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Prosopis juliflora

A Valuable Species for Arid and Semi-arid Tropics

Discussion Papers for

National Workshop on

Prosopis juliflora: Past, Present and Future

23rd & 24th March, 2011

Under

NATIONAL AGRICULTURAL INNOVATION PROJECT

COMPONENT - II

Organized by

CENTRAL ARID ZONE RESEARCH INSTITUTE, JODHPUR




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केन्द्रीय शुष्क क्षेत्र अनुसंधान संस्थान
(भारतीय कृषि अनुसंधान परिषद्)
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Message

Arid Zone, though bestowed with unique resources, has low productivity due to scanty precipitation, dominant sands terrain with poor soil fertility, high wind speed and others. In this situation, the perennial components are the first choice to improve the microclimate, on which further productivity improvement attempts can be possible. When our native perennials are very slow in growth, introduction of potential and adapted exotic is a must.

Prosopis juliflora is one such exotic, which spreads in the difficult areas like the arid region and supports livelihood of dependent community. But several characters of this species were / are under a topic of discussion to get introduced into new area. Understanding the ecological succession or explore it for its economic succession might be an option to utilize this species up to its potential. The present National Workshop on "*Prosopis juliflora*: Past, Present and Future" is a right platform to discuss the issues related to this species. It is also worthwhile to appraise the efforts put by the stakeholders.

I welcome the National and International participants and NAIP project team for the very best success of the workshop.

(M.M. Roy)

डॉ. टी. एस. राठौड़, निदेशक
Dr. T. S. Rathore, Director

शुष्क वन अनुसंधान संस्थान
(भारतीय वानिकी अनुसंधान एवं शिक्षा परिषद्
पर्यावरण एवं वन मंत्रालय, भारत सरकार की स्वायत्तशासी संस्था)
पो. ऑ. कृषि उपज मण्डी, नई पाली रोड, जोधपुर – 342005 (राज.)
ARID FOREST RESEARCH INSTITUTE
(Indian Council of Forestry Research & Education,
An Autonomous Body of the Ministry of Environment & Forests, Govt of India)
P.O. Krishi Upaz Mandi, New Pali Road, Jodhpur - 342005 (Raj).

Message

I am glad to know that the Silva section, CAZRI, Jodhpur is organizing two days workshop on *Prosopis juliflora* under the NAIP project. *P.juliflora* is a most extensively distributed woody species in arid and semi-arid tropics of India, but it is spreading like an invader. Once this species founds optimum soil and climatic conditions, it rapidly increases its distribution by changing the structure of vegetation complex and in due course of time the entire area will be dominated by this species. In turn, once established *P.juliflora* becomes difficult to remove completely. In this context, this species considered as a presence of needed tree in unwanted area. Since this species is potential to be exploited for its fuel wood and value added products from pod, it needs to be managed to offer maximum benefits which might be an appropriate strategy for its exploitation.

The present workshop and the topic chosen by the organizer has relevance in the present day context and I am sure that it will provide chance to understand and appreciate the management and their livelihood options offered by this contrary species.

I take this opportunity to convey best wishes for the success of this National Workshop.

T. S Rathore

(T.S. Rathore)
Director, AFRI

Content

Antimicrobial Activity of *Prosopis juliflora*

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Since the beginning of human civilizations, man has used different methods in the treatment and prevention of human ailments. Herbal medicine has been shown to have genuine utility and about 80% of rural population depend on it as their primary health care. Until natural products have been approved as new antibacterial drugs, there is an urgent need to identify novel substances active towards highly resistant pathogens. In the present investigation antimicrobial activity of julifloricine and juliflorine, alkaloids, isolated from *Prosopis juliflora* (common name: Angrezi Bawaliya), was studied in vitro against 10 human pathogenic bacteria at comparable concentrations of streptomycin, penicillin, gentamycin and tetracyclines. MICs of both the alkaloids against human pathogenic bacteria were determined as 1-20 µg/ml. The juliflorine alkaloid was found to be active against *Staphylococcus aureus, E. coli, Salmonella typhi* and *Streptococcus pyogenes.* In similar manner julifloricine alkaloid showed significant activity against *Enterobacter aerogenes, S. aureus, S. pyogenes, Bacillus subtilis* and *Klebsiella pneumoniae.* No significant inhibitory effect of both the alkaloids was found against *Pseudomonas aeruginosa* and *Proteus mirabilis.* All the tested antibiotics were able to give resistant pattern but some strains resistant to antibiotics were found susceptible to alkaloids.

Potential of Non-traditional Timber Species of *Prosopis juliflora* and *P. cineraria* for Handicraft and Other Small Scale Industries

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Prosopis juliflora (Swartz) DC, commonly known as Vilayti Babool has been well naturalized and spread over in the arid western parts of Rajasthan and Kutch region of Gujarat state due to its tremendous ability to colonize even edapho-climatically inhospitable sites. In Rajasthan state, Jodhpur and Jaipur are the major centres of manufactures and exporters of wooden handicrafts. Jodhpur alone is exported wooden handicraft worth Rs.1000 crores approximately (JHEA, 2010). Growing demand for manufactured products and preference for all type of handicraft resulted in consumption of more wood by the industries. For sustainability of these industry, there is need to substitute the traditionally used wood by lesser known, under exploited, locally available plantation grown timbers. *Prosopis juliflora* and *P. cineraria* were identified as potential to take up study for post harvest technologies and value addition by chemical/ preservative treatment to make suitable to use by the handicraft industry. The preservative treatment with chemicals, Copper Chrome Arsenic (CCA) and chloropyriphos was effective against insect pest attack. *Prosopis* wood treated with these chemicals in June, 2004 enhanced the resistance of wood to fungal and insect pest infection and there by increased durability and shelf life compared to control samples. Untreated wood of *P. juliflora* was not infected with any decaying agents till June 2009 after which decay was observed in the sapwood while damage was extensive in *P. cineraria.* Value added product like sofa set, utility box and pen/pencil stand have been made from treated wood of both the species. Treated wood is showing resistance till date indicating their potential for use as alternative wood in handicraft industry.

Bioresource Potential of *Prosopis juliflora* with Emphasis on Sustainable Livelihoods for Poor Rural Community

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It is a general belief that non-native or alien plants when they grow outside their natural adapted ranges and dispersal potential become invasive. These invasives are widely distributed in a variety of ecosystems throughout the world. Many invasive alien species support farming and forestry systems positively in a big way. However, some of the alien species become invasive when they are introduced deliberately or unintentionally outside their natural habitats into new areas where they express the capability to establish, invade and outcompete native species. According to International Union for Conservation of Nature and Natural Resources (IUCN), alien invasive species means, an exotic species which becomes established in natural or seminatural ecosystems or habitat, an agent of undesribale change which threatens the native biological diversity. Invasive species are therefore, considered to be a serious hindrance to conservation and profitable use of biodiversity, with significant undesirable impacts on the services provided by ecosystems. Alien invasive species there are supposed to have huge requirement and destructive modes of resource acquisition and consumption that would ultimately bring change in soil structure and nutrient composition, its profile, decomposition, moisture availability, etc. However, the case of *Prosopis juliflora* supposed to be an exotic, with proper management may turn out to be a in valuable resource.

