Use of *Prosopis* in Arab/Gulf States Including Possible Cultivation with Saline Water in Deserts

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INTRODUCTION

Mesquite (*Prosopis* spp.) plays a leading role in afforestation of arid lands. Their capability of growing on marginal land under arid conditions has made them especially suitable for this purpose. Being a multipurpose tree, they fit very well into the agroforestry system of arid land, control soil erosion, stabilize sand dunes, improve fertilizer status of the soil, provide fuel energy resources, supply feed and forage for grazing animals, furnish construction timber and furniture wood, supplement food for humans and promote honey production. Mesquite distribution is worldwide, and, although not liked by the growers of fertile land due to the danger of becoming an obnoxious weed, however, it has proved a blessing for the dwellers of degraded wasteland and barren coastal areas. The plant can withstand high temperatures, shortage of water, and saline land; therefore, it grows under haloxeric conditions as well.

Regarding the distribution of *Prosopis* spp. in Asia, one of its species namely *P. cineraria* is native of India (Gujrat, Rajastan and Haryana); Pakistan (Indus plains); Oman (eastern and western boarders of sand sea) and Saudi Arabia (southern boarder of Rub Al-Khali in vicinity of Ghanim), whereas, other species (i.e., *P. juliflora* and *P. glandulosa, P. alba,* etc.) have been introduced probably during last century.

The authors have conduced a survey of naturally growing *Prosopis* plantations of Arab Gulf states during July and August 1994 under the BOSTID Research Programme. The first author has also served as a visiting professor at Sultan Qaboos University, Oman, and visited a local *Prosopis* woodland (September through January 1990).

Prosopis spp. IN ARAB/GULF STATES

Geography of the Area

Apart from the Kingdom of Saudi Arabia, which occupies most of the Arab peninsula, four other states of the Gulf Cooperation Council (GCC), i.e., Kuwait, Bahrain, Qatar, and U.A.E., are situated at the eastern coast of the peninsula on the of Persian Gulf, whereas, the sixth state, Oman occupies the southeastern and southern part of the peninsula, facing the Gulf of Oman and Arabian Sea (Figure 1). Several aquifers are found at the coastal belt where the water table ranges from 90 to 200 m. The minimum temperature in the Gulf region remains about 18°C during winter and may reach 35°C during summer. A belt of sandstone and alluvium up to 150 km wide lies between cuesta ravines and the sea coast. The bedrock is Eocene limestone. The plain is inclined eastward toward the Persian Gulf. Annual precipitation is not more than 130 mm. There is a great dearth of good quality water; water for domestic purposes is obtained through desalinization plants. The Saudi Arabian part of the eastern coast (Al-Hasa Desert) is stony and a considerable area is moving sand. Masses of loose sand alternate with limestone hills (60–80 m high) all along the coast. The mountains of Oman in the southeastern part of the peninsula are folded ranges of Alpine orogenesis with maximum elevation of 3352 m. Some ephemeral streams flow in valleys leading to lowlands in the south of Oman. There is a strip of sandy plain along the Arabian Sea. As a result of over pumping, the groundwater is gradually becoming brackish due to sea water intrusion all along the coastal belt.

Distribution of *Prosopis* spp.

Distribution of *Prosopis* species and their uses in Arab/Gulf states is presented in Table 1. Most fast-growing *Prosopis* spp. (i.e., *P. juliflora, P. glandulosa*) were introduced into Indo-Pakistan about 1878 (Parker, 1921), from where they have most probably invaded Arab/Gulf states during late 1950s. Any record of their proper introduction into these states is not available. Species such as *P. alba,* and *P. chilensis,* are being introduced by the horticultural departments of various township of these states as roadside trees and for other ornamental purposes. However, the existence of *P. cineraria* for more than 200 years in Oman, Saudi Arabia, and the Indo-Pak subcontinent has more or less given it native status. The presence of a huge single isolated *P. juliflora* tree (more than 30 m tall) in the central plateau of Bahrain indicates the probability of its early introduction. Although the earliest record of *P. juliflora* introduction to the Indo-Pak subcontinent was in the late 1800s, local people believe this huge specimen is much older. The possibility of its dispersal through the traders of the 1500s, who came around from Africa, cannot be ignored. The soil of the central plateau is a mixture of stony-silty-loam. The climate of this area is arid and precipitation is only 50–100 mm/year, hence, growth of seedlings by dispersion of seeds could not be possible. Furthermore, there are several oil wells with a network of pipelines leading to nearby refineries. It is interesting to note that any plant of more than 15–20 years of age was not seen all over the island, whereas, a single plant more than 500 years old was growing in the central plateau.

