

Halophytic fodder

for an extreme saline-sodic ecosystem of arid and semi-arid regions

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Saline and sodic ecosystem represents one of the major ecosystems of land having an excess amount of salts in arable land. Halophytes are the plants that can tolerate salt concentration ranging from 500–100 mm NaCl (sodium chloride). One of the greatest potentials of halophytes probably rests in their utilization as forage and fodder. These palatable halophytes are nutritiously suitable to the animal. However, very few literatures are available on the palatability of these fodder resources. The studies on the nutritional quality of halophytes at ICAR-Central Arid Zone Research Institute, RRS-Bhuj, revealed that wide variation in proximate composition exists in different halophytes. Some of the common palatable halophytes found in arid Kachchh are Suaeda nudiflora, Aleuopus lagopoides, Sporobolus marginatus, Cressa cretica. These palatable halophytes can successfully be cultivated in the saline ecosystem. Detailed studies must be conducted to harvest their potential as a dryland fodder resource in arid saline soils.

Keywords: *Aleuopus lagopoides, Cressa cretica, Halophytes, Salinity, Sodicty*

SALINIZATION is one of the most serious degradations affecting plant growth and productivity, especially in arid and semi-arid areas where rainfall is insufficient to leach down excess salts out of the rhizosphere. Globally salt-affected soils occupy about 952 m/ha under the various degree of salinization. In India, about 6.73 million ha (mha) of land is affected by the salt problem. The maximum area of salt-affected soils occurs in Gujarat (2.22 mha), followed by Uttar Pradesh (1.37 mha) and Maharashtra (0.61 mha) which account for about 62.4% of the total salt-affected areas in the country. The salt-affected areas are expected to increase further with the spread of waterlogging and salinity due to an increase in canal irrigation and intensive exploitation of poor quality groundwater for irrigation. The estimate by ICAR-Central Soil Salinity Research Institute, Karnal indicates that by 2030, the country

may have about 15.5 mha areas under salt-affected soils. Salt affected soils are agriculturally unproductive because of the high contents of either soluble or exchangeable sodium, calcium or magnesium primary in the form of chloride and sulphate which have harmful effects on plant growth due to moisture stress and toxicity of some of the ions. In arid regions, saline soils may have an excess amount of boron, fluoride and nitrates. The growing human population and increased demand for food and feed put pressure on limited land resources and more and more degraded lands like saline ecosystem are being utilized for unproductive crop production. Therefore, restoring the productivity of saline lands is important not only to reduce the pressure on productive lands but also to produce sufficient food and fodder to fulfill the demand of the ever-increasing population. In general, most of the field crops are sensitive to excess salts resulting

in uneconomical crop production. However, certain vegetation which grows naturally in the saline ecosystem has salt tolerance even for more than the salt concentration of seawater. This vegetation is called halophyte and has the potential to be grown as food, feed and industrial crops on soils where no field crops are grown.

Prospects of using halophytes as fodder

Halophytes survive an extreme saline environment by developing mechanisms to overcome water deficit in the root zone arising from low water potential, ion toxicity and nutrient imbalance, and form predominant vegetation in the saline ecosystem. One of the greatest potentials of halophytes probably rests in their utilization as forage and fodder, besides other uses as food, oilseeds and industrial crops. This is particularly relevant to arid and semi-arid regions where the halophytes are most abundant and

the livestock population is high. The field studies carried out at ICAR-Central Arid Zone Research Institute, Bhuj, Gujarat established that halophytes that are palatable to the animal can successfully be grown as fodder in the extreme saline ecosystem.

Mechanisms for salt tolerance in halophytes

Halophytes are the plants that can survive in an extremely saline environment through various mechanisms that include ion compartmentalisation, salt exclusion or excretion, production of metabolites and genetic control. Higher concentration of ions, especially sodium and chloride are detrimental to the plant cell. Therefore, halophytes compact them in different plant parts. Firstly, they do not allow these ions to be absorbed by the roots. Then, if absorbed through selective translocation, these ions are stored in a differential amount in different parts, less in leaf and more in roots. Some halophytes often possess large vacuoles for storing these ions. For example, *Suaeda maritima*, a potential halophyte, occupies 77% of the mesophyll cells of vacuoles which makes it capable of accumulating a higher concentration of salt, as much as 500 mM. Although all of the halophytes exhibit better accumulation of salt, the level of total salt accumulation in the shoot is mostly species-specific, depending on different adaptive strategies.

Among several special characteristics related to the physiological adaptation of halophytes, salt excretion is one of the most efficient mechanisms that prevent excessive concentrations of salts from building up in photosynthetic tissues. Some of the halophytes possess multicellular salt glands and salt hairs; those are common in many halophytes such as *Cressa* and *Suaeda* species.

For osmotic adjustment, the accumulation of inorganic salts and compatible solutes are often regarded as the basic strategy for the protection and survival of halophytes under salt stress.