Prosopis juliflora (Sw.) DC, (Velvet Mesquite), is an invasive phreatophyte evergreen, fast growing, drought resistant, widely distributed not only in India but also in other arid and semi-arid tropical countries. It is a highly esteemed fuel wood source in rural India and several tropical countries. It is the only exotic species capable of growing on a wide variety of soils and climatic conditions. It is a valued tree for shade, timber and forage. It is a thorny, deciduous, large crowned and deep rooted bush or tree which grows up to 10 m height or more, depending on the variety and climatic conditions. It is widely distributed in the dry tropical and sub-tropical regions of Central America and Northern South America . *P. juliflora* seedlings cultivated in hydroponics are able to bioaccumulate Ni, Cd and Cr. Pods are reported to adsorb significant amounts of toxic trace elements.

P. juliflora is an ideal species for stabilizing the pegmatitic tailings of mica mines in Nellore district of Andhra Pradesh, India. It is also helpful for reclamation of copper, tungsten, marble, dolomite mine tailings and is a green solution to heavy metal contaminated soils. It is An appropriate species for rehabilitation of gypsum mine spoil in arid zone; restoration of sodic soils. It out-performed all other tree species in sand dune stabilization. Mycorrhizae are reported to greatly improve the growth of *P. juliflora* on

high pH soils. *Prosopis juliflora* was able to grow satisfactorily without amendments up to pH 9. Arbuscular mycorrhizal inocula have been isolated from its rhizosphere (low cost agrotechnology) were found to accelerate the growth of other agroforestry and social forestry legumes in perturbed ecosystems. Mycorrhizae are reported to greatly improve the growth of *P. juliflora* on high pH soils. *Prosopis juliflora* was able to grow satisfactorily without amendments up to pH 9.

The gum of *P. juliflora* is a good encapsulating material. Cardamom (Elettaria cardamomum) essential oil microcapsules were produced using its gum. *Prosopis juliflora* foliage has allelopathic effects on seed germination and seedling growth of bermudagrass (Cynodon dactylon); three cultivars of Zea mays L. (R 796, Gohar, EV 1081), four cultivars of Triticum aestivum L. (Inqalab, Chakwal, Pak 81, Rohtas) and Albizia lebbeck (L.).

Cr is an essential mineral for ruminants in tropical regions. Its pods contain high Cr concentration (upto 150 ppb) Thus, supplements Cr in fodder for animals (goats) Cr requirement for animals is >0·1 ppm, while toxic level was 1000 ppm *Prosopis* wood provided valuable furniture items and supports cottage industries. *P. juliflora* seeds serve as alternate source of the galactomannans and possible to extract into water at room temperature. Galactomannans are water-soluble neutral poly-saccharides, composed of a linear mannan backbone bearing side chains of a single galactose unit. These have wide industrial applications, mainly as thickening and stabilizing agents in a range of applications. Its leaves are ground with tobacco (*Nicotiana tabacum,* L.) and lime and placed on painful tooth are for relief (Hebbar *et al.,* 2004). It also well known for its antibiotic and antibacterial properties. Polyphenols and tannins of medicinal importance have been reported from the stem bark and pods.

P. juliflora provides shelter and breeding ground to migratory birds. Classic example is Uppalapadu wetland nerar Guntur, Andhra Pradesh, India. Thus contributing to environmental protection and conservation. However, it has some biological characters that foster invasion, hence appropriate management practices are also needed to exploit its resource potential.

Prosopis juliflora and *Leptochloa fusca* association was successful for the restoration of salt lands. Therefore grass-legume-tree association need to be tested on different sites for remediation, if necessary with biotic and abiotic amendments. There are quite a few publications reporting its fly ash landfills revegetating potential following different amendments and Rhizobium inoculation. However, *P. juliflora* has some biological characters that foster invasion, hence appropriate management practices needed to be developed for recommending it for phytoremediation.

Prosopis juliflora based for phyto-products, environmental moderation, restoration of perturned ecosystems, cleanup of toxic metals and ecosystem services and sustainable livelihoods for poor rural community are presented with specific examples in this lecture.

Use of Unconventional Feeds (Corn Steep Liquor and *Prosopis juliflora* Pods) in the Diet of Caged Laying Hens

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The present experiment of feasibility of utilization of corn steep liquor (CSL) and *Prosopis juliflora* pods in the ration of caged layer was conducted at private poultry farm in a village Karamsad (Anand District).

A completely randomized design was used with four treatments viz. T1 : Control, T2: 5% CSL, T3: 10% CSL and T4: 10% CSL plus 10% *Prosopis juliflora* pods. The layer mash formulated was isonotrogenous and isocaloric and was offered ad lib. The nutrient requirements were met as per the recommendations of BIS (1992a,b) feeding standards. The feeds were supplemented with coccidiostats as well as vitamins and birds were vaccinated as per schedule. Total 624, 24 weeks old Babcock White Leghorn hens housed at the rate of four per cage were used. Hens were randomly assigned to four dietary treatments. Each treatment was replicated 13 times in each of three rows California cage system.

The observations on egg production, egg weight, egg quality, body weights, feed intake and feed efficiency were recorded from 25th to 72nd week of age. The metabolism trail was also conducted at the end of experiment to findout balance of nitrogen, phosphorous and calcium as well as metabolizable energy content of each diet. The organ weights, abdominal fat contents, composition of liver and muscle, was also studied. The economics of feeding and return over feed cost were calculated from the record of feed consumption and income realize from eggs and birds. All the data were statistically analysed.

The results revealed that egg production was maximum T4 (304.85±1.09 eggs per 329 days and 92.16±0.47 HH %) and minimum under T1 (288.62±1.59 eggs per 329 days and 86.12±0.80 HH %). Almost similar trend and values were also noted on hen day basis. Average egg production was signification different among all four treatment groups with highest value under T4 group and lowest in control.

The average egg weight for 329 days production was signification higher under T4 (57.98 g) than all other treatments. Similar trend was also noted for egg mass (HH and HD basis). Among various egg quality traits, albumen height, haugh units, yolk index, egg yolk colour and egg shell thickness were not significantly different due to inclusion of corn steep liquor and *Prosopis juliflora* pods in layer mash. The corresponding general mean values were 6.92 mm, 83.39, 0.39, 6.72 and 0.325 mm.

The egg composition traits viz. shell, weight, albumen: yolk ratio, yolk weight, albumen weight, dry matter, crude protein, ether extract, ash, calcium and phosphorus content of eggs did not differ significantly due to inclusion of various levels of CSL or *Prosopis juliflora* pods in layer mash. The general mean values were 6.06 g, 2.01, 16.37g, 32.72 g, 27.64, 10.96, 11.48, 1.41, 0.27 and 0.91 %, respectively.