The presence of *P. cineraria* in lowlands at the margin of the hot sandy desert Ruba Al-Khali (empty quarters)in Saudi Arabia is another interesting feature. Its native woodland forest in an ephemeral river basin in Oman and along the eastern and western boundaries of Wahiba sea sand (desert) shows the capability of its growth under extremely arid conditions (Brown, 1989).

Cultivation with Saline Water

The capability of mesquite species to grow under stressed conditions have made them most important multipurpose tree of arid and semiarid regions. Their growth and development under arid conditions well documented (Felker et al., 1983a). Comparative studies on their stress tolerance conducted by various workers (Felker et al., 1983b., Ahmad et al., 1994) could help in screening the plant genomes for desired characters.

SAND DUNE STABILIZATION PROGRAMME

The programme started at the coastal belt of Pakistan by the Baluchistan Forest Department in 1970 using underground saline water was mainly aimed toward growing *Prosopis juliflora* at Pasni, Gwadar, and Pishukan, the townships located in sandy coastal belt where good quality water is absent. Ombrothermic diagram for Pasni, based on 30 year's of data (Figure 2) shows the arid climate of the area. Total area of plantation (mostly at sand dunes) was more than 300 ha. divided at three places. Some plantation at compact native sandy strata was also undertaken. Saline water was lifted for irrigation from 1–3 m deep wells dug at a distance of 1–2 km. from shoreline. Electrical conductivity of the water varied from low (1–6 dS m^{-1}) to high (7–20 dS m^{-1}) at various places. Growth performance of plants up to five years old is presented in Figure 3. The plantation is now 15–20 years old. The case history of this plantation is well documented (Khan et al., 1986). Because there was no pruning to make them monostemic, an average of 4–5 basal stems of 15–20 cm in diameter are present in 15-year-old plant. The interplant distance was maintained at 2–2.5 m for sand-dune stabilization and 5 m for fuelwood production. Each plant was irrigated with about 10–12 liters of saline water weekly during summer and fortnightly during winter months. Irrigation was suspended after two years. The plantation has significantly stopped the movement of a huge sand dune that threatened Pasni township. Furthermore, it has provided pods for feeding goats and sheep and provided fuelwood for local inhabitants. In addition, the preparation of charcoal in locally made earthen kilns has provided an other commodity for sale in nearby cities.

Growth With Reference to Interplant Distance

As mentioned earlier, plants at Pasni were placed at an interplant spacing of 2.0S2.5 m for sand dune stabilization. However, due to plant mortalities in some areas, spacing became ≥5 m between many plants. The growth patterns of these plants were different from those grown with closer spacing. All the growth parameters of 10-year-old plants with an interplant spacing of 2.0S2.5 m were significantly lower than those of the same age left at ≥5 m (Table 2). It indicates that close spacing in *Prosopis* species may be desirable only for sand stabilization purposes. However, a spacing of ≥5 m appears more suitable to obtain wood for fuel and furniture.

