Prospects of Saline Agriculture in the Arabian Peninsula

Proceedings of the International Symposium on “Prospects of Saline Agriculture in the GCC Countries”

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History of Research on Salt-Affected Lands of Iran
Present Status and Future Prospects: Halophytic Ecosystems

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INTRODUCTION

Iran covers a total area of about 165 Mha in southwest Asia. Approximately 16% of the total land surface of the country is mountainous with an elevation of more than 2000 m above mean sea level. About 53% of the country has an elevation of 1000 to 2000 m above sea level (FAO, 1997). High mountains extend along the western and northern margins of the Central plateau, leaving a broad upland with an average altitude of 1500m. The main physiographical features of Iran are:

1. The Zagros mountains
2. The Alborz mountains
3. The Central plateau
4. The Caspian coastal plain
5. The Khuzestan and the Southern coastal plains

Two great deserts extend over much of the Central plateau. Dasht-e-Lut is covered largely with sand and rocks, while the Dasht-e-Kavir is covered mainly with salt. Saline and alkaline soils are expanding in arid and semi-arid regions of Iran and cover 27 Mha of the total area of the country (Le Houerou, 1993). These saline areas include: saline alluvial soils, solonchak and solonetz soils, salt marsh soils, desert soils, sierozem and solonchak soils (Dewan and Famouri, 1964). Saline ground water, the presence of a salt layer in the soil, irrigation, transpiration, the effect of wind, precipitation and river flow are the main factors responsible for soil salinity in Iran (Ghobadian, 1969, Breckle et al., 2001). Due to diverse physiographical features and climatic conditions, the halophytic communities of Iran are rich in species compared with similar communities in South Europe or
in North America (Breckle, 1983). However, the halophytic communities in Iran are still among the most poorly known vegetation units in Iran (Akhani and Ghorbani, 1993). This dearth of information can be attributed to the inaccessibility of their growing regions due to the harsh environmental conditions and a lack of interest by botanists and ecologists. Halophytes constitute a significant part of the local flora in many places and they have been grazed or browsed by animals for a long time. In many cases halophytes represent supplementary or emergency feed during unfavorable environmental conditions, since the animals graze them only when other, more desirable forages, are not available.

**GENERAL CHARACTERIZATION**

**Climate**
The climatic condition of Iran is characterised by extreme temperatures due to its geographic location and varied topography. Summers are extremely hot with temperatures over 50°C in the Central plateau; winters, because of the high altitude of much of the country, are extremely cold with temperatures as low as -30°C in the northwest (FAO, 1997). A large part of the country is characterized by a Mediterranean type climate. The average annual precipitation ranges from less than 50 mm to more than 1600 mm (Table 1). According to Le Houerou (1990), approximately 90% of the country is arid, semi-arid or hyper-arid.

**Land use**
A relatively small part (~14.4%) of the total land area was under cultivation in 1990. Rangelands and forests cover 62.4% percent of the total area, deserts, 21% and urban areas 2.2% (Table 2). Saline and sodic soils (Table 3) cover an estimated 27 Mha of the total land area of Iran.

**TABLE 1. Rainfall pattern in Iran**

<table>
<thead>
<tr>
<th>Annual precipitation (mm)</th>
<th>(km²)</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;50</td>
<td>100 000</td>
<td>6</td>
</tr>
<tr>
<td>50–100</td>
<td>285 000</td>
<td>17</td>
</tr>
<tr>
<td>100–200</td>
<td>465 000</td>
<td>28</td>
</tr>
<tr>
<td>200–300</td>
<td>370 000</td>
<td>23</td>
</tr>
<tr>
<td>300–500</td>
<td>280 000</td>
<td>17</td>
</tr>
<tr>
<td>500–1000</td>
<td>130 000</td>
<td>8</td>
</tr>
<tr>
<td>&gt;1000</td>
<td>18 000</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>1648 000</td>
<td>100</td>
</tr>
</tbody>
</table>