Average daily body weight was significantly higher in control group over T2 and T3 treatments and the values were at par between T4 and control. Daily feed intake was significantly affected due to inclusion of different levels of corn steep liquor. It was highest in T4 (10% corn steep liquor + 10% *Prosopis juliflora* pods) followed by T3, T2 and T1. The values of T2 and T1 (control) were at par. The values of feed intake increased as the level of unconventional feed increased. Similar trend was also noted for g per kg metabolic body weight basis (g/kg 0.75). Feed conversion efficiency in terms of kg feed required to produce a dozen or a kg eggs was significantly higher in T4 group (1.38, 1.98, respectively) followed by T3, T2 and control (1.43, 2.12, respectively) groups.

The weight of heart, liver, gizzard, spleen, kidney and abdominal fat did not differ significantly due to inclusion of various levels of corn steep liquor and *Prosopis juliflora* pods in layer mash. The general mean values of these traits were 6.05, 37.04, 35.62, 0.73, 10.54 and 35.83 g, respectively.

The overall mortality per cent was very low during the considerable long period of (329 days) entire experiment. Numerically higher mortality rate was observed in T2 (3.84%) followed by T3 (3.20%), T1 (2.56) and the least in T4 (1.28%).

Average cost of feeding (Rs. per dozen eggs) ranged from 6.45±0.24 (T4) to 7.48±0.04 (T1). The differences in feeding cost were significant ($P<0.05$) due to inclusion of non-conventional feeds in layer mash. Return over feed cost (Rs. per hen) upto 72 weeks of age was maximum (Rs. 201.14±1.30) under T4 and minimum (Rs. 165.17± 1.85) under T1. Thus T4 layer mash economically more beneficial than the conventional layer mash.

The average N balance (0.90±0.10 to 1.11±0.12) and average Ca balance (1.24±0.18 to 1.70±0.16) were positive and more or less similar in all four treatment groups. However, P balance was found to be positive and significantly ($P = 0.05$) lower in T4 (0.66±0.014) than the other three groups. The metabolizable energy balance also did not differ significantly between four dietary treatment groups and the general mean value was 279.08 kcal day^{-1}.

From the above results, it can be concluded that inclusion of corn steep liquor and *Prosopis juliflora* pods each at 10% level in layer mash is economically advantageous without adversely affecting overall performance of caged layer birds. Corn steep liquor and *Prosopis juliflora* pods would thus be promising new feed ingredients for layer feed formulations.

Invasion of *Prosopis juliflora* in Indian Thar desert: Curse or Boon

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Prosopis juliflora is an alien invasive plants spreading throughout the Indian arid and semi-arid region lying under Thar desert and as well elsewhere in many states of India. Invasiveness of this plant is known to exert significant impact on the natural vegetation communities as they cause their displacement and hence exert imbalance in the natural and agricultural ecosystem. This discrepancy causes the formation of large monoculture of invasive plants in the alien environment. The plant affects not only the species diversity of the native areas, but also their ecological integrity. They grow fast, have, greater reproductive potential, competitive ability, high plasticity and allelopathy that make them successful invaders of non native habitat. Encroachments by woody species viz., *Prosopis juliflora*, have as became threaten to the natural pastoral production system in the areas. They may be responsible for a significant reduction in production potential of the rangelands. The biodiversity of the western arid Rajasthan has recently been threatened by encroachment by this woody species. The plant that has been widely spreading over the area at an alarming rate must have now exerted a substantial amount impact on the biodiversity of rangelands and arable lands. Wherever it invades the plant forms predominant exotic vegetation by replacing the indigenous grasses and other herbaceous plants that have for years been used for grazing. In addition, the plant makes land infertile and weakens the quality of grazing land, animal health, meat and milk products. It is imperative to identify rangeland species that may have the ability to resist or overcome the challenges of the plant, which is increasingly reducing the quality and quantity of the composition and biomass of the herbaceous species. The major problem facing the pastoral production in western Rajasthan is the wide scale degradation of native pasture encroached by *Prosopis juliflora*. Shrubby nature of the plant can also harbour feral animals such as pigs. This may in turn be a problem for livestock enterprise. In contrary, *Prosopis juliflora* is playing a vivacious role in supporting the livelihoods of the rural poor, including the landless, small farmers and artisans. The plant is the major source of fuel wood and fodder during the drought periods. *P. juliflora* provides shelter and breeding ground to migratory birds, thus, contributing to environmental protection

and conservation. Pods are among the earliest known foods of prehistoric man in the new world. Providing good bee pasturage also, nectar from plant yields a superior honey. Toasted seeds are added to coffee. The gum forms adhesive mucilage, used as an emulsifying agent. Gum is used in confectionary and mending pottery. Juice is used in folk remedies for that cancerous condition. The plant is a folk remedy for catarrh, colds, diarrhoea, dysentery, excrescences, eyes, flu, headcold, hoarseness, inflammation, itch, measles, pinkeye, stomachache, sore throat, and wounds. Recently, woods of the plant are being used for electricity generation and production of high quality wood charcoal. Thus, invasion of *Prosopis juliflora* in Indian Thar desert might view as both curse and boon.

Socio-economic Impact of *Prosopis juliflora* in Arid Zone of Rajasthan

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The north-western arid region receives low rainfall (100 mm to over 400 mm) high evapo-transpiration (>1700mm) and high temperature regime in summer (often maximum average day temperature >45°C) and cold winter (often average minimum night temperature <5°C). The *P. juliflora* is found on village command property and also up to some extent on the boundary of the farmers field. A study was undertaken to assess the socio-economic impact of *Prosopis juliflora* in arid Rajasthan. The data were from 120 farmers spread in five villages namely Khanpur, Golia, Gajipura, Kotra and Mandhara in Bhinmal tehsil of Jalore district of Rajasthan which were selected purposively. The results revealed that maximum number of household belonged to marginal and small farmers class. The family size was generally large (>7 members). The study revealed that in study area joint family system was prominent, however, a shift towards separate family is evident. It was also observed that buffalo population was dominant in comparison to cattle population. The trend clearly indicated the availability of more fodder and material for the concentrate. The results further revealed that maximum household were having family income between Rs. 3000-5000/- per month. Only 16% families belonged to higher income group i.e., having monthly income more than Rs. 10,000/-. *P. juliflora* is used by almost all the household for firewood purpose. In fact, this is the only source of fuel for the farmers. However, farmers allow their livestock to graze on fallen pods of the species. Some times, they also collect the pods for stall feeding of the animals with other fodders. The study further indicated some losses in crop production due to the presence of the species on boundary of the farm field.

In the target area, 1100 ha of land is under *Prosopis juliflora*, the population density is around 400 ha^{-1}. In other words, 440000 plants ha^{-1} in selected villages. These plants can produce 4400 t pods. The income generated from the collection of pods will be Rs. 8.8 m and will generate nearly 56,000 mandays in the selected villages. The expected increase in per household is around Rs. 6,000/- per year. Arid tropics lands of India have more than one million ha area under *Prosopis juliflora*. If 50% of the pods are actually collected, the estimated pod yield would be about 5 million tons (density=500 trees ha^{-1}), which can generate employment to the tune of 16 m mandays and can provide income to stakeholders nearly 5000 million rupees per year.

