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The potential of salt-tolerant plants for utilisation of saline water

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ABSTRACT - Populations in developing countries are growing so quickly that land and water are unable to sustain them. In most developing countries, prime farmland and fresh water are fully utilized. Although irrigation can be employed to bring land in arid areas into production, it often leads to salinization. The global importance of salt-affected soils can be explained by their wide distribution on all continents, covering about 10% of the total surface of dry land. Salt-tolerant plants, therefore, may provide a sensible alternative for many developing countries. In some cases, successful rehabilitation of degraded land is usually preferable, in terms of resource conservation, to opening new land. Groundwater too saline for irrigating conventional crops can be used to grow salt-tolerant plants. Even the thousands of kilometers of coastal deserts in developing countries may serve as new agricultural land, with the use of sea water for irrigation of salt tolerant plants. These plants can be grown using land and water unsuitable for conventional crops and can provide food, fuel, fodder, fibber, resin, essential oils and pharmaceutical products and can be used for landscape reintegration. This paper will cover the experiences and opportunities of the agricultural use of saline land and water. The goal of this review is to create greater awareness of salt-tolerant plants, their current and potential uses, and the special needs they may fill in developing countries.

Key words: halophytes, salt tolerant plants, saline water

RESUME - *Les populations des pays en voie de développement augmentent si rapidement que les terres arables et les ressources en eaux disponibles ne sont pas suffisants pour les maintenir. Dans la plupart des pays en voie de développement, les terres agricoles fertiles et les ressources en eaux disponibles sont sur-utilisées. Si l'irrigation permet de produire dans certaines régions arides, ceci entraîne généralement des problèmes de salinisation des sols. On peut expliquer l'importance globale des sols salines par leur distribution sur tous les continents, constituant environ 10% de la surface totale des terres. Les plantes tolérantes aux sels peuvent, donc, être une alternative raisonnable pour beaucoup de pays en voie de développement. Dans certains cas, la réhabilitation de terres dégradées est souvent préférable, en termes de conservation des ressources, à l'exploitation de nouvelles terres. Les eaux trop salines pour l'irrigation des cultures classiques peuvent servir à cultiver des plantes tolérantes aux sels. De même les milliers de kilomètres de déserts du littoral des pays en voie de développement peuvent être valorisés comme terres agricoles en utilisant des eaux de mer pour irriguer des plantes halophytiques. Ces plantes peuvent pousser sur des terres et avec des eaux qui ne peuvent servir pour la production des cultures conventionnelles et peuvent produire des graines; des combustibles, des fourrages, des fibres, des résines, des huiles essentielles et des produits pharmaceutiques et peuvent être utilisé pour la réintégration du paysage. Ce document traitera des expériences et occasions pour l'utilisation agricole des terres et eaux salines. Le but de cette revue est de faire mieux connaître les plantes tolérantes aux sels, leur utilisation actuelle et potentielle, et les besoins spécifiques auxquelles elles peuvent répondre dans les pays en voie de développement.*

Mots-clés: *halophytes, plantes tolérantes aux sels, eau saline, salinité*

INTRODUCTION

Salinity is reported to affect about 1 billion hectares (Szabolcs, 1992), mostly located in arid and semi-arid regions (Table 1). It is estimated that 20 million hectares of land deteriorate to zero or negative productivity each year in addition to that already affected (Malcolm, 1993). Saline soils of various nature and degree occupy over 80 million hectares in the Mediterranean basin (Hamdy, 1995). This situation is not only being made worse by further land deterioration but also by population increase.

Finding ways to make marginal land and saline wasteland productive will permit better quality land to be farmed in more rational ways and lessen the risk of degradation.

In recent years, it has been demonstrated that revegetation of saline habitats with halophytic species is profitable and provides many additional benefits (Marcar et al., 1993). There are about 6000 species of terrestrial and tidal halophytes in the world and 700 species in the Mediterranean climate area (Le Houérou, 1991). In general, these species are neglected and usually considered impediments rather than opportunities for agricultural development.

Increased research on the selection of halophytic species of economic uses, with appropriate management, could result in the rehabilitation and revegetation of salt-affected land and the use of marginal water.