**TABLE 2. Land use classification in Iran**

<table>
<thead>
<tr>
<th>Type</th>
<th>Area (x10⁶ ha)</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rangeland</td>
<td>90.7</td>
<td>55</td>
</tr>
<tr>
<td>Desert, desertified and degraded</td>
<td>34.6</td>
<td>21</td>
</tr>
<tr>
<td>lands</td>
<td>12.2</td>
<td>7.4</td>
</tr>
<tr>
<td>Forests</td>
<td>23.8</td>
<td>14.4</td>
</tr>
<tr>
<td>Agricultural land</td>
<td>3.7</td>
<td>2.2</td>
</tr>
<tr>
<td>Cities, lakes, etc.</td>
<td>165</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Ganji. and Farzaneh (1990)

**TABLE 3. Areas of saline and sodic soils in the Mediterranean isoclimatic zone**

<table>
<thead>
<tr>
<th>Country</th>
<th>Area (x10⁶ ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iran</td>
<td>27.0</td>
</tr>
<tr>
<td>Iraq</td>
<td>7.0</td>
</tr>
<tr>
<td>Israel</td>
<td>0.03</td>
</tr>
<tr>
<td>Jordan</td>
<td>0.2</td>
</tr>
<tr>
<td>Kuwait</td>
<td>0.2</td>
</tr>
<tr>
<td>Oman</td>
<td>0.3</td>
</tr>
<tr>
<td>Pakistan</td>
<td>10.5</td>
</tr>
<tr>
<td>Qatar</td>
<td>0.2</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>6.0</td>
</tr>
<tr>
<td>Syria</td>
<td>0.5</td>
</tr>
<tr>
<td>United Arab Emirates</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Source: Le Houerou (1993)

**Halophytic vegetation**
The numbers of halophytic species in some of the Asian-Mediterranean basin countries are shown in Table 4. Iran has the highest number of plant species (6,170 species) when compared with countries around the Gulf and

**TABLE 4. Number of halophytes in various Asian-Mediterranean basin countries and ecozones**

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of halophytic species</th>
<th>Total flora</th>
<th>% of halophytes in the flora</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iran</td>
<td>354</td>
<td>6,170</td>
<td>5.7</td>
</tr>
<tr>
<td>Iraq</td>
<td>135</td>
<td>1,200</td>
<td>10.4</td>
</tr>
<tr>
<td>Jordan</td>
<td>260</td>
<td>2,100</td>
<td>12.4</td>
</tr>
<tr>
<td>Kuwait</td>
<td>80</td>
<td>450</td>
<td>23.0</td>
</tr>
<tr>
<td>Palestine</td>
<td>300</td>
<td>2,800</td>
<td>10.7</td>
</tr>
<tr>
<td>Qatar</td>
<td>70</td>
<td>435</td>
<td>16.0</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>250</td>
<td>2,200</td>
<td>11.4</td>
</tr>
<tr>
<td>Syria</td>
<td>280</td>
<td>3,460</td>
<td>7.5</td>
</tr>
<tr>
<td>United Arab Emirates</td>
<td>70</td>
<td>450</td>
<td>15.6</td>
</tr>
</tbody>
</table>

TABLE 5. Proportions of the various families of Iranian halophytes

<table>
<thead>
<tr>
<th>Family name</th>
<th>Percentage of total number of halophyte species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chenopodiaceae</td>
<td>28</td>
</tr>
<tr>
<td>Poaceae</td>
<td>14</td>
</tr>
<tr>
<td>Asteraceae</td>
<td>7</td>
</tr>
<tr>
<td>Brassicaceae</td>
<td>5</td>
</tr>
<tr>
<td>Plumbaginaceae</td>
<td>4</td>
</tr>
<tr>
<td>Cyperaceae</td>
<td>4</td>
</tr>
<tr>
<td>Tamaricaceae</td>
<td>4</td>
</tr>
<tr>
<td>Zygophyllaceae</td>
<td>4</td>
</tr>
<tr>
<td>Polygonaceae</td>
<td>4</td>
</tr>
<tr>
<td>Boraginaceae</td>
<td>3</td>
</tr>
<tr>
<td>Caryophyllaceae</td>
<td>3</td>
</tr>
<tr>
<td>Fabaceae</td>
<td>3</td>
</tr>
<tr>
<td>Capparaceae</td>
<td>2</td>
</tr>
<tr>
<td>Orcharlachaeae</td>
<td>2</td>
</tr>
<tr>
<td>Gentianaceae</td>
<td>2</td>
</tr>
<tr>
<td>Apiaceae</td>
<td>2</td>
</tr>
<tr>
<td>Other families</td>
<td>8</td>
</tr>
</tbody>
</table>

Source: Breckle (1986)

the eastern Mediterranean. Halophytic species comprise more than 354 species, which constitute 5.7% of the total flora in Iran (Breckle, 1986).

