Saline agriculture: Scaling up opportunities and challenges

Webinar, Tuesday 26th May 2020

Speakers:

Dionysia-Angeliki Lyra
Arjen de Vos
Andrés Parra González
Structure of the presentation

1) Introduction to the topic

2) Opportunities for cultivation of conventional vegetable crops under saline conditions

3) Projects on Halophytes value chains in MENA region

4) Implementation of a Decision Support Tool (DST) under saline conditions. A showcase of the Mediterranean Region

5) Conclusions
1) Introduction: Vexing challenges

...lockdowns pushed focus on local food production
Doughnut Economics theory by Kate Raworth

[Image: Diagram showing the Doughnut Economics model with various sectors including environment, social, and economic aspects]

https://www.weforum.org/agenda/2020/05/doughnut-model-amsterdam-coronavirus-recovery/
Why Saline Agriculture?

- Releases pressure on good quality water and land resources
- Utilizes wastelands and poor quality water resources
- Provides new sources of food, feed, biofuels, fiber
- Generates employability particularly youth and women
- Climate change mitigation: rehabilitation of degraded lands, CO$_2$ sequestration
- Climate change adaptation: improves resilience of local communities

*Improved food and nutrition security. Improved livelihoods.*
Resources for saline agriculture implementation

- Saline water resources (brackish ground water, seawater, reject brine from desalination, drainage water, aquaculture effluents, etc.)

- Degraded soils (saline, saline-sodic, barren lands)

- Plants (salt-tolerant varieties of conventional crops, halophytes)
Crops Salinity Tolerance

Plants’ dry matter increases

Salinity tolerance (increase in dry matter as % control)

NaCl (mM)

Salinity increases

Halophytes

Saltbush

Arabidopsis

Durum wheat

Rice

Barley

Bread wheat

Tail wheatgrass

Alfalfa

(Munns and Tester, Ann. Rev.PB, 2008)
2) Opportunities for cultivation of conventional vegetable crops under saline conditions

The Salt Doctors – who we are -

*Dr. Arjen de Vos*

E-mail address: arjen@thesaltdoctors.com

**Mission:** Improve crop yield under saline conditions and bring the solutions into the hands of farmers

Service provider to develop and implement scalable solutions, work towards large-scale impact
The Salt Doctors – who we are -

**Mission:** Improve crop yield under saline conditions and bring the solutions into the hands of farmers.

- **teaching**
- **salt tolerant seeds**
- **scalable solutions**
- **salinity assessments**
- **training & capacity building**
- **research & demonstration**

**WASAG** The Global Framework on Water Scarcity in Agriculture

Service provider to develop and implement scalable solutions, work towards large-scale impact.
Salinity, what are we dealing with?

Around 400 million hectares of **saline soils** (potential to feed up to 2 billion people!), the **majority is low to moderately saline** (<8-10 dS/m (EC$_e$)) (Wicke et al, 2011, Shahid et al., 2018, Negacz et al. 2020 (subm.))
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Mostly moderate salinity level?

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Bangladesh delta:
57% of saline soils < 8 dS/m
75% < 12 dS/m

Source: BARI 2010, modified by Negacz, 2019
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Mostly moderate salinity level?

**Bangladesh delta:**
- 57% of saline soils < 8 dS/m
- 75% < 12 dS/m

Source: BARI 2010, modified by Negacz, 2019

**East of Egypt Nile delta:** 40% of all land is saline, of which 70% < 8 dS/m

Source: Hammam & Mohamed, 2018
Measuring soil salinity

Pakistan, Bangladesh, Kenya, Vietnam, Egypt, Jordan

Moderate salinity levels
Salt tolerant varieties of conventional crops?

800 varieties of 50 different crops tested (2012-2019)

under controlled field conditions, The Netherlands

(moderately) tolerant, high yielding varieties found for potato, carrot, cauliflower, beetroot, among others

More potential...
but...saline agriculture is more than a salt tolerant crop

Cropping (techniques) + socio-economic factors

- climatic conditions (temperature, rainfall, ...)
- soil (salinity, structure, pH, fertility, tillage, ...)
- water (salinity, total amount, storage, irrigation, ...)
- crop (salt tolerant, yield, market, cultivation, ...)
- input materials (seeds, irrigation equipment, ...)