The decreasing availability of fresh water for agricultural use, while the need for production of food and fuel from plants is increasing, is a problem common to many areas in the world. This dilemma requires the increasing use of lower quality or saline water for crop production.

Fortunately, there are abundant sources of such water that could be used for irrigating crops. However, the salinity of those water sources typically exceeds the limit tolerated by conventional crop plants. The standard approach to this problem is to increase the salt tolerance of cultivated or domesticated plants, but the gains come slowly. Furthermore, there are reasons to believe that we may be approaching the upper limit to salt tolerance in many of our present crops. The alternative approach to the problem is to make use of those plants (halophytes) that have high tolerance for salinity. The requisite complex of characteristics necessary for salt tolerance is already present, and all that is needed is to improve the characteristics necessary to make desirable crop plants out of them.

Within the past decade, substantial progress has been made in evaluating halophytes for their potential use as crop plants (Aronson, 1985; O'Leary, 1988; Malcolm and Pol, 1986; Le Houérou, 1979, 1985 and 1986). Large collections of halophytes from all over the world have been assembled in Israel, Arizona, Australia and Pakistan, and many of them have been screened for salt tolerance and nutritional value. Several of them have been found to be both highly productive when irrigated with highly saline water and to have high nutritional value for use as forage (O'Leary, 1986). However, there are differences in each of these features depending on where the plants are grown and the salinity of the water used for irrigation (O'Leary et al., 1985; Watson et al., 1987). Thus, it is important that, while the utility of halophytes has been clearly demonstrated in principle, the actual use of halophytes for a particular purpose has site-specific requirements.

Furthermore, now that the long-held assumption that there was a biological constraint to use of highly saline water for plant production has been seriously weakened if not disproven, the physical limits to use of highly saline water become more recognizable. Now that we start thinking about actually using highly saline water to grow crops, attention must be given to the proper soil/water management practices required to prevent salinization of the land or other harmful side effects. Unfortunately, this area has not received enough attention yet.

***Table 1** - Distribution of salinity and alkalinity in countries mainly affected.*

Country	Solonchak	Saline phase	Solonetz	Alkaline phase	Total
North America					
Canada		264	6974		7238
U.S.		5927	2590		8517
Mexico & C. America					
Cuba		316			316
Mexico	242	1407			1649
South America					
Argentina	1905	30568	11818	41821	85612
Bolivia		5233	716		5949
Brazil	4141		362		4503
Chile	1860	3140		3642	8642
Columbia	907				907
Equador	387				387
Paraguay		20008	1894		21902
Peru	21				21
Venezuela	1240				1240
Africa					
Afars & Issas Territory	59	1682			1741
Algeria	1132	1889		129	3150
Angola	126	314	86		526
Botswana	1131	3878		670	5679
Chad	2417		3728	2122	8267
Cameroun				671	671
Egypt	3283	4077			7360
Ethiopia	319	10289		425	11033
Gambia		150			150
Ghana	200			118	318
Guinea		525			525
Kenya	3501	909		448	4858
Liberia		362	44		406
Libya	905	1552			2457
Madagascar	37			1287	1324
Mali		2770			2770
Mauritania	150	490			640
Morocco	42	1106			1148
Niger			111	1378	1489
Nigeria	455	210		5837	6502
Portuguese Guinea		194			194
Rhodesia				26	26
Senegal	141	624			765
Sierra Leone		307			307
Somalia	1043	526	3754	279	5602

***Table 1** - contd.*

Country	Solonchak	Saline phase	Solonetz	Alkaline phase	Total
South West Africa	562		1751		2313
Sudan		2138		2736	4874
Tanzania		2954		583	3537
Tunisia	990				990
Zaire		53			53
Zambia	2924			863	863
South Asia					
Afghanistan	2979	177			3101
Bangladesh		2479			3017
India	24317	20243		574	23796
Middle East	6679				
Iran	28	1582		686	27085
Iraq	74	47			6726
Israel	209				28
Jordan	290	106			180
Kuwait	1103				209
Muscat and Oman	225				290
Qatar		9353			10456
Sarawak	6002				225
Saudi Arabia	180	1538			1538
Sri Lanka					6002
Syria	1089	20			2002
Trucial States		532			532
Turkey					1089
North and Central Asia	7307				
China	3728			437	2500
Mongolia		28914			36658
Solomon Island	11430	342			4070
U.R.S.S.		238	30062	89566	238
Southeast Asia		39662			170720
Indonesia					
Cambodia		13213			13213
Malaysia		1291			1291
Thailand		3040			3040
Viet Nam	16567	1456			1456
Australasia		983			983
Australia			38111	301860	
Fiji		702			357240
		90			90