Wood Quality

Wood quality of *P. juliflora* varies with the age of plants. Figure 4 shows the specific gravity (SG) of wood samples collected from plants of various ages. Specific gravity increased steadily up to approximately five years of age, but, thereafter, became more or less asymptotic. The specific gravity of 4-, 5-, and 9-year-old plants at Pasni growing in nonsaline soil did not significantly differ from those growing at sites irrigated with saline water. Being related with age, it showed the following relationship:

$$SG\ (wood) = 0.577 + 0.0823\ Age\ (years) - 0.0046\ Age\ (years)^2$$

F = 28.965	**(t = 5.495)**	**(t = –3.895)**
r = 0.9038	**(P < 0.001)**	**(P < 0.002)**

The mature *P. juliflora* has considerably higher specific gravity values compared to 0.61 in *Alibizzia lucida*, 0.61 in *A. lebbak*, 0.68 in *Azadirachta indica* (Manjunath, 1948), and 0.58S0.68 in *Pinus roxburghii* (Krishnamurti, 1969) and is somewhat comparable to 0.80 in *Acacia nilotica*, 0.97 in *A. modesta* (Manjunath, 1948), 0.82 in *Dilbergia sisso* (Sastri, 1952), and 0.91 in *Quercus dilata* (Krishnamurti, 1969).

The calorific value of mesquite wood is also higher, ranging from 3974 to 4636 kcal/kg in dry wood (4215.70 ±28.16 kcal/kg). It was lowest in 1-year plants and maximim for 13-year-old plants (Figure 4).

The wood of *P. juliflora* is heavy and hard, hence, appears to be an excellent fire-generating material. Although growth of the plant is subsequently reduced under highly saline conditions, the quality of the wood is not affected significantly.

Useful conclusions could be drawn from the experiment conducted to study comparative growth of different *Prosopis* species/accessions using saline water irrigation. Six-month-old seedlings of 20 different species/accessions (8 exotic and 12 indigenous) were pre-conditioned to salinity by irrigating them with water of increasing salinities prior to transplantation in pits where they were irrigated with underground saline water (EC: 14-16 dS m^{-1}). Growth performance of the six best species/accessions at the age of 2 years is shown in Figure 3. It is quite evident that local species of *P. juliflora* and *P. glandulosa* would be most suitable for stabilizing sand dunes because of their short stature and multistemic spreading characteristics, thus helping in stopping sand drift. Whereas, exotic species of *P. juliflora* and *P. alba* introduced from Brazil and Texas (U.S.A.), respectively, would be suitable as roadside trees and for timber for furniture/house building. Local *Prosopis* species, if pruned regularly, are also capable of becoming monostemic trees, but their rate of growth is slower as compared to the exotic species.

It has been proven that *Prosopis* spp. are capable of providing shade, fodder, fuelwood, timber, etc., from the wasteland where no other plant of commercial importance could grow due to prevailing arid and haloxeric conditions (Felker et al., 1983a; Khan et al., 1986; Riveros, 1989; Charan and Chouhan,

1993). They also play a leading role in stabilization of sand dunes and stopping shifting sand in hot sandy deserts. Hence, due emphasis should be given to using this plant for the benefit of mankind.

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Table 1. Distribution of *Prosopis* Species and Their Uses in Arab/Gulf States

States	Species	Habitat	Uses
Kuwait	***P. juliflora***	**Introduced during 1950s, now quite wild, grows luxuriantly in patches along coastal sandy belt. Vernacular Name: Ghaf.**	**Fodder, fuel, charcoal, shade, stopping drifting sand, stabilizing sand dunes, roadside tree.**
	P. glandulosa	**Introduced during 1950s, now quite wild, grows luxuriantly in patches along coastal sandy belt. (relatively less vigorous than *P. juliflora*)**	**Fodder, fuelwood, shade, roadside tree.**
	P. alba	**Introduced lately.**	**Ornamental.**
	P. chilensis	**Introduced lately.**	**Ornamental.**
Saudi Arabia	***P. farcta***	**Native, scanty growth around agricultural area and depressions. Found in Wadi Sirhan, At-Qatif, Al-Hasa. Vernacular Name: Yanbut, Awsay.**	**Folk medicine.**
	P. juliflora	**Introduced during 1950s, scattered patches in low land and dry seasonal river beds/wadis in central coastal lowland, Dhahran, Farsan island, Al-Khubar and Al-Dammam. Vernacular Name: Ghaf.**	**Shade, stopping drifting sand, roadside tree.**
	P. cineraria	**Native, few localised patches at shallow sand at southern margin of Rab' al-Khali (empty quarters). Vernacular Name: Ghaf, Shibhan, Hadib**	**Fodder, shade, pole for fencing and hutment.**
	P. koelziana	**Native (confused with *P. cineraria*) found at coastal and central lowland, near ruin sites or villages, northern Al-Hasa Oasis, al Muhtaragah, Sabkhah-south of Thaj, Qarn Abu Wail, Yabrin depressions.**	**Fodder, fuelwood, shade.**
	P. alba	**Introduced lately.**	**Ornamental.**