Prosopis juliflora: A Status in Different Forest Blocks of Rajasthan

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Prosopis is one of the most important tree genera in many tropical and subtropical regions of the world belonging to the family Leguminosae. The genus consists of 44 recognized species, of which 40 are native to the Americas. Among other four, *Prosopis africana* is native to Africa, whereas *P. cineraria, P. farcta* and *P. koelziana* are native to the near East and Pakistan, with the range extending into India for *P. cineraria* and into Cyprus and subtropical North Africa for *P. farcta. Prosopis* species are highly appreciated in their native range for fuelwood and excellent charcoal, whereas the pods of some *Prosopis* species have been a staple food for many indigenous peoples as it contains about 9-17% protein and 15-37% sugar. Because of high protein and sugar content domestic and wild animals uses pod of *Prosopis* as fodder and disperse the seeds of this species through their dropping in many natural and manmade habitats. Because of range of wide adaptability and absence of natural enemies in new areas, *Prosopis* spp. particularly *P. juliflora* has become a noxious weed in almost all habitats inviting criticism from farmers and pastoralists who want eradication of this species. Further, forests are not uncommon from infestation of *P. juliflora*, which may affect floral composition of these forests. Out of 27 districts covering 588 blocks surveyed, *P. juliflora* was recorded in the forest blocks of all districts except Pratapgarh. Diameter at breast height, height and crown diameter varied from 12.26 to 48.82 cm, 1.51 to 7.83 m and 2.63 to 9.00 m, respectively, whereas average basal area ranged 111.3 to 2252.8 cm^2 per ha. *P. juliflora* density and frequency of its occurrence (F) varied from 0.8 ha^{-1} and 2.78% in Sikar to 17.81 ha^{-1} (Pali) and 68.97% (Ajmer district), respectively. Abundance (A) was highest (i.e., 320.7 tree ha^{-1}) in Pali district. Greater than 0.05 value of A/F ratio indicated contagious nature of *P. juliflora*. Conclusively, 35.4% of forest blocks are infested with *P. juliflora*, which likely to increase in future.

Extent of Invasion of *P. juliflora* in Different Land Use Types in Barmer Region in Western Rajasthan

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Because of wide adaptability and absence of natural enemy species of *Prosopis* have become a noxious weeds spreading aggressively in natural and managed habitats. Many farmers and pastoralists made it clear that this plant is a cause for serious concern to their livelihoods and they are claiming that this plant is killing their animals and simply want its eradication. However, a widespread need for fuel wood, the main source of rural energy in dry region- one can imagine that *Prosopis* is regarded a redeemer or at least a valuable plant among the rural population, particularly poorer households. This manuscript is prepared based on a survey study conducted during summer of 2006 in Barmer, an arid district of Rajasthan to assess floral diversity in different land uses like community, forests and agriculture lands. Four hundred twenty one plots of 1 ha area were surveyed for tree species including *P. juliflora* covering 327 plots in agriculture, 78 plots in community and 16 plots in forest lands at three areas i.e., Kawas, Guda Malani and Sindhari. A total of 13 species were recorded. In this 12, 11 and 8 tree species were observed in Guda Malani, Kawas and Sindhari areas. Average of land uses for the areas, frequency of occurrence of *P. juliflora* ranged from 36.3% in Kawas to 19.8% in Shindhari areas, whereas density varied reverse in order i.e., 3.4 trees ha^{-1} in Kawas to 44.7 trees ha^{-1} in Sindhari area. Abundance of *P. juliflora* was 40.1 trees ha^{-1} in Kawas to 14.9 trees ha^{-1} in Guda malani area. Among the land uses, 43.7% community land, 31.8% forest lands and 10.6% agriculture lands were infested by *P. juliflora*. Here density of *P. juliflora* was 13.1 trees ha^{-1}, 60.2 trees ha^{-1} and 3.8 trees ha^{-1} in the respective land uses. However, abundance of *P. juliflora* varied from 17.5 trees ha^{-1} in agriculture land to 33.1 trees ha^{-1} in forest lands. Conclusively, *P. juliflora* infested all the types of land uses covering about 30% of the studied area and needs to be managed judiciously to control its spread and the negative impacts.

Floral Diversity in Geologically Important Bar-conglomerate Formation of Pali District of Rajasthan

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Floral study was conducted during March 2010 in the geologically important area known as Bar-conglomerate formations with varying types of rocks with a view to find out relations between vegetation with soil and the rocks from which the soil is formed. A total number of 11 plots of 0.1 ha were surveyed for trees and shrubs along a stretch of about 40 km and diversity status including status of *P. juliflora* measured and described here. Under shrubs and herbs were measured in an area of 1 m^2. A total number of 10 trees, 7 shrubs and 4 under shrubs/herbs were observed. Butea monosperma was greater in collar girth and 1st forking height, whereas *Acacia nilotica* was greater in height and crown diameter. The lowest growth variables were recorded for *Flacourtia indica.* Average population was highest for *P. juliflora* (i.e., 6.5 tree per plot) followed by *Z. mauritiana* (1.9 tree per plots) with an average population of 16.9 tree per plot for trees. There were 116.8 shrubs per plot and 4.8 herbs per plot. *P. juliflora* among tree, *Euphorbia caducifolia* and *Z. nummularia* among shrubs and *Tephrosia purpurea* among the herbs dominated the area. Frequency of occurrence, density and abundance was the highest for the *P. juliflora* and lowest for *Acacia tortilis,* a planted species. The diversity indices calculated for different plant forms indicated that highest and lowest species richness was for tree and shrubs, respectively, whereas Shanon-Weiner index was highest for shrubs and lowest for herbs. Species dominance was greater for herbs and lesser for shrubs as compared to the other plant forms. The evenness index was the highest for shrubs and lowest for the herbs. Conclusively, the area is diverse in terms of shrubs, but *P. juliflora* dominated in terms of frequency of occurrence, density and abundance, and needs to be managed in such a way to improve the diversity and productivity of indigenous vegetation.