Source: Szabolcs, 1989
Note: Areas in 1000 ha

It has now been established that there are some feasible potential roles for halophytes for economic agricultural use of salt-affected wasteland using halophytic species (O'Leary et al., 1985; Aronson, 1989; Qureshi et al, 1993; Marcar et al. 1993; Malcolm, 1993). There are major problems to be overcome to determine and select the best species and ecotypes to be used in the vast areas of degraded salt-affected soils around the world. A comprehensive survey of the halophytic vascular plants of the world (Aronson, 1989) reveals that more than 1500 species of true halophytes occur in saline coastal environments and desert interiors. Many of them are useful, beneficial and it is economically feasible to irrigate them in saline environments, if the proper management methods are developed, particularly for soil related problems which represent the major limitation. This paper will focus on the possible uses of halophytes, and species that may be suitable for economic production in saline environments. We will also touch on some practical methods for the establishment of halophytic species and problems to be overcome in order to domesticate them.

HALOPHYTE USE AS FODDER

Halophytes are naturally adapted to vast areas of salt-affected range lands (Le Houérou, 1992; Wilson, 1992) and they have been grazed or browsed by animals for a ong time. Halophytic grasses, shrubs and trees are all potential sources of fodder. The genus *Atriplex* includes 48 species and subspecies in the Mediterranean basin, and at least 5 of them could be used as forage shrubs (Le Houérou, 1992). Surveys of natural vegetation in many parts of the world (Qureshi et al., 1993; Batanouny, 1992) have shown that several halophytic species are grazed by animals. However most of them are at present largely undomesticated. Interest in the introduction of halophytic fodder shrubs to agriculture in different countries appears to have risen in the last few years, particularly in developing countries with arid and semi-arid climates. There has even been an increase in awareness of the needs for productive vegetation on saline land among researchers, extension services, and agricultural administrations. The use of halophytes in dryland/rain fed applications will be extensively reviewed in this volume, by others. The outstanding research and technology in Australia to develop *Atriplex* spp. for use in saline areas has now been transferred to Pakistan and India to be applied to the vast areas of degraded salt-affected soils in those countries (Qureshi et al., 1993; Malcolm 1992).

Forage production from salt-affected waste-land in Australia has been reviewed elsewhere (Runciman, 1986). Valuable production has been obtained from salt-affected land through the establishment and use of salt tolerant plants as forage for sheep and cattle. The choice of species for planting at a site depends on the purpose of the revegetation, the severity of salinity, the waterlogging, and the climate. Several grasses and forbs (*Paspalum vaginatum, Paspalum dilatatum, Puccinilia ciliata* cv. *Menemen, Thinopyron elongatum*, and *Trifolium fragiferum*) are very useful pastures species suited to high and mildly salt-affected lands. The most promising shrub species for Australia were *Maireana brevifolia, Atriplex amnicola, A. undulata, A. barclayana*, and *Halosarcia* spp. It is essential that the plant chosen for revegetation should be useful for grazing or multiple cutting, and capable of recovering and maintaining a productive stand under regular use. Grazing studies on *Atriplex* spp. and *Maireana* spp. in Western Australia have shown that forage production can be obtained, and this forage has a useful function in the farming system (Malcolm, 1993). Economic studies indicate that farmers are making money from saline wasteland (Salerian et al., 1987). This technology has proven to be successful also in Pakistan where provenance trials and establishment studies using *Atriplex* and *Maireana* species, have demonstrated a great potential for supporting livestock on wasteland to fill the winter feed gap.