Inorganic salts include chloride and sulphate of sodium, potassium and magnesium. Very often, the ratio of sodium to potassium exceeds 10 in dicot halophytes, whereas, it is one or less than one in monocot halophytes. In dicot, sodium replaces the role of potassium in a plant cell. The soluble compounds include soluble carbohydrates, proline and polyols. Based on the different mechanisms of adaptation to salty condition, halophytes have been classified into 3 types, viz. (i) salt excluding, (ii) salt excreting and (iii) salt accumulating.

Salt excluding: In these plants, the root system possesses an ultrafiltration mechanism and this characteristic leads to the establishment of such species as the dominant component of the mangrove vegetation. Example: *Salicornia* species, *Avicennia* species, etc.

Salt excreting: These plants regulate internal salt levels through foliar glands. Example: *Avicennia* species, *Urochondra setulosa*, *Cressa cretica*, etc.

Salt accumulating: These halophytes accumulate high concentrations of salt in their cells and tissues and overcome salt toxicity by developing succulence. Example: *Suaeda* species, *Cressa cretica*, etc.

Major halophytes as palatable fodder

The halophytes are the vegetation that grows and completes their life cycle at very high salinity levels. The common halophytes growing on the saline ecosystem are *Urochondra setulosa*, *Aeluropus lagopoides*, *Sporobolus marginatus*, *Sporobolus helvolus*, *Suaeda nudiflora*, *S. fruticosa*, *S. maritima*, *Cressa cretica*, *Avicennia* spp, *Salvadora persica*, *Salvadora oleoides*, *Salicornia* spp, *Salsola* spp and *Cyperus bulbosus*. Based on fodder production, nutritious quality and easiness in planting, the major palatable halophytes identified at Central Arid Zone Research Institute, Bhuj, Gujarat are *Suaeda nudiflora*, *Cressa cretica* (both dicots) and *Aeluropus lagopoides* and *Sporobolus marginatus* (monocots). These halophytes are

naturally grazed by cattle, buffalo, sheep, goat and camel in Banni grassland of Kachchh region of Gujarat. On inquiry, the local people told that when buffalos feed on *Suaeda nudiflora*, fat content in milk increases considerably. The details of these palatable halophytes are given as:

***Suaeda nudiflora*:** This is dicot halophyte having crude protein content of about 14%. Locally it is known as Khari grass. Three species namely, *S. nudiflora*, *S. fruticosa* (both in dry and saline ecosystem) and *S. maritima* (in sea-shore) have been observed in Banni area of Gujarat. Their leaves are swollen and contain more water than the other parts. This species is grazed by camel, sheep, goat and buffalo. Na: K ratio in leaf ranges from 10–18 whereas in root it ranges from 3–5. This halophyte can be planted either through seed or root-slip by adopting row to row spacing of 60 cm. Dry fodder yield ranges from 3–5 t/ha. This halophyte was observed to be growing well in the salinity level even up to 80 electrical conductivity (EC) of soil.

***Cressa cretica*:** This is also a dicot halophyte having crude protein content from 12–14%. In this halophyte, leaf proportion is higher than branch parts. This is grazed by cattle, buffalo, camel, goat and sheep. However, it is palatable only up to 45–60 days after planting, after that, salt content in leaves increases in higher quantity and animal can not feed on it. Na: K ratio in leaves ranges from 5–10. At a later stage of crop growth, salt particle excreted by leaf glands is seen on the tip of the leaves. It can be planted through seed only by adopting 30–45 cm spacing between the rows. This halophyte yields about 2–3 t/ha of dry fodder. *Cressa cretica* fares well in a salinity range of 20–40 electrical conductivity of soil.

***Aeluropus lagopoides*:** This is a monocot halophyte contains about 7–8% crude protein. This is non-salty fodder and is grazed by cattle, buffalo, sheep, goat and camel. The Na: K ratio in the leaves ranges from 0.2–0.3 and is always less than 1. This can be planted either through seed or root slip/stem cutting by



Suaeda nudiflora



Cressa cretica



Aeluropus lagopoides



Sporobolus marginatus

Palatable halophytes grown at ICAR-Central Arid Zone Research Institute, RRS-Bhuj, Gujarat

adopting a row to row spacing of 45–60 cm. The dry fodder yield ranges from 3–4 t/ha. This halophyte was observed in good growth in the salinity range of 40–80 electrical conductivity of soil in Kachchh region of Gujarat.

***Sporobolus marginatus*:** This is a monocot halophyte with a crude protein content of 6–7%. It is highly palatable, non-salty grass and is grazed by almost all animals. The local people in Kachchh region call it *Meethi ghas* (sweet grass). The Na:K ratio in the leaves ranges from 0.2–0.3, whereas in the root it ranges from 0.6–0.8. It can be planted either through seed or root slip by adopting a spacing of 60 cm of the row to row. Its dry fodder yield ranges from 3–5 t/ha. The halophyte was found to be grown in a soil salinity level of 30–40 electrical conductivity of soil.