There are 16 major halophytic plant families known in Iran (Table 5): These encompass 92% of the 354 halophytic species identified. The ranking order of halophytic families with respect to the number of species is: Chenopodiaceae > Poaceae > Asteraceae > Brassicaceae > Plumbaginaceae > Cyperaceae > Tamaricaceae > Zygophyllaceae > Polygonaceae > other families.

RESEARCH PROJECTS CONDUCTED DURING THE LAST 35 YEARS

In total, 432 projects have been conducted on different aspects of salinity, of which 53% are on soil, 20% on water and 27% on the other aspect of salinity (Figure 1). The contributions of halophytic species to total salinity projects was 36%. On the basis of commodity, these projects were carried out on Atriplex sp., Diplachne fusca (Kollar grass), Salsola sp., Haloxylon sp., Nitraria sp., Aeluropus sp. and Salicornia sp.

FIGURE 1. Distribution of projects on different aspects of salinity (%)

REVIEW OF MAIN SCIENTIFIC WORKS CONDUCTED

Halophytic resources

Breckle (1981; 1983) studied, in Iran, the halophytes and their ion accumulation. He calculated the time-span for salt-accumulation in northeastern central Iran, within the Turan area. Breckle (1982) explained the salt cycle in general, and discussed the relationship between it and human activity in the Turan area of Iran and Afghanistan. Breckle (1986) studied the ecology of halophytes along salt gradients in Iran and Afghanistan. He stated that the halophytic communities of Iran and Afghanistan are richer in species in comparison with similar communities in south Europe or in North America. Asri (1995) determined the ion content in some halophytic species during different seasons of the year. He reported that the sodium content formed the highest dry matter of the plants followed by potassium, calcium and magnesium. Akhani and Gorbani (1993) studied the halophytic vegetation and flora of Iran. They classified the halophytic vegetation of Iran into 10 vegetation units, which belong to 73 different genera. Jafari (1994) identified saline areas and halophytes in Iran. Pabot (1967) undertook a comprehensive survey on Iranian rangelands and pasture plants. He made the first classification of land use of Iran. Based on his classification, Iran was divided into five different floristic zones. Breckle et al. (2001) reviewed the main factors, which are important to desertification all over the world. They concluded that fluvial and aeolian soil erosion, enhanced salinity by waterlogging, pollution, pesticide and other toxic materials are some of the human impacts on desertification. Boykin (1972) studied the contribution of rangelands to the economy of Iran. In an economic analysis of range reseeding costs, he mentioned that it would take up to four years before economic benefits would be experienced by the range users. Ganji and Farzaneh (1990) reviewed the desertification and sand dune stabilization projects in Iran. They mentioned that sand
dunes, an outcome of desertification in Iran, result from a long history of damage to former agricultural lands and have a significant impact all over the country. In fact, the first serious effort to check the encroachment of dune fields was initiated in 1965 on 100 ha adjacent to the village of Haresabad near the city of Sabsevar, and on two 10 ha plots near Ahwaz. Le Houerou (1975), studied some parts of the rangelands, deserts and saline areas of Iran as part of a mission for the Range Organization of Iran. He visited different parts of Iran and collected information about plant communities and basic resources. He reported that the rangeland potential in Iran was much higher than one could imagine. But careful management was needed to sustain rangeland production over time.

Chenopodiaceae
Janighorban (1993) studied the methods of propagation of a salt desert species known as *Halocnemum strobilaceum*. She stated that simple cutting at 15 cm had the best rooting and was better than heel cutting.