Potential Use of *Prosopis juliflora* and Current Need to Explore Value Added by Products of the Tree

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Biomass considering as a renewable substitute for fossil fuels has several potential benefits which includes: reduction of greenhouse gases, recuperation of soil productivity and degraded land, economic benefits from adding value to agricultural activities and improving access and quality of energy services. Abellon Cleanenergy is focusing on Bio-energy – Biomass Pellet manufacturing as trade name "Pellexo", Bio-Power, Bio-fuels, and other forms of clean energy and value added product generation. Energy security is key concern and needs to be tackled before it becomes a crisis a few years from now. Hence fossil fuel combustion needs to be substantially reduced for three main reasons; energy security, human health and climate change mitigation. With reference to the search for bio-energy feed stock, *Prosopis* tree is considered to be the best candidate due to its fast growing, salt-tolerant and drought-tolerant capabilities that can grow in areas receiving less rainfall. Present work highlights the value chain potential of the *Prosopis* tree as bioenergy feed stock along with value added by products. Stem and leaves of *Prosopis* tree is having GCV (Gross calorific value) between 3500-4500 Kcal Kg^{-1} and ash content 4-0.5% which seems a good raw material for solid biofuel. Currently, India produces conventional bio-ethanol from sugar cane molasses and production of advance biothanol is still in the research and development phase. Using fermentation technology, potential part of the *Prosopis* pod that is mesocarp containing 45-50% of fermentable sugar is converted to bio-ethanol which can be used for transportation fuel after blending with conventional fuel. In our experiments 77% pure bioethanol was produced from mesocarp flour using distillery yeast. Same *Prosopis* mesocarp flour were also fermented by different yeast strains such as *P. stipitis, P. tannophilus* and *C. shetatae.*

Results indicate that variety of micro organisms are capable of fermenting *Prosopis* pod mesocarp with varying efficiency. To make a project viable value added product development and exploration of byproduct is necessary. So, post fermented residue was analyzed for their protein, crude fiber, fat and microbial count. Results indicate that it is rich in protein, fiber and has no negative sides to be explored as one of the most potential candidate for animal feed along with exocarp and endocarp of the *Prosopis* pod. Spent wash generated during down stream processing of fermented residues still containing nutrients that can be converted in to energy source by biomethanation, also explored as a liquid fertilizer for field crop. As per universal law of fermentation, 50% pure CO_2 will be generated during sugar fermentation by yeast. This CO_2 is being utilized as a carbon source to cultivate lipid rich algal cell during mesocarp fermentation. This tree plays a pivotal role in combating desertification and drought through its intensive plantation on refractory areas to enhance their ecostability.

Biomass Production and Equations for Predicting Biomass of Different Component of *Prosopis juliflora* Growing Naturally in Arid and Semi-arid Areas of Rajasthan

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Prosopis juliflora commonly known as 'Vilayati Babul' in India is one of the most important species of degraded lands of arid and semi-arid regions. Because of its wide adaptability it has occupied habitats of varying soils and terrains including degraded pastureland, forest lands and agriculture lands. Because of invasion in agriculture land and pasture lands, farmers and pastoralists are against this species despite a high potential of fulfilling fuelwood requirement and carbon stock generation for which the drylands are generally undermined. Though a lot of researches are their biomass equations are yet not available for this species in dry areas including arid ones. Accurate estimation of tree biomass is of fundamental importance in management of any silvicultural system and of regional carbon accounting. Thus aim of this study is to develop equations for predicting individual tree total biomass and economic wood biomass. During a study a total 34 trees of *Prosopis juliflora* were failed and roots were excavated from 7 districts of Rajasthan to observe biomass of different components like root (up to 0.5 cm diameter), stem and braches up to 2.0 cm diameter, twig (<2.0 cm diameter) and leaves. Collar diameter (D) of uprooted trees ranged between 3.10 and 23.90 cm, whereas tree height ranged between 3.10 and 9.60 m, which were used for developing equations. Linear and non-linear equations were used in finding out relationship between D and total biomass, aboveground biomass, root biomass and economic wood biomass. The developed equation i.e., Biomass = aD^b showed, in general, the best results, where a and b are regression constants. The expansion factors for foliage (twig and leaf) biomass and root biomass was also developed for accurate prediction of biomass of and carbon stock in *Prosopis juliflora* in Rajasthan.

In-silico Molecular Docking of Known PLP Ligand in Glutathione-s-transferases (GSTs) Protein

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Glutathions S-transferase (GSTs) enzyme found in *Prosopis juliflora* and Pyrodoxal-phosphate (PLP) is a prosthetic group of some enzyme. PLP play important role in heme synthesis, lysine catabolism. Conversion of the DOPA to Dopamine and conversion of the excitatory neurotransmitter GABA. In this study PLP Ligand mining form Glutathione S-transferases (GSTs) protein from homology based searching in PDB. Eleven reference protein (PDB: 3PSL, 3HQT, 3KKI, 2WK8, 3C30, 2WKA, 3P4F,3DWW,2WK7, 2WK9, 3C38) identified based on maximum structure similarity. Out of identical protein (2WK8 and 2WK9) above 90% (ABL Region) in the most favored regions according to Ramchandran Plot analysis with help of PROCHECK V3.4.4 which is based on Ramchandran Plot calculation. Finally, molecular docking performed by ARGUSLAB v4.0.1 docking tools. The method based on DOCK Engine server, flexible Ligand and DOCK calculation. We dock PLP molecule inside the cavity of GSTs protein based on argus DOCk engine best Ligand pose energy -8.4263.kcal/mol out of eleven GSTs proteins.

Prosopis juliflora: Implications for Economic Utilization in Arid Region

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Prosopis species are of great importance in arid and semi-arid regions of the world and are classified as life supporting species. *Prosopis juliflora* is one of the important species of genus *Prosopis*, has wide ecological amplitude. Wider ecological amplitude, tolerance to biotic and abiotic stresses coupled with the ability of fast growth, coppicing and dispersal lead to wide spread distribution of this species in arid and semi-arid regions. It thrives well on marginal lands, sandy, rocky and gravely wastelands and alongside roads and railways.

P. juliflora is source of fuel wood, charcoal, timber, fodder, gums, and valued as a species for soil conservation and aesthetic purposes. Presently bulk of the fuel wood demand of people in the arid and semi-arid tract of north western India is met by this species. It can also be profitably cultivated in different types of marginal, waste lands, salt affected soils. Despite economic and soil restoration advantages, this species has become a subject of controversy amongst scientists, social activists, environmentalists, agriculturalists and policy makers. Thorny nature, invasion habit and suppression of indigenous vegetation are major concerns about the species among stakeholders.

Farmers in the region prefer *P. juliflora* only on farm boundaries as wind break or live fence. There is need to strengthen the people participation and community management programme in order to manage the invasion of *P. juliflora* by utilizing its full potential for various purposes. Furthermore, there is necessity of co-ordination between inhabitants and policy makers with involvement of research organizations/social organizations to maintain its desirable density, and proper utilization for economic products and also to maintain biodiversity of arid region. Therefore, it is an urgent need to evaluate its negative and positive aspects and fine tune the management options to minimize its negative impacts, and harnessing its positive impacts with active participations of all stakeholders. There is ample scope to utilize it for waste land rehabilitations, energy plantations and creating vegetation cover in arid and semi-arid region.

Chemical Composition of Various Milling Products of *Prosopis juliflora* and *P. pallida* Pods

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The genus *Prosopis* contain 44 species, is spread over throughout Africa, South America and South and South-east Asia. It is native to Central and South America, now spread throughout the arid and semi-arid tropics. *P. juliflora* is an exotic in the Indian sub continent and has been introduced in India in 1857 from Latin America; the ruler of the princely state of Marwar introduced this plant into Rajasthan in 1913. This plant provides fuel, timber, and highly palatable and nutritious pods in large quantities which are avoidly consumed by domestic as well as wild herbivores; the flowers produce good quality nectar for honey and which is also consumed by birds. Considering its pods as an important source of nutrients for the livestock, the study was conducted to assess nutrient contents of *P. juliflora* pods and its products obtained by milling with multi-purpose plot thresher (MPPT) and full circle hammer mill (FCHM). For the comparison *P. pallida* pods have also been analyzed under this study. The mature *P. juliflora* and *P. pallida* pods, fallen on the ground were collected from the field, from Jodhpur and Jalore (Sanchor) in Rajasthan, and Kutch districts in Gujarat, both during summer and winter seasons. These pods then dried in the sun, milled by MPPT and FCHM, and analyzed for its approximate principals, viz., total minerals, ether extractives, crude protein, total carbohydrates and gross energy.