Table 1. Distribution of *Prosopis* Species and Their Uses in Arab/Gulf States (continued)

States	Species	Habitat	Uses
Bahrain	***P. juliflora***	**Scattered patches of young plants on coastal lowland of the island. A huge single tree (said to be more than 500 years old) is found growing on a mound in central plateau of the island where several oil wells are also present. It is called "Tree of Life" by the locals and its photograph appears on postcards. Vernacular Name: Ghaf.**	**Roadside tree, often planted in close spacing at an area of few hectares on sandy desert. Lower branches are cut regularly to avoid bushy habit. The close canopy provides shade against blazing sun. This place is used for picnics by local people.**
	P. glandulosa	**Introduced during 1950s, scattered patches of young plants are found at coastal lowland. (less vigorous than *P. juliflora*)**	**Ornamental.**
Qattar	***P. juliflora***	**Introduced during 1950s, grows around farmland, isolated, plants are present in depressions. Vernacular Name: Ghaf**	**Hedge plant around orchards, roadside tree, ornamental.**
	P. glandulosa	**Introduced during 1950s, grows around farmland, isolated, plants are present in depressions. (less aggressive than *P. juliflora*)**	**Hedge plant around orchards, roadside tree, ornamental.**
U.A.E.	***P. juliflora***	**Introduced during 1950s, scattered patches at coastal lowland, aggregates in Rasul-Khaima. Vernacular Name: Ghaf**	**Fodder, fuelwood, roadside tree, hedge plant stopping shifting sand, timber for second-class furniture.**
	P. glandulosa	**Introduced during 1950s, scattered patches at coastal lowland, aggregates in Rasul-Khaima. (less vigorous than *P. juliflora*)**	**Fodder, fuelwood, roadside tree, hedge plant stopping shifting sand, timber for second-class furniture.**
Oman	***P. cineraria***	**Native, woodland around depressions in shifting sand and dry river bed. Eastern and western boundaries of Wahiba sea sand. Found in seasonal dry river beds and wadis.**	**Fodder, fuelwood, shade, poles for hutments.**

Table 2. Effect of Interplant Distance on Some of the Growth Attributes of 10-Year-Old *P. juliflora* Plantation

Growth Attributes	Interplant Distance	
	2.0 to 2.5 m	≥5 m
Average height (m)	6.45 ±0.61	9.80 ±0.69
Average number of stems per plant	4.12 ±0.96	7.75 ±2.87
Average diameter of stem (cm)	18.74 ±1.84	26.12 ±4.26
Average canopy cover per plant (m^2)	56.66 ±8.36	88.66 ±14.30
Average basal area per plant (dm^2)	10.61 ±1.03	32.92 ±7.66