Fayaz and Heidari Sharif Abad (1998) studied the natural distribution pattern of *Haloxylon persicum* in relation to climatic and edaphic factors at 7 sites in Southeastern Iran (Sistan and Baluchestan). They demonstrated that the planting of *Haloxylon persicum* at low density in a region with 100 mm of rainfall and higher may be successful if supplemental irrigation is provided. The alteration of peroxidase enzyme and isoenzymes in branches and seeds of *Haloxylon ammodendron* were investigated during a complete seasonal cycle by Ali Ahmad Korori et al. (1996). Afgham-Shoara (1995) studied the distribution of different plant communities in relation to the *Haloxylon* species. He concluded that the density of the *Haloxylon* species had a positive effect on the amount of plant crown.

Nemati (1977) studied the use of the *Atriplex* species for rangeland improvement in Iran. He found that in the central plateau of Iran, the best time to transplant *A. halimus* and *A. lentiformis* was September, while for *A. canescens* the best time was October and November. In this study he mentioned that plastic bag transplantation was more successful than bare root transplanting. Based on his data, *A. canescens* was the most frequently adopted shrub species for plantation in the central plateau in comparison to *A. halimus* and *A. lentiformis*. Eskandari (1995) studied the establishment of *Atriplex* in relation to pedology. He reported that soil texture; low soil humidity and salt accumulation around the roots of *Atriplex* are the main factors that have a negative effect on plant establishment. Howeizeh et al. (1999) studied different *Atriplex* species in the arid salt-land of Khuzestan. They reported that *A. halimus* had the best combination of nutrient levels, with high protein and fat, and low ash. Regrowth and dry matter production was also highest in *A. halimus*. Ahmadi-Roknabadi et al. (2000) studied the effects of absorption and accumulation of salts in water and soil on the dying out of *Atriplex* in Chah Afzal-Kavir. They reported that an accumulation of the sulfate ion in plants was the most important factor in this process. Naseri et al. (1998) studied the interaction between *Atriplex canescens* and the environmental conditions at two different areas in Kerman province. They reported that *Atriplex canescens* grew better in Joopar than in Kabutar Khan. This may be due to the higher rainfall and water holding capacity of the soil in Joopar. Farah-Vash (1997) studied the salt resistance mechanisms of *Atriplex*. He collected different samples from different parts of Iran and then determined the optimum temperature and also the threshold of salt tolerance of the two native *Atriplex* in Arzabarjaen. Amouii and Ahmadian Tehrani (1995) studied the cariotypes of three exotic *Atriplex* (*A. canescens*, *A. halimus*, and *A. lentiformis*) in Iran. They reported the variation in the number of chromosomes and also the length of different chromosomes in these three species.

Ghorbanli et al. (1996) studied the ecophysiological aspects of *Salicornia europaea* and *Halimione verruciferum*, at Urmia Lake area. They reported that *Salicornia* has more total protein than *Halimione*, and also both shoots and roots of *Salicornia* had more ash content than *Halimione*, but both species showed similar seasonal changes in ash content.

Taheri (1998) studied the effect of salinity on the germination of *Salso lassara* and *Limonium iranicum*. She reported that high salinity reduced the germination percentage of *Salso lassara*, but low salinity increased it. She added that salinity inhibits the germination of *Limonium*.

Poaceae
Malcolm (1971) reported that *Puccinellia distans* occurs naturally with *Atriplex verrucifera* and *Camphorosma perenne* on sandy loam to sandy clay saline flats in Northwest Iran.

Hossieni (1998) studied the autecology of *Puccinellia distans* in the Gilan and Dasht regions. He reported that *Puccinellia distans* occupied more than 100,000 ha of the Gilan and Dasht regions. He added that *Puccinellia distans* is a halophyte which can produce about 900 kg of biomass per ha per year. Abarsaji (2000) studied some of ecophysiological characteristics of *Aeluropus spp.* in the saline and alkaline rangelands in the north of Gorgan, Iran. He reported that the best temperature for germination of both species of *Aeluropus* was 25–30°C.