Chemical analysis of *P. juliflora* and *P. pallida* pods and its milling products revealed that whole *P. juliflora* pods contained 4.15% minerals and 12.8% crude protein, whereas, its epicarp had 3.75% total minerals, 9.75% ether extractives, 9.20% crude protein, 77.30 total carbohydrates and 464 kcal%, gross energy; mesocarp possessed 3.75% minerals and 9.20% crude protein. The smallest particles (<72 mash) of mesocarp contained highest level of total minerals (8.1%), ether extractives (6.65%), crude protein (10.37%) and gross energy (432 kcal%). These values showed decreasing trend as the particles size increases from <72 to >8 mesh. Total minerals and crude protein content of un-ripened *P. pallida* pods were higher than its ripened pods; minerals and crude protein levels showed decreasing trend as mesocarp particle size increased from <72 to >8 mesh. The data further indicated that minerals and crude protein content of *P. juliflora* and its milling products were higher than that of the whole pods and respective fractions of *P.*

pallida pods, however, a reverse trend has been recorded with the mesocarp fraction (<72 mash particles size) of these pods. The whole seeds contained 32.0% crude protein and 13.20% minerals, and the seed meal (de-gummed seeds) recorded as high as 44.00% crude protein, 8.35% ether extractives, 44.9% total carbohydrates, and 513 kcal%, gross energy and merely 2.77% minerals. The data further indicated that composition of the pod epicarp and its fibrous mesocarp fractions (>8 mash) are comparable with that of wheat bran, and of *P. juliflora* seed-meal is comparable with guar meal, therefore, in livestock feed formulations, wheat bran can be replaced with pod-epicarp and/or –mesocarp, and the guar meal with *P. juliflora* seed-meal.

Value Added Feed Products from *Prosopis Juliflora* Pod Milling Products

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Prosopis juliflora pods collected from the field were sun dried and processed using multi-purpose plot thresher (MPPT) and full circle hammer mill (FCHM). The fibrous-epicarp (A), endocarp (B) and amorphous-mesocarp (C) obtained by MPPT milling and fines (D) by FCHM milling were tried for production of multi-nutrient-feed blocks (MNB), multi-nutrient-feed mixtures (MNM), and supplement-fodder-block (SFB) and complete-fodder blocks (CFB). The chemical analysis of A, B, C and D milling products, on as such basis, contained 6.9, 7.1, 8.1and 6.3 % preformed water, and on dry matter basis, contained 95.3, 95.8, 94.0 and 92.4% organic matter, 4.7, 4.2, 6.0 and 7.6% ash, 7.37, 10.70, 12.76 and 13.9% crude protein, 3.92, 4.24 9.16 and 2.4% ether extractives, 84.41, 80.86, 72.05 and 76.1% total carbohydrates, and 425, 436, 467 and 417 kcal% gross energy, respectively. The standard formulation block (MNB-S), comprised of 44.5% molasses, 4.31% urea in 4.0% water, 4.3% each common salt, vitamin-mineral mixture and dolomite, 32.10% wheat bran, 5.10% guar meal and 1.0% guar gum dust, and the blocks in which wheat bran of MNB-S were replaced by A (MNB-A), B (MNB-B) and C (MNB-C) products, on as such basis contained 2.7, 3.0, 2.7 and 4% preformed water, and on dry matter basis, contained 78.3. 82.6, 82.8 and 84.1% organic matter, 21.7, 17.4, 17.2 and 15.9% minerals, 22.9, 20.7, 22.2 and 20.9% crude protein, 4.1, 7.0, 6.04 and 6.0 ether extractives, 51.3, 54.8, 54.6 and 57.2% total carbohydrates and 381, 411, 409 and 412 kcal gross energy, respectively. The chemical analysis of the MNB-S and the blocks produced from *P. juliflora* milling-products (MPs), i.e., MNB-A, MNB-B, and MNB-C indicated that moisture and protein content of both the types of blocks was comparable, ash contain was high in MNB-S than MPs, organic matter, ether extractives and total carbohydrates were appreciably high in MPs than MNB-S, which was reflected in higher gross energy content in MPs than MNB-S. The volume of MNB-A, MNB-B, and MNB-C blocks was 2300, 2500 and 1857 cu cm, and bulk density, 0.97, 1.02 and 1.16 gm/cu cm, respectively. These values were comparable with the MNB-S.

Similarly 3 formulations of multi-nutrient mixture using A, B and C products were developed. The standard nutrient mixture (MNM-S) contained 33.3% wheat bran (WB), whereas, the mixture produced from A, B and C (MNM-A, MNM-B and MNM-C) contained mixtures of 21.7% WB and 25.10% A, 20.4% WB and 25.5% B and MNM-C,

respectively. The chemical analysis of these mixtures revealed that moisture contain in all the mixtures were comparable, but ash content was high in MPs mixtures. The ether extractives of MNM-S and MPs mixtures were comparable but total carbohydrate and gross energy content of MPs mixtures were high, the protein content of MNM-B and MNM-C was also appreciably higher than that of MNM-A and MNM-S mixtures.

Attempts have also been made to develop formulations and technology for production of complete-fodder-block (CFB) and supplement-fodder blocks (SFB) using *P. juliflora* pod fines (D) obtained by its processing pods in FCH mill. CFB comprised of 90% D and 10% molasses, and SFB of 4.9% molasses, 2.0% urea, 1.5% each of vitamin-mineral mixture, common salt and dolomite, 8.2% guar meal, 73.5% D and 4.9% tumba seed cake. CFB and SFB on as such basis contained, 7.5 and 8.1% preformed water, and on dry matter basis contained, 91.7 and 92.4% organic matter, 8.5 and 9.9% ash, 1.6 and 2.0% ether extractives, 11.7 and 22.3% crude protein, 78.3 and 67.9% total carbohydrates and 406 and 415 kcal% gross energy. The results of the study indicated that *P. juliflora* milling products, A, B, and C can be used for production of multi-nutrient blocks and nutrient mixture, and the D can be used for production of CFB and supplement-fodder blocks for supplementation of critical nutrients to desert livestock. These products are not only nutritionally superior, but also cheaper over the standard formulation livestock feed-products.