- farmers (preference, level of knowledge, role model)
- training/capacity building (pilot, long term demo, ...)
- entrepreneurship (market, business model, ...)
- policy (rules, regulations, government participation, ...)
- PPP (public private partnerships, ...)

- crop selection
- cultivation strategy
- inputs
- knowledge & skills
- market
- scalable solutions
Example Capacity Building Egypt

Improving crop, soil & water management under saline conditions

The Salt Doctors

NECTÆRRA
water research & consulting

Heliopolis University
for Sustainable Development

Delphy

SEKEM

Wasag
The Global Framework on Water Scarcity in Agriculture

Orange Knowledge Program, Nuffic (NL)
Implementation Pakistan, salt tolerant potato (2016-2017)

In Pakistan, 6 million hectares of salt affected farm land

Activities: validation and demonstration salt tolerant potato, introduction at field scale, training, capacity building and marketing

Result: 28% yield increase under moderate saline conditions, compared to the local variety (average soil salinity = 8 dS/m)
Implementation Kenya, salt tolerant carrot, 2018

Activities: tailor-made cultivation strategy salt tolerant carrot, training, capacity building and marketing, smart water management (water harvesting), develop approach for agro-forestry

Results: 94% yield increase compared to local variety, model for 98% groundwater use reduction
Implementation Bangladesh (2017-2020)

Set up test facility, testing local crops for salt tolerance
Training-of-trainers, 200 lead farmers, 5000 group farmers
Providing knowledge, skills and seeds to the farmers

From 1 crop season per year > 2-3 seasons

Results
- after 2 years, based on independent project evaluation:
  260 random surveys from 1920 group farmers and 80 lead farmers

- Food security increased from 15% to 65%
  - Based on Household Food Insecurity Access Scale 0 (full food security)

- Use of salt affected fallow land increased from 0% to 76%

- average household income increased by 34%
  - Percentage with more than 100 euro increase:
    - 55% for lead farmer, 4% for group farmer

- Employment increased by 10% for lead farmer, 41% for group farmer

- Vegetable consumption (150 g/day, 10 months/year) increased from 26% to 74%

- Household improved dietary diversity increased from 75% to 100%

- Women with improved skills for sustainable food production increased from 9% to 79%

- Access to land for women increased from 4% to 87%
Ambition The Salt Doctors

Realize global network, accelerate innovation and implementation, work towards large-scale impact
The SalFar project – soilexperts, microbiologists, economists, farmers, experts in watermanagement, regional planning, policy development, climate experts

Objectives

• Promote resource efficiency
• Testing salt tolerance of crops
• Test fields in regions around the North Sea
• Workshops for farmers and policy makers
• Creating new business opportunities for farmers
• Sharing knowledge and experience around the world
Challenges

• (moderately) tolerant varieties of conventional crops have been identified, but salt tolerance often not interesting (yet) for breeders (?)

• Yield under saline conditions can be improved greatly, but also requires improved soil and water management...
  • This complexity makes implementation difficult (?)

• Saline agriculture is more than cultivating a salt tolerant crop
  • socio-economic factors: market opportunities for farmers, training, showcase results, with local problems asking for local solutions (tailor-made solutions...)

• First implementation shows that saline agriculture is possible and profitable, but how to move towards large-scale impact...?

• Conventional crops mostly for moderate saline conditions, can halophytes be used for high saline conditions?
3) Projects on Halophytes value chains in MENA region

International Center for Biosaline Agriculture (ICBA)

Mission: To work in partnership to deliver agricultural and water scarcity solutions in marginal environments to ensure sustainable livelihoods and food security.

