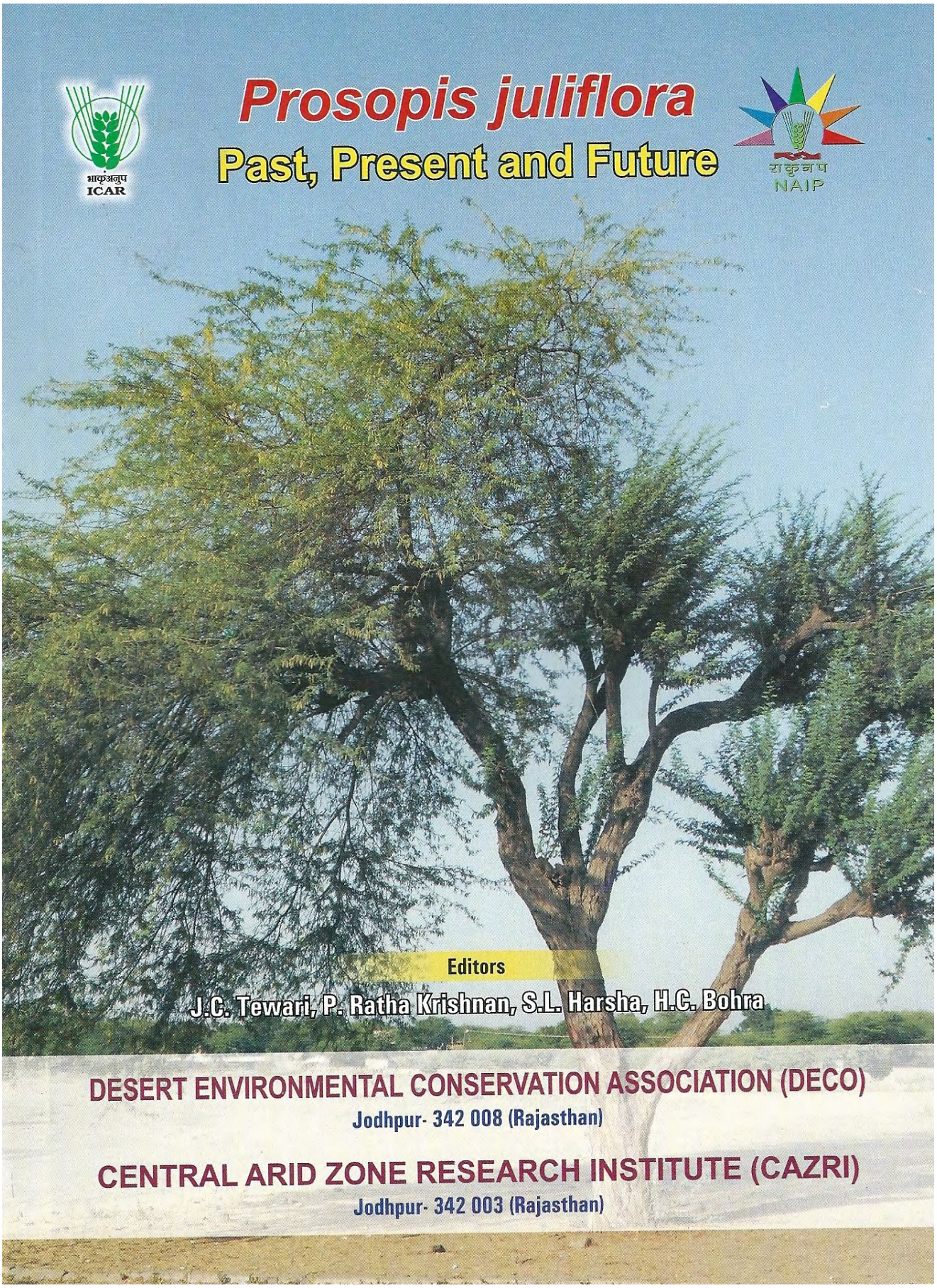

Prosopis juliflora

Past, Present and Future

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Prosopis juliflora: Weed or Wealth – A Review