Biomass Production and Carbon Stock of *Prosopis juliflora* and Dynamics of Soil Properties in Different Regions of Kutch, Gujarat

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Prosopis juliflora, commonly known as mesquite (USA), vern or vilayati Babul (India) was introduced to the Indian sub continent at Sind province in Pakisthan in 1877 from South America and later on it was introduced to other arid and semi arid regions of India. Due to its wider adaptability to different soils and landscapes in arid environments, it became one of the most important species for reclamation of degraded lands in the desert. In Kutch, it is widely distributed in almost all the taluqas especially in cultivable/non cultivable waste land and is used for fuel and soft coke (twigs), and cattle feed (mainly pods). As scientific documentation is meager on potential biomass production and its associated change in soil properties especially for Kachchh region of Gujarat, this study was undertaken to generate required information.

The investigation was carried out at selected sites of 4 talukas of district Kutch, Bhuj, viz., Bhuj, Mandavi, Banni and Naliya Bhuj, Gujarat (23° 12' to 23° 13' N latitude and 69° 47' to 69° 48' E longitude). The soil of the experimental site was gravelly sand in texture with shallow depth (21 cm), low in organic C (0.24%), available N (121 kg/ha), and P (3.21 kg/ha), and medium in available K (179 kg/ha) with pH 8.6. The region is characterized by low and erratic rainfall, high temperature, high wind velocity and high potential evapo-transpiration. The mean annual rainfall is 326 mm, the maximum summer temperature at the site is 45°C and minimum winter temperature is 1°C.

For biomass production, five trees of *Prosopis juliflora* (thorny) and *P. alba* (thorn less), established in 1995 at CAZRI, RRS, Bhuj were randomly selected and observations on height, girth at 50 cm above ground, number of stems, diameter at breast height (DBH), canopy cover and dry matter production (above ground) were recorded. Soil samples from different depths were collected from different sites and analyzed for organic carbon, pH and EC and bulk density. Soil samples from degraded land (without plantation) were also analyzed for comparison.

The data on growth parameters indicated that trees of *P. juliflora* were taller (3.75 m), had more girth at ground level (10.76 cm) and DBH (9.16 cm), more canopy cover (27.20 m^2) and produced greater dry matter (10.61 kg $tree^{-1}$) than those recorded by

P. alba. The corresponding values for *P. alba* were 2.92 m, 10.16 cm, 4.26 cm, 19.16 m^2 and 11.30 kg $tree^{-1}$, respectively. The biomass production per ha was computed for *P. juliflora* as 11.79 t ha^{-1} and for *P. alba* as 10.55 t ha^{-1}. The carbon stock of *P. juliflora* was in the range of 19.23 t ha^{-1} at Naliya to 95.45 t ha^{-1} at Bhuj.

The pH and EC (dS m^{-1}) values of soil ranged from 8.09 to 8.54 and 0.27 to 9.92, respectively, in different soil profiles under the plantation of *Prosopis* spp. The corresponding values for these parameters under degraded soil (without plantation) were 8.95 and 0.34, respectively. The organic carbon in the soil was higher (0.11 to 0.36%) under the plantation compared with that recorded under the degraded soil (0.07%). Thus, soil organic carbon improved considerably under the plantation of *Prosopis* spp, compared with that under degraded soils. It suggests that plantation of *Prosopis* spp in Kutch region will not only provide much needed fuel wood and fodder for animal but will also improve the fertility status of the degraded soils.

Invasion of *Prosopis juliflora* in Banni Region: GIS and RS Perspective

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The present study was carried out during the year 2009–2010 in Banni region (23° 19' to 23° 52' N; 69° 8' to 70° 11' E) covering an area of 2,61,772 ha of Kutch district. Banni is a mudflat located between Kutch mainland and Greater Rann of Kutch. Due to its alluvial nature and topographical conditions it used to be a very rich grassland supporting the livestock of not only Kutch but also the livestock from neighboring districts as well as states like Rajasthan and Madhya Pradesh. Presently the grassland is facing sever degradation due to *P. juliflora* invasion, salinity ingression, uncontrolled grazing, immigration of livestock and climate change.

The Gujarat State Forest Department had planted initially about 31,550 ha exclusively of *P. juliflora* in 1960s as a measure to check the advancement of the Rann. The arid and semi-arid Banni provided more suitable condition for the growth and extension of the hardy *P. juliflora*. Currently, *P. juliflora* is rapidly invading in Banni grasslands and the traditional pastoral land as well as grass with other good vegetation area has encroached hundreds of kilometers away from the earlier.

Indian remote sensing satellite IRS – IC and 1D data is used for the present study which has spatial resolution of 23.5 m. The Banni was falling under 2 scenes of cloud free satellite data of path (89 and 90) and row (55). The FCC (False Colour Composite) and subset of Banni from satellite data were prepared with the use of ERDAS IMAGINE (9.3) and Arc GIS (9.3) image processing software. On the basis of field data ground control points (GCP) and differences are recorded as tonal/colour or density variations on the imagery. The supervised classification method was used at 1:50,000 scale for analysis. This study was undertaken to show the expansion of *P. juliflora* in Banni grassland by using LISS III IRS 1C and 1D data of post monsoon years 1997 and 2009.

In the present study, it was found that in Banni is *P. juliflora* dominant area is about 86,569 ha, followed by Grass with sparse *P. juliflora* (44,091 ha) and *P. juliflora* with other vegetation (43,867 ha). *P. juliflora* was dominant in all good grassland areas of Banni i.e. Luna, Chhachla, Sargu, Daddhar and Lakhabo area. The highest *P. juliflora* density was recorded in Misariyado Panchayat (2508 trees ha^{-1}) while low density was recorded in Berdo Panchayat (95 trees ha^{-1}).

A comparative analysis of area under *P. juliflora* dominance showed that during 1997 it was about 10% of the total area of Banni and in 2009 it increased to 32.52% at an alarming rate of 4,540 ha $year^{-1}$ (45% per year), which indicates aggressive encroachment of *P. juliflora* and decline of the native flora. Earlier, remote sensing data predicted that the expansion of the species in the Banni area of Gujarat is at the rate of about 25 km^2 per year and by the year 2020 more than 56% of the area would be under *P. juliflora* (Sastry *et al.*, 2003).

This analysis through the integration of GIS and RS technologies clearly indicated that the once Asia's finest grassland in Banni region is gradually being taken over by the aggressively invading *P. juliflora*, playing pivotal role in degradation of the grassland which in turn is affecting ecology as well as livestock based economy of the region.

Prosopis juliflora-A Protector of Desert Vegetation

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Prosopis juliflora was introduced to Sind (Pakistan) in 1877 and later on in many parts of the country and has proved useful as a pioneer tree to improve degraded lands. The then ruler of Jodhpur state introduced it in 1913 in many arid and semi arid parts of Rajasthan with a great success. The state government declared this species a "Royal Plant" in 1940 and exhorted the public to protect it. It also encouraged large scale planting with this species.

It proved to be the most versatile plant for afforestation on shifting sand dunes, coastal sands, eroded hills and river beds, saline terrains, dry degraded and wasteland with scanty and erratic rainfall. *P. juliflora* is a true gift from Heaven which provides green fodder from leaves and concentrated fodder from pods. It grows well in regions with 150-600 mm rainfall. It is a fast growing and reproduces by coppicing and through root suckers. It is profusely growing on vast wasteland and quality of feed supplies through pods and its good quality fuel wood produced in short rotations. It is a boon to the desert dwellers, therefore remaining always in great demand in most parts of the arid and semi-arid regions. Although it is an introduced tree species, it is now well adapted to the Indian dry zones.