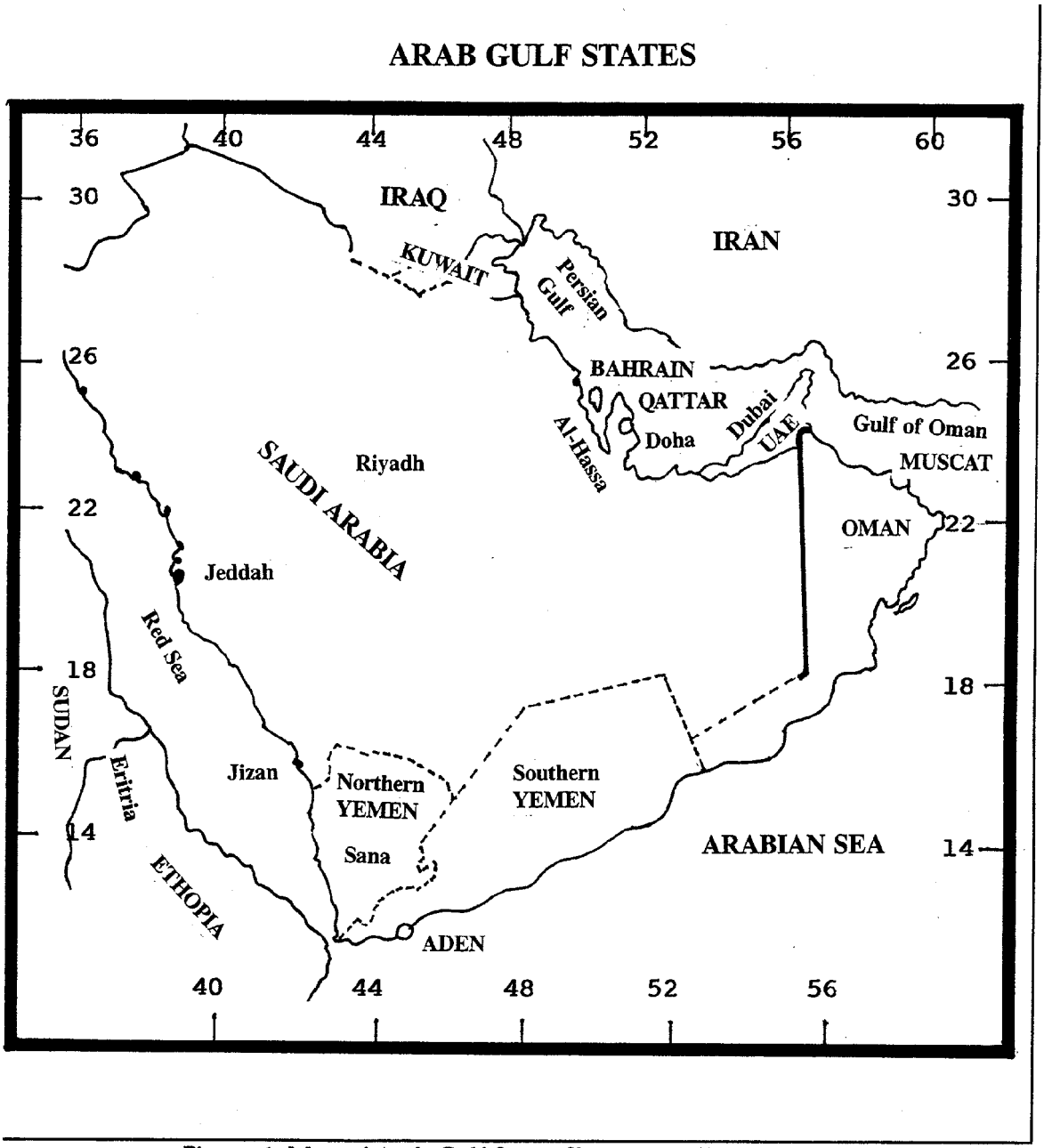

Figure 1. Map of Arab Gulf States Showing Different Places Where *Prosopis* Species Are Found