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Prosopis juliflora (Sw.) DC (Vilyati Babool), an evergreen tree is native to south America, central America and the Caribbean. The history of the first introduction of *Prosopis juliflora* into India is about 130 years old (Tewari, 2006). Introduction of species was first seriously attempted in 1870s and different people have different views about its introduction in India. It was first introduced in Punjab during 1875 (Rawat *et al.*, 1992); in Cuddaph district of old Madras Presidency during 1876 (Reddy, 1978); in Sind during 1877 (Kaul, 1956), whereas, Gupta and Blara (1972) reported that *Prosopis juliflora* was introduced to India in 1857 from Mexico. These reports indicate that the tree was introduced somewhere during 1870s. Literature revealed that it was declared "Royal Plant" in 1940 by the Former King of Jodhpur state and placed under government protection (Muthana and Arora, 1983). Large scale aerial seeding of this tree was undertaken to establish sand dunes and sand storms in Rajasthan (Harsh *et al.*, 1996). The most abundant distribution of this species is found in the Kuchh region of Gujarat, the arid western part of Rajasthan, western and south-central parts of UP, the western part of Haryana, and in a few pockets of extreme north Andhra Pradesh. In its entire range of distribution, thickets of the species are found here and there in a variety of habitats and settings (Tewari *et al.*, 2000). Because of natural inter species hybridization over the years different morphological and physiological variations are found among the natural stand of *Prosopis juliflora* in different parts of the country and attributed reason is the existence of different forms of the species in different places. Within *juliflora* there is a great variation in terms of number of stems, straightness, pod production, size and shape of thorns, thornlessness and size and shape of canopies.

Prosopis juliflora as a Weed

P. juliflora is capable of growing in a wide variety of soils and situations. It is, however, generally not found in frost prone areas, the Himalayan region or in warm humid tracts such as the north eastern region, West Bengal and Kerala (Tewari *et al.*, 2000). Because of its deep rooting system that consumes much moisture and thick canopies which has shading effect on it's under vegetation, *Prosopis juliflora* has survived where other tree species have failed and in many cases become a major nuisance. It is an aggressive and invading species that has spread rapidly due to its great tolerance to the extremely refractory conditions of the most parts of arid zone. *Prosopis juliflora* has invaded, and continues to invade, millions of hectares of rangeland in south Africa, east Africa, Australia

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and coastal Asia (Pasiecznik, 1999). In 2004, *Prosopis* was rated one of the world's top 100 least wanted species (Invasive Species Specialist Group of the IUCN, 2004). In the native region of *Prosopis juliflora* (from Mexico to Peru) where, the people have developed local economies based on this tree and its products. Vilayati babool is a foreigner in India, the tree has been introduced long back, but the knowledge of multipurpose use of this tree has not been so far known to all. The prolific growth of *Prosopis juliflora* invaded communal grazing lands discourages grass growth and hence leaving there little or no grass for livestock. In fact, it ranks first in term of distribution, abundance and aggressive encroachment of rangelands. The incidence of malaria associated with the expansion of *Prosopis* thickets is also the frequently mentioned problem. Associated all the problems has kept *Prosopis juliflora* in category of a weed.