Zygophyllaceae
Moshaghi and Esmaili Sharif (1997) studied the effects of water salinity on the germination and seeding growth of *Nitraria schoberi* in three different provinces. They reported that germination was reduced by increasing EC, but did not show any significant effect on germination up
to 8 dS/m. They added that significant variations were found between the provinces. Karimi and Arzani (1998) studied the most suitable collection time for *Nitraria schoberi* seed in the Myghan desert region. They reported that the most suitable time for *Nitraria schoberi* seed collection is when the humidity level is 20–25%, because in such conditions the highest level of germination will be achieved. Rezaie and Malakutei (1994) studied the effect of salinity on the yield of *Nitraria* and *Atriplex* in the Migan Kavir, Arak. They found that *Nitraria* was more sensitive to the types of salts and the degree of salinity, and also that this species can survive better than *Atriplex* in areas where Na₂SO₄ occurred. Rezaie (1993) compared the effects of different concentrations of salinity on *Nitraria schoberi* and *Atriplex* spp. establishment. He reported that, while salinity decreased the early growth and dry matter yield of both species, *Nitraria schoberi* was more sensitive than *Atriplex*.

**Soil and water resources**

Asri (1996) studied some halophytic species in terms of water, ash and inorganic content. He reported that annual halophytes have higher water content than perennials. He added that different halophytic species had different amounts of ash and inorganic content, but, compared with non-halophytic species, the halophytes have more ash and inorganic content.

Kowsar (1991) studied the utilization of floodwaters for stabilizing the moving sands by sedimentation of the suspended load while recharging an empty aquifer with a potential volume of 100 million m³. He used eight different floodwater systems for planting some seedlings of salt tolerant species such as *Eucalyptus camaldulensis*, *Acacia cyanophylla*, *A. salicina*, *A. victoriae* and *Atriplex lentiformis*. He stated that floodwater spreading has dramatically changed the appearance of the study area. Nemati (1977) evaluated the problems of rehabilitation of the steppic zone in Iran by summarizing some ecological factors affecting vegetation growth and recommending suitable techniques.

Guitti (1996) studied the effect of different kinds of afforestation on soil salinity. He demonstrated that *Tamarix* and *Atriplex* plantations are effectively useful in decreasing the salinity of surface soil.

Djavanshir et al. (1996) studied the ecological characteristics of *Haloxylon aphyllum*, *H. persicum*, *Petropylum euphratica* and *Tamarix aphylla* in Iranian deserts. They put forward some recommendations for the choice of species for plantations in relation to soil texture and salinity, water table and climate.

Asri (1993) studied the effect of physical factors on the distribution of halophyte communities in the area of Lake Oromieh. He mentioned that edaphic factors are the most important for the establishment of plant communities in the region around the lake. Mohajer-Milani and Javaheri (1998) studied the water requirements for the reclamation of salt affected soils in different parts of Iran and for different crops.

**Halophytes as Forage**

Koocheki (1996) reviewed the use of halophyte species for animal feed and for combating desertification in Iran. He concluded that although halophytes constitute a substantial proportion of the total flora of Iran, little has been done regarding their utilization and potential uses. Koocheki (2000) reviewed the potential of saltbush (*Atriplex spp.*), as a fodder shrub in the arid lands of Iran. Koocheki and Mohalati (1994) studied the nutritive value of 12 halophytic range species from the arid regions of Iran. They stated that, under the harsh conditions in the salt affected areas of Iran, halophytic species produce a large quantity of forage, which can be used as animal feed.

Tork Nejad and Koocheki (2000) evaluated the economic aspects of fourwing saltbush (*Atriplex canescens*) as a forage source, and hence for meat production, in Iran. They estimated the total investment per hectare over a 10 year period at US$200 /ha, however, the net annual income from one hectare of *Atriplex* plantation can be as high as US$200.

**FUTURE RESEARCH PRIORITIES**

Halophytes are predominant in rangeland communities in saline areas. A close relationship between livestock herds and halophytic communities as a fodder source has been established, but this has not been properly utilized on a large scale. However, at the local level, the use of halophytes for different purposes, such as feed, industrial use, household use, etc., is well established in salt affected areas. Therefore, the following activities should be prioritized in order to make better use of these halophytes on a larger scale:

- proper land surveys related to a better evaluation of present halophytic plant communities
- updating plant classification for better identification of these plants.
- re-evaluation of present plant propagation methods and adaptation of new technologies for effective propagation of these plants.
- better utilization of halophytes as food, feed, fiber and medicinal plants, based on new technologies.
- provision of national gene banks and halophytic botanical gardens for preservation of these genetic resources.
• evaluation of the feeding value of halophytic range plants for the better adaptation of these plants in degraded rangeland, and

• recognition of the medicinal potentials of halophytic species.

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