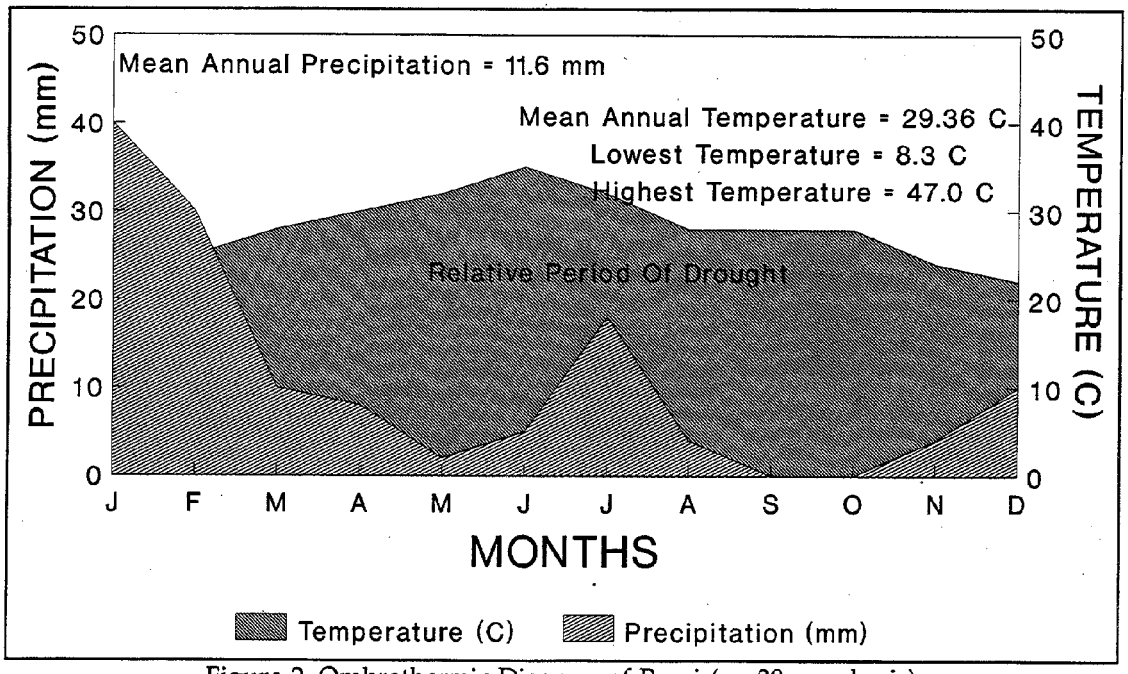

Figure 2. Ombrothermic Diagram of Pasni (on 30-year basis) Where Sand-Dune-Stabilization Programme Was Started in 1970