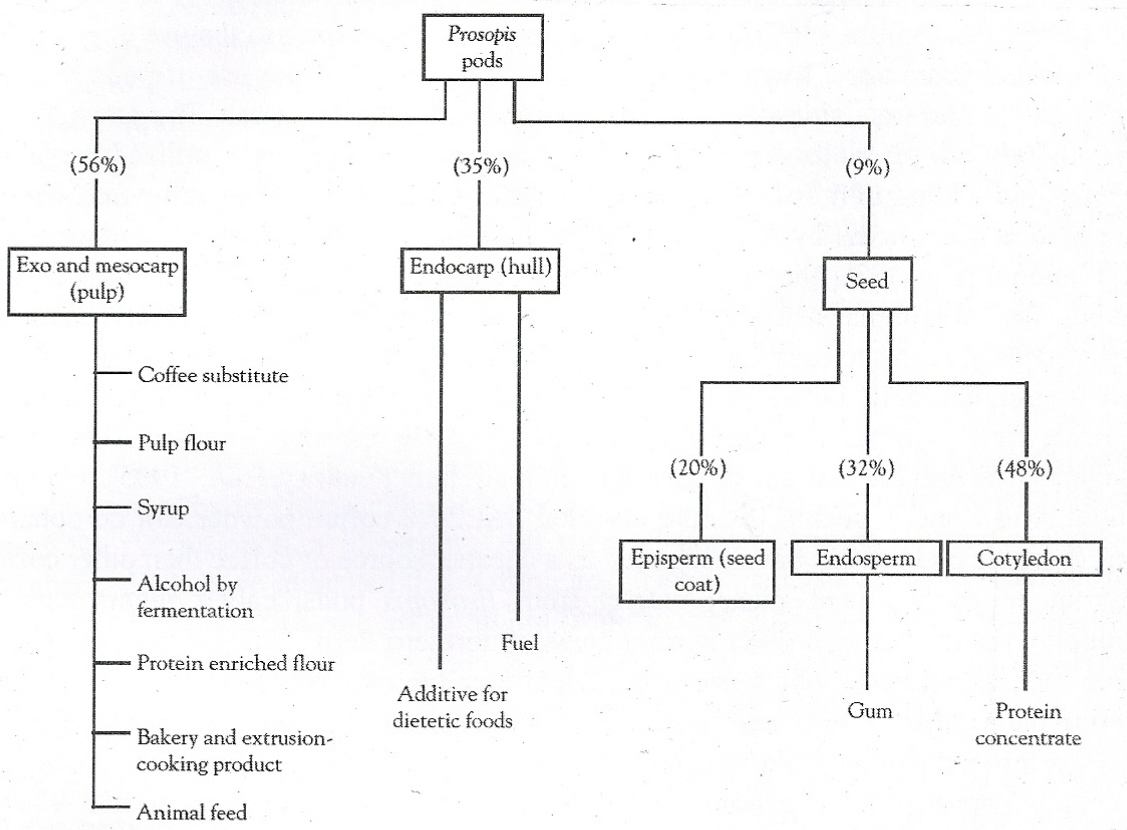
Prosopis juliflora Turned into Wealth

Invasion of *Prosopis juliflora* can be turned into a significant resource for the local population, if the usefulness of this species is recognized from the angle of diverged products from it. The usefulness of *Prosopis juliflora* has long been recognized (Muthana and Arora, 1983; Silva, 1988; Silva, *et al.*, 1988). It is considered to be a valuable tree species of the desert ecosystem. Its multiple use possibilities have attracted growing interest in this species, especially in arid zone. This species is one of the most efficient species to convert energy into biomass as a primary producer. It produces biomass about 25 to 30 t ha^{-1} $year^{-1}$ at the short rotation age of 4 to 5 years (Patel, 1986), It is therefore, necessary to improve the management of this natural resource through scientific and technical studies to obtain various raw materials in perpetuity for agro-industrial utilization. Let us discuss the wealthiest products derived from this species.

Pod Production and its Uses

Prosopis juliflora trees have a tremendous potential for pod production. Pod production is estimated to be about 20 kg $tree^{-1}$ $year^{-1}$ (Shukla *et al.*, 1984), thus, about 10 metric tons/ha (500 trees/ha). The pods are collected twice a year (winter and summer). The maximum pod production is between March and June. Regarding the composition of dried pods, it has been reported that the pods contain: protein, 16.5%; fat, 4.2%; carbohydrate, 57%; fibre, 16.8%; ash, 5.4%; calcium, 0.33%; phosphorus, 0.44% (Vimal and Tyagi, 1986) and 12.46 to 15.51 ppm copper, 22.11 to 22.30 ppm manganese, 18.30 to 28.01 ppm zinc, and 203 to 638.8 ppm iron (Shukla, *et al.*, 1984). Considering arid & semi-arid that contribute 40% (131.6 mha) of total geographical area (329 mha) under *Prosopis juliflora*, and that of 40% (52.64 mha) actually under *Prosopis juliflora*, it is estimated that about 52.64 million tons of pods could be collected from an estimated area of about 52.64 mha in the entire arid zone of India. If 50% of the pods were actually collected, the estimated yield would be about 26.32 million tons, which could provide employment to millions of people and earn hundreds of millions of Rupees as country income.

Fractions and potential uses from processing and separation of *P. juliflora* - *P. pallida* pods (Adopted from Pasiecznik *et al.*, 2001)



Use of Pod in Animal Feed

Ripe pods are said to have high nutritive value, i.e., rich in sugar and nitrogen and are greedily eaten by most of the herbivorous animals and livestock. Studies on palatability and nutritive value of pods and their source on productive and reproductive status of milking cattle have been conducted by Central Arid Zone Research Institute, Jodhpur under National Agricultural Innovation Project. Crushed or ground *Prosopis juliflora* pods provided good fodder without causing any digestive adverse effect on cattle resulting good animal performance. Further, it can also be mixed with wheat and rice-straw, tumba (*Citrullus colosynthesis*) seed cake, guar (*Cyamopsis tetragonaloba*) korma, til (*Sesamum indicum*) seed cake, ground-nut cake, wheat bran, maize grain and molasses, etc., to make it more nutritious, palatable, and valuable. The Institute has succeeded in preparing highly nutritive livestock feeds from these pods after seed separation. The whole project provides employment to the rural poor through collection of pods. The project also provides a highly nutritive cattle feed that is cheaper than other available cattle feeds.

