Salicornia bigelovii: a promising halophytic species for salinized coastal regions

Globally, soil salinity constitutes a growing problem that contributes to land degradation with approximately 7% of the earth's land surface having salt-affected soils. The process of increasing the concentration of total dissolved salts in soil and water is known as salinization. It can be caused either by natural processes such as mineral weathering and gradual seawater intrusion or by artificial processes such as irrigation. On a global scale, it has been estimated that every minute 3 ha of currently arable land becomes unproductive due to salinization. It has been quantified that about 100 mha of land have become saline due to poor irrigation management which equals to approximately 11% of irrigated areas worldwide. Soil salinization has severely affected the agricultural production in over half of the world's countries. Countries which are characterized by disproportionately high areas of saline land are Australia, Pakistan, Bangladesh, Thailand, and several countries in Central Asia. Many projects have been implemented in these countries for the rehabilitation of saline and degraded lands. Cultivation of these lands could contribute to the increase in food production to feed a growing world population, which is expected to reach 9.1 billion people by 2050 and hence global food production will need to increase by up to 70% by this time to match this growth. Scientific or technical advances that allow crop growth in saline soils could contribute to the urgently increasing food needs.

Biosaline agriculture is an effective method of reducing the impact of salinity in salt-affected lands. Glycophytes (salt-sensitive) are the majority of crops used in modern agriculture and cannot withstand salinity even at low concentrations. Breeding for salt-tolerant crops is the conventional method for developing salt resistant varieties. However, breeding traditional crops for salinity tolerance is a time-consuming, labor intensive and complicated process at plant and cellular level. Halophytes, on the other hand, constitute of plants that thrive when

Screening S. bigelovii *genotypes at ICBA research station in Dubai*

grown in hostile saline conditions, where other traditional crops cannot survive. The use of halophytes for biosaline agriculture is a promising solution, since the plants already possess the most important and difficult trait of salt tolerance, through different mechanisms. However, wild halophytes need to be domesticated and improved, so that they can be converted into viable and high yielding crops.

Salicornia bigelovii (dwarf glasswort) is a halophyte that belongs to the family Chenopodiaceae, a well-known family for its salt-tolerant species. Dwarf glasswort is an annual leafless, fast-growing, succulent halophyte with increasing scientific and social recognition as a crop due to its high salt-tolerance and multiple uses. The leaf tips of the halophyte can be consumed by human either fresh or as pickled vegetable. The fresh (green) biomass can also be used in mixture with other forages for livestock feed. *S. bigelovii* seeds have high concentrations of good quality oil (≈30%) and low salt content (<3%), characteristics that make it promising as an oilseed halophytic crop especially for biofuel purposes. Seedcake can also be used as animal feed due to its high protein contents (≈45%). *S. bigelovii* has also been proposed as a halophytic species of good commercial value for integrated aqua-agriculture systems (IAAS), since it can be grown with aquaculture effluents that serve as a source of nutrients and water for irrigation.

The International Centre for Biosaline Agriculture (ICBA) has been conducting experiments on *S. bigelovii* for the last three years at ICBA research station in Dubai, in collaborative projects with King Abdullah University of Science and Technology (KAUST), Saudi Arabia and Masdar Institute (MI) of Science & Technology, Abu Dhabi. The projects have been targeted to assess the adaptability of dwarf glasswort in United Arab Emirates (UAE) conditions and to optimize the management practices for its cultivation, trying to explore its economic potential to be grown as oilseed, fodder or vegetable crop. More than 45 different *S. bigelovii* genotypes have been screened for a large set of growth parameters under groundwater (≈20 dS/m) and seawater (≈55 dS/m) irrigation treatment.

Preliminary results indicate the potential of growing Salicornia under the conditions in Gulf Cooperation Council countries and particularly in the UAE, both for biomass and seed production. These halophytic populations constitute a valuable plant genetic material to be tested further for potential breeding programs. The next step is to move from small scale research screening to commercial/semi-commercial scale production trials that ICBA plans. Testing different irrigation systems can provide information on the irrigation

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Salicornia bigelovii *grown in ICBA research station using high salinity water*

efficiency for the crop. The ultimate aim would be to select salt-tolerant genotypes with desirable morphological and phenological traits adapted to UAE conditions, for seawater irrigation farming. Given the proper *S. bigelovii* germplasm, in combination with suitable agronomic practices, it seems that such halophytic plantations could be economically viable for biofuel, particularly aviation, as well as for biomass both as vegetable and residual fodder for livestock.

Selected Publications

Brown, J. J., Glenn, E. P., & Smith, S. E. (2014). Feasibility of Halophyte Domestication for High-Salinity Agriculture. In *Sabkha Ecosystems: Volume IV: Cash Crop Halophyte and Biodiversity Conservation* (pp. 73-80). Springer Netherlands.

Ismail S. (2005). ERITREA- Visiting *Salicornia* plantation & Manzanar Project. Client Report. 9 pp.

Panta, S., Flowers, T., Lane, P., Doyle, R., Haros, G., & Shabala, S. (2014). Halophyte agriculture: success stories. *Environmental and Experimental Botany*. 107:71-83.

Rozema, J., & Flowers, T. (2008). Crops for a salinized world. *Science*, 322(5907), 1478-1480.

Rozema, J., & Schat, H. (2013). Salt tolerance of halophytes, research questions reviewed in the perspective of saline agriculture. *Environmental and Experimental Botany*, 92, 83-95.

Ruan, C. J., da Silva, J. A. T., Mopper, S., Qin, P., & Lutts, S. (2010). Halophyte improvement for a salinized world. *Critical reviews in plant sciences*, 29(6), 329-359.

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Environmental cost and face of agriculture in the GCC countries - fostering agriculture in the context of climate change

New Publication

The recent release of the book "Environmental cost and face of agriculture in the Gulf Cooperation Council (GCC) countries - fostering agriculture in the context of climate change" edited by Shabbir A Shahid and Mushtaque Ahmed relates how the 2008 global food crisis and the sudden increase in commodity prices brought the issues of food security and sustainability of food production to the forefront in the Gulf region.

The book arises from a meeting held in July 2012 hosted by the Gulf Research Center in Cambridge. ICBA together with Sultan Qaboos University in Oman held an Agriculture Workshop at the meeting, which attracted participants from Australia, Bahrain, India, Kuwait, Oman, Saudi Arabia, Turkey, UAE, UK, and Morocco. This volume is the result of the workshop and covers topics such as, prospects of agriculture in a changing climate, potential of climate smart agriculture, protected agriculture, intensification of local agriculture production, food security, improved water use efficiency, challenges in using treated wastewater, investment in foreign agriculture, and agricultural research and development. The recommendations of the workshop have set the scene for future agriculture opportunities in the GCC countries to sustain food and nutritional security.