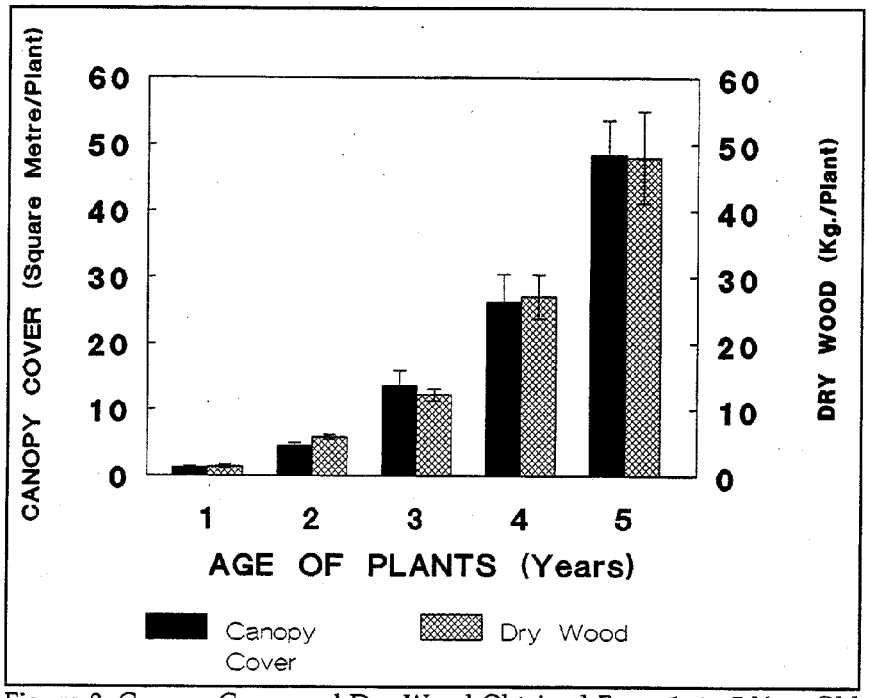

Figure 3. Canopy Cover and Dry Wood Obtained From 1- to 5-Year-Old Plantations of *P. juliflora* Irrigated With Highly Saline Water (EC: 7.0 to 9.2 dS/m) at Coastal Sandy Belt of Pasni (Pakistan)

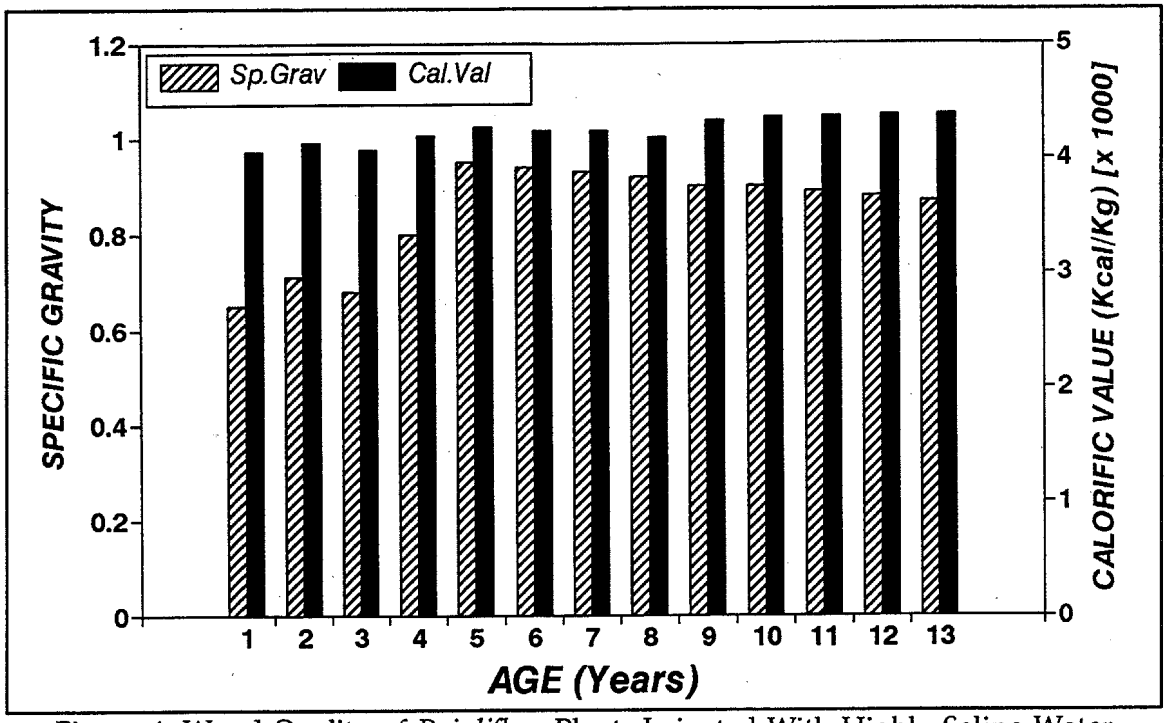

Figure 4. Wood Quality of *P. juliflora* Plants Irrigated With Highly Saline Water (EC: 7.0 to 9.2 dS/m) at Coastal Sandy Belt of Pasni