Use of Pod in Human Food

Prosopis pods were eaten by humans in the Tehuacan valley in Mexico as long ago as 6500 BC (Smith, 1967), and there are other reports relating to the use of pods over one thousand years ago (Towle, 1961). It can be assumed that the use of pods for food and wood for fuel was widespread amongst early man in the Americas. The powder from *Prosopis juliflora* (thorn less) pods contains 13% glucose which can be utilized in making biscuits after adding to it 50% wheat fine flour. During drought and scarcity, the pods are even used as food items by poor people. Because of the high carbohydrate content and good amount of protein, the spongy walls of ripe pods are highly nutritive and used in making meal for humans. Coffee substitute has been made from *P. juliflora* in Brazil (Rocha, 1990), with the roasting of just the coarse pulp flour. Flour is roasted at 120°C until it becomes dark brown, during which time it agglomerates into larger granules requiring further grinding. The final product is used in the same way as filter coffee granules. *Prosopis* coffee substitutes are caffeine free (Vieira *et al.*, 1995). Work at Central Arid Zone Research Institute revealed that 20% coffee powder can be obtained from *Prosopis* pods which have been seen as a cheaper source of coffee than other coffee. A syrup, or concentrated sugary extract from *Prosopis* pods, called 'algarrobina', is commonly made from *P. pallida* in rural areas of northern Peru. This syrup is made from whole or crushed pods which are soaked in water for two hours before pressing and filtering the resulting liquid, and finally concentrating the liquid by evaporation. The dark brown syrup obtained is more viscous than honey and exhibits a peculiar brightness. The process is carried out on a household level in rural Peru using very simple kitchen equipment, and the 'algarrobina' produced is sold in reusable glass bottles (Estrada, 1974; Alza *et al.*, 1998).

Use of *Prosopis juliflora* Wood

Prosopis juliflora can be classified as hard and heavy woods due to their high density (more than 300 kg m^3) and specific gravity (0.70). It is excellent firewood (calorific value is 4800 k cal kg^{-1}) that burns slowly and evenly and holds heat well. Because of its superior quality, it is considered to be one of the best charcoals (Vimal and Tyagi, 1986). Dry wood, on destructive distillation gives 33.9% charcoal, 1.24 methanol and 124.8 litre kg^{-1} of gas (Varshney, 1996). These materials in general have low ash content and high heating value and produce hard and stable charcoal on combustion. *Prosopis juliflora* is hardest of the hard woods and most suitable for charcoal making and electricity generation (Singh, 2008). The traders opined that charcoal from *Prosopis* is preferred than other sources due to its high carbon content and calorific value. Varshney (1996) assumed that 500 trees ha^{-1} produce 24 kg dry biomass at end of five years (12 dry metric tons per 5 years = 2.4 tons $year^{-1}$) and 16.6% wood-to-charcoal yield for 0.4 tons of charcoal per ha-year. Based on this assumption, if 20% of the total area actually

covered by *Prosopis* in India is harvested and processed into charcoal each year then, the approximately about 4.21 million tons of charcoal per year is yielded in perpetuity on a five-year cycle. Thus, annually thousands of million bags of charcoal would be available. In this way, thousands of millions man-days of labour could be generated for employment. Rural women in arid and semi-arid areas mostly use wood as fuel. It is estimated that more than 50% of the total fuel wood requirement in arid and semi arid areas is met by *Prosopis juliflora* trees. Larger branches and trunks yield a high quality timber, comparable in colour, finish and physical attributes to Indian rosewood and other commercial hardwoods. Its exceptional property is its negligible shrinkage (4.17%) which is much less than for oak, maple or walnut trees (14-16%). Because of this quality furniture items made from *Prosopis* wood develop little or no cracking or warping later on (Singh, 2008). In India use of *Prosopis* wood in furniture industries is very limited because of non-availability of straight bole trees and also some extent because of a lack of knowledge. In other countries, *Prosopis* species are widely used for making furniture because of their high quality wood. The wood of *P. juliflora* is soluble to varying degrees in water, sodium hydroxide, alcohol and benzene, which means that it can be successfully pulped for the production of writing and printing papers, textile fibres, tyre cord or cellophane. Tests have indicated that writing and printing papers could be produced from *Prosopis juliflora* logs having 30 to 50 cm in girth with 50% cellulose and 30% lignin (Madan and Tandon, 1991).

