine (Salinity 25 ppt)
- Algae Farming
- Desalinated Water (Salinity 0.3 ppt)

**Vegetables**
- Saline Groundwater (Salinity 15 ppt)

Design: ICBA Agriculture for Tomorrow
Coastal modular farm

Coastal modular farm (MERD-MOCCAE)

Seawater

1st Fish species tank water

2nd Fish species tank water

Aquaculture drainage in a mangroves area

Salicornia

ICBA-2  ICBA-3  ICBA-9  ICBA-10
Sustainable integrated solutions

Pilot integrated farm at ICBA

Farm in Al Dhaid (UAE)

More profitable use of desalinated water and integrated solutions for the reject brine use

Farm in Al Wagan (UAE)

Better management of the available water resources – Introduction of halophytes irrigated with reject brine
Performance to date: return on investment

Salicornia (samphire) = a multi-use halophyte

<table>
<thead>
<tr>
<th>Fresh Biomass Yield (t/ha)</th>
<th>1.3 time</th>
<th>3 times</th>
<th>12 times</th>
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<tbody>
<tr>
<td>Salicornia</td>
<td>8</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Forage grasses</td>
<td>56</td>
<td>75</td>
<td></td>
</tr>
</tbody>
</table>

Uses of reject brine

Seed yield = 3.25 t/ha
Halophyte-based products

Rock samphire smoked tilapia with quinoa

Jelly of Salicornia

Crackers of Salicornia and rock samphire

Salicornia and rock samphire bread

Expo Live Innovation Impact Grant Program
Global success stories

1. Greening Eritrea project

https://www.youtube.com/watch?v=ibWYfC8z9co
Global success stories

2. Behar (Ras-Al-Zawr project) Saudi Arabia

• Giant pivot-irrigation arms sprayed seawater pumped straight from the Arabian Gulf to produce the initial *Salicornia* crop in five 50-hectare circles

• Based on feasibility study, circles of *Salicornia* could one day cover up to 200,000 hectares along both coasts of Saudi Arabia, providing up to 120 million kilograms (34 million US gallons) of vegetable oil a year
3. EU project “Saline crops. A contribution to the diversification of the production of vegetable crops by research on the cultivation methods and selection of halophytes (1993-1996)

- Domesticate a number of plant species, naturally growing in saline or brackish soils that are locally gathered for consumption as a vegetable in the EU

The company (spin-off) is active (Belgium): http://www.scrops.com/seeds.html

Global success stories

4. Salt Farm Texel - Netherlands

Screening salt-tolerant varieties of conventional crops and halophytes for commercial production

Salt-tolerant potato varieties

Project in Bangladesh:

https://www.youtube.com/watch?v=JahZsRaK_S0&feature=youtu.be
Global success stories

5. Sun drop farm – Australia (2010)  
http://www.sundropfarms.com/

- Applied in the desert
- Desalination of seawater through solar tower
- Solar tower is also used to produce energy to power the plant growing systems and to heat and cool the greenhouses
Major crops in human diet

- Roughly 30,000 palatable plant species have been identified throughout the world.
- Just 150 plant species are cultivated.
- Around 100 crops supply about 90% of the calories in the human diet.
- Rice, wheat, maize and potato alone provide 60% of human energy source.

More than 7,000 crop species have been used in the human history for food.
The way forward

• Biodiversity of crops is very important and can help in coping with biotic and abiotic threats to agricultural production. Introducing and scaling up proven salt-tolerant crops and conserving local varieties is a priority.

• Breeding for salt-tolerant crop varieties is relatively new and needs to be expanded.

• Innovative technologies: genomics, metabolomics, nanotechnologies, precision agriculture, drones, remote-sensing applications, sensors, other water-saving technologies.
Center of Excellence looking at Agriculture for Tomorrow

Thank you

www.biosaline.org

ICBA is a founding member of the Association of International Research and Development Centers for Agriculture (AIRCA)