E-mail address: d.lyra@biosaline.org.ae
Halophyte agriculture: Success stories

Suresh Panta\textsuperscript{a}, Tim Flowers\textsuperscript{b}, Peter Lane\textsuperscript{a}, Richard Doyle\textsuperscript{a}, Gabriel Haros\textsuperscript{c}, Sergey Shabala\textsuperscript{a,*}

\textsuperscript{a} School of Land and Food, University of Tasmania, Hobart, Australia
\textsuperscript{b} School of Plant Biology, Faculty of Natural & Agricultural Sciences, The University of Western Australia, 35, Stirling Highway, Crawley, Western Australia, 6009, Australia
\textsuperscript{c} The Punda Zoie Company Pty Ltd, Melbourne, Australia
1) **Human food**: quinoa, sea kale, (rock) samphire, pearl millet, etc.

2) **Forage & animal feeds**: Atriplex, Sporobolus, Distichlis, Paspalum, etc.

3) **Oilseed crops**: Suaeda, Kosteletzkya, Salicornia etc.

4) **Energy crops**: Tamarix, Phragmites, Miscanthus, Spartina, Typha etc.

5) **Phytoremediation**: Sesuvium, Atriplex, Salicornia etc.

6) **Medicinal plants**: Ipomoea, Tamarix, Pandanus, Iceplant, etc.
A. Quinoa

Nutritional value

Table 3: Mineral content of quinoa and selected foods, mg/100g dry weight

<table>
<thead>
<tr>
<th></th>
<th>Quinoa</th>
<th>Maize</th>
<th>Rice</th>
<th>Wheat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>148.7</td>
<td>17.1</td>
<td>6.9</td>
<td>50.3</td>
</tr>
<tr>
<td>Iron</td>
<td>13.2</td>
<td>2.1</td>
<td>0.7</td>
<td>3.8</td>
</tr>
<tr>
<td>Magnesium</td>
<td>249.6</td>
<td>137.1</td>
<td>73.5</td>
<td>169.4</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>383.7</td>
<td>292.6</td>
<td>137.8</td>
<td>467.7</td>
</tr>
<tr>
<td>Potassium</td>
<td>926.7</td>
<td>377.1</td>
<td>118.3</td>
<td>578.3</td>
</tr>
<tr>
<td>Zinc</td>
<td>4.4</td>
<td>2.9</td>
<td>0.6</td>
<td>4.7</td>
</tr>
</tbody>
</table>

Source: Koziol (1992)
A.1. Morocco: Quinoa Value Chain

Seed yield (T/ha)

<table>
<thead>
<tr>
<th>ICBA Q1</th>
<th>ICBA Q2</th>
<th>ICBA Q5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.9</td>
<td>1.5</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Local seeds

Quinoa Rehamna
A.2. Kyrgyzstan: Development of Quinoa Value Chain

Pioneer farmer Azamat Kaseev, Kyrgyzstan

- 2.5 kg of seed sown in 1 ha → provides up to three tones of quinoa seed
- Quinoa retail price goes up to 700 Kyrgyz soms per kilogram (10 USD), while seeds can fetch up to 2,000 Kyrgyz soms per kilogram (28 USD)
B. Salicornia (sea asparagus, samphire)

Uses

Healthy benefits

- Minerals content show that Salicornia is better than asparagus. More sugar and healthy MUFA and PUFA fats; more fiber, more calcium, magnesium and manganese.
- Calcium and magnesium are good for healthy bones.
- Calcium, magnesium, potassium and chloride all are important for nerve function and impulses, muscular contraction and heart/cardiac health.
Inland integrated agri-aquaculture farms developed by ICBA

Uses:
- Halophytic Forages
- Salicornia
- Other Halophytes (mustard, quinoa)

Vegetables:

Halophytes:

Inland Modular Farm (ICBA):
- Fish Farming
- Aquabrine (Salinity 25 ppt)
- Algae Farming

Reject Brine (Salinity 25 ppt)

Desalinated Water (Salinity 0.3 ppt)

(Desalination) RO-Unit

Saline Groundwater 15ppt

WASAG The Global Framework on Water Scarcity in Agriculture

Expo Live Innovation Impact Grant Program
Develop a sustainable halophyte-based industry model in a desert environment that could be further replicated.
Halophytic dishes (2018)

- Rock samphire smoked tilapia with quinoa
- Salicornia jelly
- Salicornia juice
- Crackers of Salicornia and rock samphire
- Salicornia and rock samphire bread