Medicinal Value of *Prosopis*

In India, boiling wood chips, a bark extract is used as an antiseptic on wounds, and gum is used to treat eye infections (Vimal and Tyagi, 1986). Research done at Central Arid Zone Research Institute, Jodhpur (Azam *et al.*, 2011) resulted in identification of antioxidant compound which is present in concentrated form (6-8%) in the heart wood of *P. juliflora*. The compound was identified as (-)-mesquitol ($C_{15}H_{14}O_6$) which was compared with existing pharmacologically/therapeutically accepted antioxidant probucol and α-tocopherol and found that (-)-mesquitol is better than probucol and α-tocopherol drugs. *Prosopis* wood is reported to have medicinal value for treatment of rheumatism and against miscarriage. Some of the alkaloids of *Prosopis* species are reported to be antifungal and antibacterial. In Brazil, *P. juliflora* flour is used as an aphrodisiac, syrup as an expectorant and tea infusion against digestive disturbances and skin lesions (Rocha, 1990).

Use of *Prosopis juliflora* Biomass

Prosopis juliflora is an excellent candidate for short rotation energy plantations considering its fast growing nature, higher biomass production potential, drought and heat tolerance and excellent coppicing ability. It was reported that total biomass from *Prosopis juliflora* ranked first amongst the high biomass producing native trees of arid

and semi arid regions of India (Singh, 2008). It provide livelihood security to the rural population, settled in arid and semi arid drought prone regions. *Prosopis juliflora* trees maintain their greenery and continue to grow even during severest of the severe droughts in desert states like Rajasthan. Wherever thickets of *Prosopis juliflora* are existing in the country and there is danger of encroachments to agricultural fields, the trees can be harvested to generate electricity. Kuchh region of Gujarat has ample scope for electricity production as *Prosopis* thickets are naturally growing in this tract. Singh (2008) has made tentative calculations about electricity generation from biomass based upon pure gas mode technology revealed that 1.4 kg biomass is required to generate one unit of electricity. It indicates that 110 KWe plant will need 545 tons biomass per year when it runs for 16 hours a day for 300 days in a year. Cost of biomass based electricity generation will be around Rs. 5.75 per unit. *Prosopis juliflora* biomass is reported to be better for electricity generation because of higher heating value of its biomass.

Use of *Prosopis juliflora* Gum

Prosopis juliflora exudes gum from the sap wood. On average, about 40 g of gum is produced from one plant. However, under drought conditions more gum is exuded. A single person has been estimated to be able to collect 1-2 kg of *P. juliflora* gum/day in India (Tewari, 1998). The trade in exudate gum has been increasing in India, with *P. juliflora* gum estimated to make up approximately 80% of that total gum production in Gujarat (Tewari, 1998). *P. juliflora* gum exudation increased at higher temperatures and ceased completely at the beginning of the rainy season (Tewari, 1998). The gum forms adhesive mucilage, with favourable physical and chemical properties, that can be used as an emulsifying agent. *Prosopis* gum also finds use in confectionery, mending pottery, and as an adulterant and substitute for gum arabic. (Krochmal *et al.*, 1954). Owing to the high content of arabinose, which is easily separable, the gum has proved to be an excellent source of this sugar. Furthermore, the gum contains: D-galactose, 45%; L-arabinose, 24%; L-rhamnose, 13%; and glucuromic acid, 13.7%. It possesses fairly good adhesive strength and can be used as paper adhesive for brown paper and wall paper (Vimal and Tyagi, 1986).