In Chile, forage production from salt affected wasteland was based on the use of *Prosopis tamarugo* and *P. chilensis* in the rainfed area and *Trifolium pratense* cv. *quinqueli* and *T. fragiferum* under irrigated conditions (Squella, 1986). The *Prosopis* species have a high ash content which limits their palatability especially for goats. They have a nutritive value and digestibility of a moderate quality hay, and can be used as feed for livestock provided a supplement is added. Animals eat leaves and fruit either from ground or by browsing.

In Pakistan, on saline soil, the most productive perennial grasses were *Diplachne fusca*, *Echinochloa crusngalli* and *Cenchris ciliaris* (Kernick, 1986).

The introduction of Distichlis spicata in the area of a dry salt lake outside Mexico city reduced windblown dust while serving as forage for cattle (Llerena, 1993). Grown on 20000 hectares of salt flats, this may be among the world's largest areas devoted to an introduced halophyte.

In the western San Joaquin Valley in California (USA), studies have shown that *Atriplex* sp., particularly *A. barclayana* offer a variety of desirable agronomic characteristics as irrigated forage crops using high salinity drainage water (Watson, 1991).

In Asiatic Russia, *Kochia prostrata* is used for browse, and well adapted to arid areas and does well on saline/alkali soils (François, 1986).

In field trials conducted in highly saline sodic soils in the province of Naklon Ratchasima and Mahasarakan in northeast Thailand, *Sporobulus* sp. demonstrated a great tolerance to salt (Yuvaniyama et Arunin, 1993). *Sporobulus virginicus* showed a great recovery after salt damage and has great promise as a forage crop in affected soil of northeast Thailand.

Halophytes, particularly *Atriplex* species have been introduced into many Mediterranean areas specifically for the purpose of increasing forage productivity and rehabilitating these depleted Mediterranean rangelands. Several field projects and programmes in Algeria and Tunisia (Le Houérou, 1975), Morocco (Choukr-Allah, 1991) and Libya (Le Houérou, 1991) have evaluated species suitable for increasing fodder production under dry and irrigated conditions on a range of soil types. *Atriplex nummularia, A. halimus*, and *A. lentiformis* have a good tolerance to drought and salt and are well established in the Mediterranean Basin.

The most important exotic species planted on a large scale in the Mediterranean countries (Spain, Libya, Morocco, Algeria, Tunisia and Egypt) is *A. nummularia*. Several thousand hectares in North African countries have been planted to *Atriplex* spp., their contribution to animal feeding varying with site and agromanagement practices (Le Houérou, 1991).

On saline/alkali soils in Tunisia, with EC_e values about 20 dS/m and annual rainfall of 400-600 mm, sowing of local cultivars of perennial grass *Fertuca elatior* and *Trifolium fragiferum* have been successful and produced good forage yields (Kernick, 1986).

In Libya, several thousand hectares of mixed stands of *Acacia saligna* syn, *A. cyanophylla* and *Atriplex canescens* have been established in large fenced areas to provide supplementary grazing in autumn and spring.

It appears then that the list of halophytic species to be used as forage and which can be grown on saline soils in semi-arid and arid areas is quite large. The extension of these forage plants into farming practice will depend on their compatibility with the current land use system, on farmer acceptance and on the provision of adequate incentives to encourage pasture and forage crop production. Therefore, farmers and pastoralists will need to become more directly involved in the planning and implementation of pasture and forage crop development programmes.

PRODUCTIVITY OF FORAGE HALOPHYTES

Feeding systems in several developing countries, characterized by a pre-Saharan climate, are exclusively on open range feed resources since supplementary feed is rare. These natural halophyte ecosystems are usually considered to have low productivity. In the Mediterranean regions, stands of *Atriplex halimus* subsp *schweinfurthii* in moderately saline depressions may have a productivity of 0.5 to 5 t DM/ha/yr of forage (Le Houérou, 1985). The reported annual productivity of halophyte communities varied from 0.5 to 9 t/DW/ha. The variability in productivity is related to the growing environment including ecological conditions of soil and climate and management applied. Palatable biomass of *A. nummularia* planted in the southern part of Morocco averaged about 0.5 t DM/ha/yr (Tazi et al, 1991). This low productivity is mainly related to the water availability and soil depth. In addition, the average precipitation in these areas is 70 mm/year. As a consequence hundreds of hectares of *A. nummularia* are dying after a period of five years. Higher yields were reported in Australia and Pakistan where annual precipitations are between 400 to 500 mm.