Chef: Doxis Bekris
Halophytic products (2019 - 2020)

- Salicornia burger
- Salicornia cheesecake with camel milk and cheese
- Salicornia crackers
- Salicornia smoothie
- Salicornia biscuit
Halophytic Kitchen Lab Program (2019 - 2020)

https://www.emiratessoilmuseum.org/education-programs/university-programs/halophytic-kitchen-lab

...to raise public awareness on halophytes
B.2. Building Sustainable Networks and Unleashing Entrepreneurial Potential in Farming Communities living in Marginal Areas

- Development of quinoa value chain in Egypt
  - Development & implementation of business model
  - Development of a seed production unit for quinoa
  - Capacity building

- Salicornia production trials in Egypt
  - Establishment of Salicornia
  - Assessment of demand
  - Farmers’ training

- Training on integrated farming in UAE
  - Training videos translated in Urdu, Arabic for farm workers
  - Smart applications
B.2. Building Sustainable Networks and Unleashing Entrepreneurial Potential in Farming Communities living in Marginal Areas

**Quinoa**
- Quinoa trials in New Valley
- Quinoa-olive fruit paste
- Quinoa condiment mixed with herbs and spices
- Quinoa biscuits

**Salicornia** (primarily as feed)
- Salicornia trials in two locations at the Red Sea Governorate

Food For the Future II
Halophytic food products

Cosmetics products based on local Halophytes
Challenges

- Improved halophytic germplasm
- Mechanization of the harvest and seeds cleaning processes
- Customize the halophytic production on the local climatic & socioeconomic context
- Sustainability of Saline Agriculture projects (All 3 pillars)
- Creating the market segment for halophytes
- Convincing the consumers
- Training the farmers to use saline water resources sustainably

WASAG The Global Framework on Water Scarcity in Agriculture
4) Implementation of a Decision Support Tool (DST) under saline conditions. A showcase of the Mediterranean Region

Andrés Parra González

E-mail address: aparra@cebas.csic.es

Mission: To generate necessary knowledge through research to achieve the sustainability of the scant resources in semiarid areas, focusing on their proper management, making possible the development of a quality agriculture to obtain healthy and safe food
General facts at farm level

- Non-efficient irrigation systems
- Different water sources, qualities and availability
- Multiple crops under the same irrigation regime
- Limited reliance on non-conventional waters: saline, brackish, brine, reclaimed waste waters...
- Predominance of low-cost technologies
- Lack of awareness/access to modern solutions
A DST to manage different water sources

Help farmers to contrast information provided by the DST with their personal knowledge and experiences

- Examination of multiple alternatives
- Identification of unpredicted situations
- Better use of data and resources
- Reduce costs
The Excel Tool

**Input parameters**
- Water and soil analysis
- **Crop:**
  - Variety/rootstock
  - Density
  - Growth stage/age
- Irrigation method

**Output**
- Relative crop performance and recommendations:
  - Suitable stages for using different water qualities
  - Possible benefits on fruit quality
  - Toxicity hazards
- Water quality and soil structure info (SAR/CROSS)
- Fertilizer recommendations
Challenges

Several options to reduce the pressure on freshwater resources...

- Explore different scenarios through a reliable, cheap and quick way
- First stage, general information
- Next steps?
  - more crops/ varieties (site-specific)
  - more parameters (crop ET/LF/turbidity/TSS...)
  - Database up to date
  - DST app-based?
Conclusions

1. Saline Agriculture is feasible in salt-affected areas through multidisciplinary approaches
2. Tailormade and sustainable solutions
3. Proper technical cultivation practices package: improved germplasm; effective management practices and pre-/post- harvest processes
4. Developing the value chain of halophytic products is imperative
5. Raising public awareness initiatives on halophytes → create the market segment
6. Training and capacity building programs are very much needed
7. Digital technologies can facilitate the saline agriculture activities
8. Preservation & Enhancement of agrobiodiversity within saline agroecosystems
Save the date...

WEBINAR 3

Water and soil management in salt affected areas

TUESDAY 2 JUNE 2020 | 15:00 – 16:30 CET
Thank you