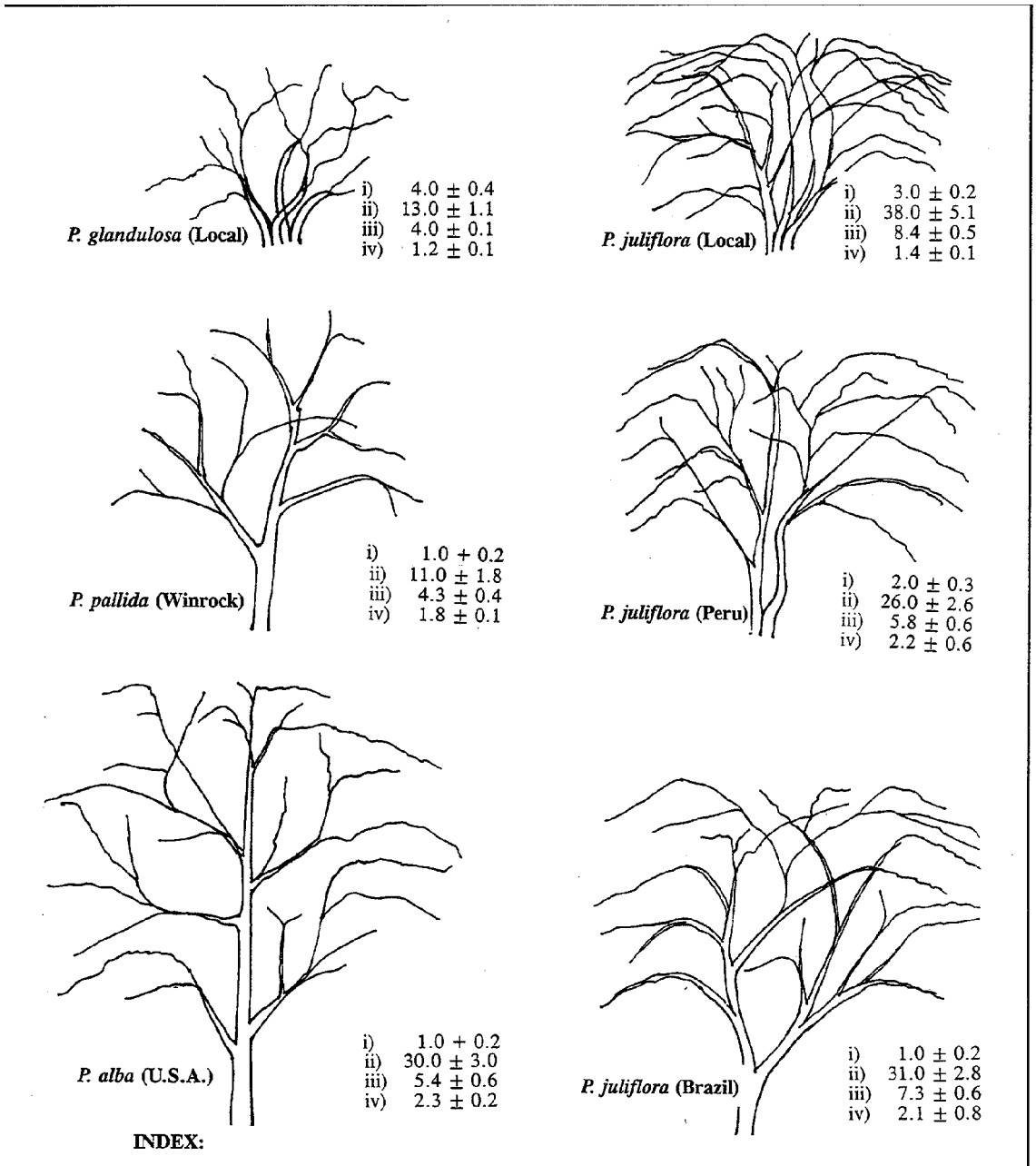

Figure 5. Growth Performance of 2.5-Year-Old *Prosopis* spp. Accessions Irrigated With Saline Water (EC: 14 to 16 dS/m)