Role of *Prosopis* in Carbon Sequestration

Prosopis trees and woodlands world-wide may account for a significant amount of sequestered carbon, though tree species in arid and semi-arid zones are not considered when calculating carbon balances at present. Felker *et al.* (1990) estimated that carbon stored as woody biomass was equivalent to 2-20 t C ha^{-1} in *P. glandulosa* stands in the USA, with an additional 1.4-18.4 t C ha^{-1} sequestered as reserves of soil carbon, assuming 25% canopy cover (Geesing *et al.*, 2000). While such data is expected to vary greatly between sites and species, they indicate the considerable quantities of carbon stored in

woody biomass and soil reserves. Even a single rotation of *P. juliflora* would lead to significant amounts of total carbon sequestered. Using the figures above, it may be estimated that *Prosopis* plantations could sequester carbon in excess of 1000 kg ha^{-1} yr^{-1}, with a yet unseen value in the emerging global market for 'carbon credits'. Arid zones presently contain the lowest levels of carbon in the world on a per hectare basis, and it is necessary to consider the role of arid zone forests in carbon sequestration on a regional and global level.

Soil Reclamation by *Prosopis juliflora*

Prosopis litter falling on the ground adds to the humus content of the salt affected soils. The organic acids produced from the decomposed litter react with native calcium carbonate and release calcium, which exchanges with sodium on the exchange complex. Being highly tolerant to soil sodicity, the *Prosopis* roots open up otherwise impermeable sodic soil and thus facilitate entry of water in the deeper layers. The carbon dioxide released by its roots during respiration interacts with water and produces weak acids like carbonic acid. Such acid facilitate dissolution of precipitated calcium carbonate already present in sodic soils. Thus, help in reclamation of the sodic soil. It reclaims the soil to such an extent that agricultural crops can be grown without amendments.

***Prosopis juliflora* Combating Desertification**

Desertification is an international problem and *P. juliflora* is solution to this. No single species should ever be seen as the sole answer but rather as a tool in the continuing fight against desertification, land degradation and resource depletion. Shelterbelts of *P. juliflora* and *P. pallida* are planted around fields in many semi-arid regions to reduce wind speed. This reduces wind-induced soil erosion, decreases desiccation by reducing transpiration and consequently increases plant and animal production. Shelterbelts can comprise one or more rows of trees, commonly three but up to ten. In India, shelterbelts of *P. juliflora* were found to have a positive effect in reducing soil erosion compared with other species and control plots. Gupta *et al.* (1983) noted a 36% reduction in the magnitude of wind erosion behind *P. juliflora* shelterbelts. Shankarnarayan and Kumar (1986) noted a decrease in area wind speeds of 33-38%, 17-26% and 12-21% at distances of 2, 5 and 10 times the height of the trees, with consequent reduction in the quantities of soil removed by erosive forces. In Sudan, wind speed was reduced by an average of 14% inside *P. juliflora* plantations, and with reductions up to 36% at high wind speeds (El Fadl, 1997). Seed disposal of this species on vast areas has helped natural regeneration and produced significant results in creating green belts and windbreaks to check the rapidly spreading problem of desertification.

Conclusion

Gone are the days when *Prosopis juliflora* was considered to be a weed. Due to its multiple uses, it has gained public acceptance as a plant of recognized economic value. Today it is the tree species utilized for its each and every part in various ways on a commercial basis. *Prosopis* pods are a good source of livestock fodder feed in drought prone areas which is cheaper, more nutritious and locally available fodder resource. Its larger branches and trunks yield a high quality timber, comparable in colour, finish and physical attributes to Indian rosewood and other commercial hardwoods. Fruit pods are high in sugar and protein and are a rich food source for man and beast. *Prosopis* exudate gum is comparable to gum arabic. *Prosopis juliflora* is hardest of the hard woods and most suitable for charcoal making and electricity generation. The tree has played a pivotal role in combating desertification and drought through its intensive plantation on refractory areas to enhance their eco-stability. Their importance is positive, in terms of the provision of raw materials, but also negative, in terms of weediness reducing agricultural productivity. Hence, time has come to pool the scientific and research findings for multiple agro-industrial uses of *Prosopis juliflora*. The inherent capacity and potentiality of *Prosopis* can be converted into an even greater asset besides generating tremendous local employment opportunities and numerous benefits through application of scientific and technical methods.

Future Possibilities

It is necessary to explore the feasibility of obtaining new products from *Prosopis juliflora* such as activated carbon, gas, organic acids, acetic acids, methanol, acetone, etc. through wood distillation. There is also a possibility of extracting carotene from its green leaves. The foliage, along with other organic matter, could be used as a green manure or compost.

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