Some of the most extensive areas of halophytes were planted between 1971 and 1977. Over 50 000 ha of depleted rangeland were planted in the Middle East, including about 42 000 ha which were planted to *Atriplex canescens* (Leigh, 1986). The carrying capacity of this land was increased from about 0.025-0.05 sheep/ha/yr to 0.5 sheep/ha/yr. In North Africa, some 50 000 hectares of *Atriplex* have been planted with over 50% of acreage represented by *A. nummularia* (Le Houérou, 1991).

There is an abundance of information in the literature showing that the productivity of halophytic species can be increased substantially when irrigating even with high saline water (Watson, 1991). In a trial using five species of *Atriplex* yield varied between 16 to 70 t FW/ha/yr and 6.4 to 12.8 t DW/ha/yr in Tunisia (Sarson, 1970). Field trials conducted in southern Morocco show clearly that the productivity values, in general, are substantially higher for irrigated *Atriplex* even though the response to irrigation, varied from one species to another (Table 2).

Table 2 *- Effect of watering regimes on biomass production of five species of Atriplex spp. - salt content of the irrigation water = 10 g/L*

		Lentiformis	Barclayana	Glauca	Halimus	Deserticola
Fresh weight (g/plt)	Irrigated	425.6	432.7	150.6	196.6	376.3
	Rainfed	225.0	226.0	103.3	88.3	225.0
Dry weight (g/plt)	Irrigated	95.6	89.7	40.7	40.6	61.7
	Rainfed	47.3	64.0	35.3	20.3	47.0

There was 100% increase in dry matter production of *A. lentiformis* and *A. halimus* under the irrigated regime. In general, irrigation had more effect on fresh weight biomass than on dry weight production.

Sea water irrigation of halophytes for animal feed has been reviewed showing its feasibility if certain precautions were taken (Glenn et al., 1995). In general, it can be concluded that halophytes have high yield potentials that can be realized under irrigation even with salt content as high as the sea water (O'Leary, 1988).

FUEL CROPS

There have been large-scale efforts to establish tree plantations on alkaline soils. In Australia, on areas of moderate to high salinity, highly salt tolerant species, especially within the genus *Acacia*, which may have fuelwood value, may be used (Marcar et al., 1993). The same author also suggested a list of species to be used in salt-affected wasteland (Table 3). Le Houérou has also described several salt tolerant species to be used for fuel and of economical value in North Africa, the Near and Middle East (Le Houérou, 1985 and 1986).

Table 3 *- Reported salt tolerant trees (Marcar et al. 1993)*

GENUS			
Eucalyptus	*Acacia*	*Melalenca*	*Casuarina*
E. occidentalis	*A. ampliceps*	*M. halmaturorum*	*C. glauca*
E. sargentii	*A. ligulata*	*M. thyoides*	
E. halophila	*A. stenophyla*	*M. glomerata*	
E. camaldulensis	*A. marconochiana*	*M. quinquenervia*	
E. diptera			

In India, attempts to plant trees directly onto severely saline/sodic soils have met with little success (Abrol, 1986), unless the soil was improved by the application of amendments, or by other cultural practices. Studies by Sandhu and Abrol (1981), have shown that if an auger hole (15cm diameter) is perced through the calcareous pan and refilled with a mixture of original soil, gypsum, and farm manure (in the rate of 25:1:4) seedlings of several species were able to establish in sodic lands.

It has been reported (Aronson, 1989) that 290 tree species with economic potential could tolerate salinity levels of 7 to 8 dS/m. The present and future roles of salt tolerant trees as fuel including the use of trees for restoring the ecology of salt-affected land has been reviewed by Aronson et Le Floc'h (1995).

The use of woody halophytes like mangrove as a source of charcoal for many years is a good example of using halophytes as fuel crop. The Indian Ocean coasts of East Africa and Madagascar have estuarine and brackish water coastal marshes that support vegetation which is predominantly mangrove (Ruwa, 1992). This species was historically used in this region for provision of wood, and associated production e.g. fodder and honey production. Nevertheless, the anthropogenic impacts, particularly the overcutting of these mangrove trees for wood, is increasing desertification in these areas.