Nutritional quality of halophytes

Crude fiber ranged from 18.2% in *S. nudiflora* to 28.1% in *A. lagopoides*. The halophyte forages contained high levels of ash (14.7–37.7%) and silica (1.9–8.5%), which could limit intake and digestibility of halophyte as forages. The sodium (Na) and phosphorus (P) contents in most of the halophyte forages were more than the recommended dietary level for cattle. Among the halophytes, *Cressa cretica* and *Suaeda nudiflora* could be

a potential source of crude protein and minerals for livestock fed on low-quality roughages. However, anti-nutritional factors in halophyte fodder associated with a high saline environment have to be investigated for integrating these resources in animal feeding schedule.

Major agronomic practices (sowing, spacing, fertilizer, yield):

The monocot halophytes tolerate soil salinity even up to electrical conductivity (EC) of 80 dS/m, while dicot halophytes tolerate a moderate

salinity up to EC of 20–40 dS/m. While monocot halophytes namely, *S. marginatus* and *A. lagopoides* can be grown either through seed or through root-slip, dicot halophytes (*Suaeda nudiflora* and *C. cretica*) should be grown only through seed. The halophytes should be planted after the first rainfall in July so that surface salt on the soil may leach down to the sub-surface, facilitating satisfactory germination of the seeds. A row to row spacing of 45 cm for *C. cretica* and *A. lagopoides* and 60 cm for *Suaeda nudiflora* and *Sporobolus marginatus* should be adopted. In monocot halophytes about 100 kg N/ha should be top-dressed after 45 days of the planting when sufficient soil moisture is available in the root zone (Table 1). However, no response to phosphatic fertilizer on growth and fodder yield was observed. In dicot halophytes, no fertilizer application is required.

Harvesting of halophytic fodder

These halophytes can be either grazed by the animal directly on the field or can be cut and stored for future use. However, studies on nutritional quality revealed that ash and silica contents increase in the halophytes towards the maturity stage. In *C. cretica*, salt content in leaves increases after 45–50 days of



Feeding of livestock on halophytes grown in Banni grassland, Gujarat

Table 1. Response of monocot halophytes to nitrogen on forage yield

N Fertilizer (kg/ha)	<i>Sporobolus marginatus</i>		<i>Aeluropus lagopoides</i>	
	Green fodder (t/ha)	Dry fodder (t/ha)	Green fodder (t/ha)	Dry fodder (t/ha)
0	4.05	2.12	3.21	2.18
50	5.13	3.48	3.55	2.43
100	6.25	3.93	4.65	3.56
150	6.06	3.87	5.13	3.55

planting and may result in the non-palatability of the fodder. Therefore, the best time for grazing or cutting is 50–60 days after planting. Under best agronomic practices, halophytes yield about 3–5 t/ha of dry fodder.

Large area field demonstrations

A large area (0.10 ha) field demonstration on 3 farmer's fields of Kachchh district of Gujarat was organized during 2019–20. *Sporobolus marginatus* was planted through root-slip by adopting a row to row spacing of 60 cm in the month of July after the first rainfall. The soil was saline-alkaline with EC of 24.5 dS/m and pH of 9.5. The halophyte grew luxuriously and was harvested after 60 days of planting. On average, the halophyte produced 5.6 tonne/ha of green fodder and 3.27 t/ha of dry fodder (Table 2).

Table 2. Fodder production under the farmer's field (2019–20)

Farmer	Height of main axis (cm)	Green fodder (t/ha)	Dry fodder (t/ha)
Farmer I	77.8	6.14	3.68
Farmer II	65.8	5.77	3.46
Farmer III	85.8	5.05	2.66
Range	65.8–85.8	5.05–6.14	2.66–3.68
Mean	76.47	5.65	3.27

SUMMARY

The saline-sodic ecosystem is one of the major ecosystems of arable land. About 6.77 million ha area of the country is affected by various degree of salt accumulation. This area is expected to even increase further in near future, exerting more pressure on already limited cultivational land. Normally, field

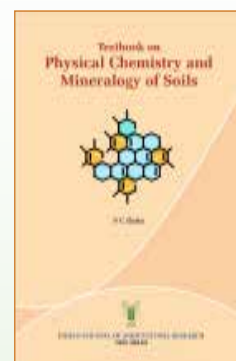
crops are highly sensitive to salt concentration and produce a highly uneconomical yield. However, halophytes, tolerant to higher salt concentrations can be very well cultivate on saline-sodic soils. Field studied carried out at Central Arid Zone Research Institute, Bhuj, Gujarat, stated that some of the palatable halophytes having good nutritional qualities can be cultivate as fodder crop even in the salinity level of 80 EC of the soil. However, before these halophytes are included in the regular diet of the animal, some more studies, especially on anti-nutritional factors need to be studied so that suitable management strategies can be formulated for feeding the animal.

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Textbook on Physical Chemistry and Mineralogy of Soils

Physical chemistry of soil and soil mineralogy are the two pillars which form the basic foundation of soil science. Once the students become familiar with these basic concepts, they can easily understand the other properties of the soil, say physical and biological properties, pedology and soil fertility. To become an expert of soil fertility, comprehensive knowledge of all the soil properties is essential which in turn is supported by the knowledge of physical chemistry of soils and soil mineralogy.

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TECHNICAL SPECIFICATIONS

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