It appears then that considerable scope exists in the choice of trees for agroforestry, woodlot and plantation schemes on salt-affected land under both dryland and irrigated conditions. Minimum investment is needed to implement these findings in the rural economies of developing countries.

SALT TOLERANT TREES

Moderately to highly salt-tolerant trees, which can provide a range of wood and non wood products as well as other benefits are available (Marcar et al., 1993). One of the most common uses of trees biomass is firewood. Also, other products such as pulp chips and cellulose feedstock for industrial purposes like manufacturing plastics, chemicals and liquid fuels are possible (Whitehead et al., 1988; Goddon, 1989). Leaf oils can be simply and cheaply extracted from leaf biomass of several eucalyptus (e.g. *E. polybractea, E. radiata, E. smithii* and *E. globulus*) and tannins from the bark of *Acacia mearnsii* (Marcar et al., 1993). Several salt-tolerant *Acacia*, such as *A. saligna, A. stenophylla, A. salicina* and *A. ampliceps* have the potential to provide forage and fodder (Vercoe, 1987). This by-product could provide a means to increase financial return. At the present time, sufficient knowledge is now available to consider implementation of saline management schemes incorporating trees in dryland and irrigated areas.

ORNAMENTALS AND LANDSCAPE

Many attractive and useful ornamental halophyte species have been identified (Aronson, 1985). The expansion of the tourism industry in many developing countries as well as the development of cities in coastal areas, justify the use of halophytic species to be irrigated with marginal water to free fresh water for human consumption. Intensive research programmes to identify ornamental species (Table 4) suited to saline environments and/or to irrigation with saline water has been developed in Israel (Forti, 1986). Some species, like *Maireana sedifolia*, are commercially produced for cut branch production and exported to Europe. An updated list has been published by Forti (1986). Similarly, some species like *Limonium* already have counterparts in the florist industry, and could be cultivated with brackish water as a cut flower.

Several grasses have been selected by the University of Arizona to be irrigated with saline water of over 15g/L and could make a very good green cover. Also, trees like *Eucalyptus occidentalis* and *E. sargentii* could stand a salinity over 30 dS/m and are used in landscaping.

OTHER USES OF HALOPHYTES

Halophytes and salt tolerant plants can be used to produce economically important materials such as essential oils, gums, resins, pulp and fibber.

Essential oils

In India, the male flowers of kewda (*Pandamus fascicularis*), a common species of screw pine, are used to produce perfume and flavoring ingredients. The kewda plant is salt-tolerant and has been planted in coastal areas to check drifting sand.

Oil seed yields of 2 mt/ha, equivalent to soybean and other conventional oilseeds, have been documented for *Salicornia bigelovii* grown on seawater in 6 years of field trials in Puerto Panasco (Glenn et al., *1991*).

***Table 4** - Salt resistant ornamentals for the Dead Sea shore*

Soil salinity (EC_e: dS/m) 0-5	5-15	15-25	25-50
	TREES		
Acacia victoriae *Delonix regia* *Zizyphus spina-christi*	*Acacia gerardii* *A. raddiana* *A. salicina* *A. tortilis* *Casuarina glauca* *Olea europaea* *Parkinsonia aculeata* *Pistacia atlantica* *P. vera* *Prosopis juliflora* *Washingtonia filiflora*	*Eucalyptus sargentii* *Phoenix dactylifera* *Tamarix articulata*	
	TALL SHRUBS		
Acacia schlerosperma *Dodonaea viscosa* *Pittosporum phyllaraeoi-des* *P. torbira*	*Callistemon rigidus* *Calotropis procera* *Dichrostachys nutans* *Pistacia lentiscus* *Retama raetam* *Schinus terebinthifolius* *Tamarix chinensis* *"Mapu"*	*Maireana sedifolia* *M. pyramidata*	*Suaeda monoica*
	SHRUBS		
Bougainvillea spectabilis *Carissa grandifolia* *Cassia eremophila* *Euphorbia pulcherrima*	*Agava* spp. *Aloe* spp. *Atriplex* spp. *Cacia mexicana* *C. sturtii* *Cineraria maritima* *Clerodendron inerme* *Yucca filifera*		
	SMALL SHRUBS, GRASSES, GROUNDCOVERS		
Santolian chamaecy-parissus *Inula crithmoises*	*Arctotis grandis* *Aster alpinus* *Catharanthus roseus* *Galenia secunda* *Gazania splendens* *Lampranthus albus* *Myoporum parvifolium* *Oenothera drummondii* *Pennisetum asperifolium* *Portulacaria affra* *P. elephantipes* *Ruellia cilliosa*	*Crithmum maritimum* *Enchylaena tomentosa* *Glottiphyllum* spp. *Limonium axillare* *L. perezii* *L. pruinosum* *Lippia nidiflora*	*Sesuvium verruco-sum* *Suaeda vera*
	ANNUAL FLOWERS		
Celosia cristata *Lobularia maritima*	*Clianthus formosus* *C. puniceus* *Portulaca oleracea*		
	LAWNS		
		Paspalum vaginatum	

Gums and resins

Grindelia camporum, a salt-tolerant perennial shrub exudes large amounts of aromatic resins. The amount of resin produced ranges from 5 to 18 percent of the dried biomass. This resin has properties similar to the terpenoids in wood which are used commercially in adhesives, varnishes, paper sizing, printing inks and soaps. *Sapium sebiferum*, the Chinese tallow tree, is a small marshland tree native to subtropical China. The major economic potential for this tree is its high yield of oil seed (more than 10 tons/ha). The seed contains both an edible hard vegetable fat and an inedible liquid oil. The edible fat is a potential substitute for cocoa oil and the inedible oil appears promising as a dyeing oil for paints and varnishes.

Simmondsia chinensis (jojoba) is a perennial desert shrub with seeds that contain oil with a structure similar to sperm whale oil. It has been grown successfully in Israel near the Dead Sea irrigated with brackish water (5-6 dS/m).

Pulp and fibber

In Egypt, *Juncus rigidus* has been used to produce paper (Zahran et al., 1984). In India, nine month culms of *J. rigidus* indicate that 1.5 - 2.0 tons per hectare of pulp for paper-making can be produced on saline soil (> 10 dS/m). In Pakistan, irrigation with 17 dS/m water gave yields of 5.5 kg per m2 per year of *Saccharum griffithii*. The roots of this grass are used for rope and mats, and the leaves are used to produce paper pulp (Ahmad, 1987).

CONCLUSION

The use of halophytes for rehabilitation and reclamation of salt-affected lands has proven to be feasible if certain precautions are taken. Survey and analysis of the sites, their geophysical, chemical, pedological and hydrological conditions as well as their natural vegetation are the first step in any programme of potential use of salt-affected lands. Plantations of halophyte species are justified when they can make areas productive. The soil / water management practices to provide adequate drainage and other soil-related aspects are critical factors in using saline water for irrigating halophytes. The management of certain halophytic species (*Atriplex* spp.) is well documented (Malcolm, 1995; Le Houérou, 1995) and work to produce improved forms suiting local conditions in many countries all over the world is proceeding. Halophyte use for forage is limited by the high salt content which may represent a serious constraint to their use. Even though it has been proven in Australia, where there are about 1 million hectares of planted *Atriplex*, that their use for annual feeding is economically feasible. However, it could be used as complementary feed or as source of fodder during the winter feed gap. Sufficient knowledge is now available to consider implementation of saline land management schemes incorporating trees and shrubs in dryland and irrigated areas. The use of halophyte trees for fuel production, forage landscaping and soil reclamation is well documented (Aronson, 1985; O'Leary, 1988; Le Houérou, 1985 and 1986; Forti, 1986).

There is a need for developing the proper agromanagement and conditions to maximize the productivity of these known economical halophytic species. Also, considerable efforts toward genetic improvement of the crop characteristics, just as there is with any crop. Therefore, before halophytic species can occupy a significant role in the agricultural development of salt-affected land, we have to treat them as a normal cash crop.

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