It can be grown as a tree, a shrub and as a hedge. It is a useful sand binder and has established as reputation as good and fast growing species for reclamation of degraded grasslands and wastelands where no other valuable tree species would easily grow. It a drought resistance and tolerates mild frost and has the ability to withstand adverse conditions. Beside its various uses, it acts as a protector of natural vegetation as during cold its branches are cut everyday to fulfill fuel wood requirement by local poor people and if this tree was not there then there are a great chances that people might cut down the local tree like khejri *(Prosopis cineraria)* and other which could be a more dangerous scenario to the local biodiversity of the desert. It can be said that it is a protector tree of local desert vegetation.

Natural Germination of *Salvadora persica* Under *Prosopis juliflora* in the Protected Conditions on Arid Salt Affected Soils in Jodhpur, Rajasthan

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Prosopis juliflora is a xerophytic and is adapted to many soil types under a wide range of moisture conditions. The value of the tree lies in its exceptional tolerance of drought and marginal soils. *P. juliflora* is highly allelopathic and does not allow the growth of any other species. Leaf extracts and leaf leachates of *P. juliflora* are inhibitory. Decaying leaves are also inhibitory at early stages of decomposition. Live roots are not found to be inhibitory in co-germination and interplanting of seeds. Chemical investigation of the extracts showed the allelopathic compounds to be phenolic in nature in the species. Slow decomposition and heavy accumulation of leaf litter below *P. juliflora* may possibly result in accumulation of toxic substances in soil layers, inhibiting growth of other species. In this communication, a natural germination of *Salvadora persica* under *P. juliflora* was observed in experimental area of arid salt affected soils.

A *Salvadora persica* plantation has raised on a saline alkali lithic, calcid, coarse sandy to loamy sand soil in Gangani, Jodhpur in the year 1997. The soil pH ranged from 8.2 to 9.8 and EC from 4.2 to 16 dS m^{-1}. The area was fenced and was having *Prosopis juliflora* along the fences. Natural germination of *S. persica* seedlings from the seeds of experimental trees was observed under the trees of *P. juliflora* found along the fence first time in 2007, ten years after the plantation of *S. persica*. Seedlings were observed under 35.7% trees of *P. juliflora* out of which 15.7% seedlings survived and matured to grown up plants in 2011 four year after their emergence. Natural germination is also observed under the experimental trees of *S. persica* (facultative halophyte) and *Suaeda nudiflora* (Succulent halophyte), but these seedlings did not survived probably high EC may have resulted in it, while EC under *P. juliflora* is less. Thus, *P. juliflora* helped in natural germination of *S. persica*.

Prosopis Juliflora – A Wonder Tree for Avifauna in a Wetland Ecosystem

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Water is essential for life on earth, so is the case with wetlands. They are the ecotones which provide sustenance to more than 40% of the biodiversity. *Prosopis juliflora* is one such vegetational component that essentially enriches the wetland ecosystem by its exhaustive presence especially when soils are saline. The many fold attributes of *Prosopis juliflora* can be innumerated at large but the species is also associated with myths and doubts. So far the past has been experimental and present seems to be bitter but future has to be decided on the basis of its large data base which in actual may be able to project the reality of its existence as weed, invasive or beneficial.

Prosopis juliflora is a wonder tree especially in wetland ecosystem in particular for avian diversity. In arid lands where due to high evaporation rate most wetlands become hyper-saline progressively, the only tree species, which thrives well is *Prosopis juliflora* and in many ways harbour and support large number of species of animal biota. Most important among them is the avifauna. Large number of avian species uses *Prosopis juliflora* for heronries. The older trees of *Prosopis juliflora* are the most suitable roosting and nesting sites for birds as big as Black-necked Stork. Raptors too find an elevated vintage point from where they prey upon animals in an open water spread zone of wetlands. Besides, the tree has ability to fix nitrogen in soil thereby enhancing the capacity of water inundated areas for production of blue-green algae which becomes a component of food web for majority of wetland birds. *P. juliflora* species as vegetational component of most lands whether fellow, waste, forest or agricultural, has significant rôle to play along with its other attributes of various nature.

Prosopis juliflora can sustainably be utilized for developing suitable habitat in a wetland ecosystem for most aquatic and wetland dependent birds including waterfowls. The present study highlights the various role of *Prosopis juliflora* in supporting faunal diversity in a wetland ecosystem.

Do *Prosopis juliflora* (Swartz) DC Withstand Climatic Aberration in Semi-arid Regions of Central India? A Case Study from Bundelkhand

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Extreme winter conditions resulted in large losses of life, both human and animal, as well destruction of crops in different parts of world. *Prosopis juliflora* (Swartz) DC know to grow in harsh weather conditions characterised with rigours droughts, extreme temperatures and low and scanty rainfall. *P. juliflora* known to tolerate day time shade temperatures of over 50°C, and soil temperatures in full sunlight as high as 70°C in Africa and Asia. The tree is generally frost hardy; however few forms exhibits tenderness to frost and none will survive at -5°C. *P. Juliflora* seedlings were killed by a -2°C frost in Spain, while *P. Juliflora* was noted to suffer frost damage but survive when temperatures fell below 0°C in India.

Prosopis juliflora (Swartz) DC., more akin to Australian form, has colonised on the parched tank bed at Central Soil & Water Conservation Research & Training Institute Research Centre, Datia, since 2002. It has grown lavishly from year to year over five hectare of area. Average height of the stand is 4.95m, average girth 15.11cm and carrying growing stock of 121m^3 ha^{-1}. In the year 2011, the winter minimum temperature dropped down to -1.5°C in the month of January, which was record lowest temperature and lowest monthly mean minimum temperature (3.2°C) since last two decades in the region (Table 1). Low temperature associated with frosty weather prevailed over first two weeks of January 2011. Die-back of *P. juliflora* was observed in low lying depressions on the dried tank bed in third week. Complete die-back up to around 96% covering almost five hectare was observed from fourth week of January. *P. juliflora* die-back has been attributed to extreme low temperature recorded from -1.5°C to 3°C during first 12 days of January (Fig.1 & 2). Low temperature is known to cause physiological drought inside plant system. Low lying areas usually hold higher level of soil moisture coupled with low temperature prevailed for a considerable period might be the reason for freezing of available soil moisture to the plants. Later on, it was observed that plants have been recuperating from the central axis since first week of March 2011. No die-back symptoms were observed in plants grown at higher elevation in the adjoining area. This kind of effect has been noticed in Datia district of Bundelkhand region for the first time.

P. juliflora gaining importance in many afforestation ravines and achieving livelihood security in different developmental programmes. The tree is an aggressive

invader and coloniser covering fairly extensive tracts with its abundant natural regeneration in a short time. Thus, the attention of scientific community is required with great gusto for further research on effect of climatic aberration and recommendation to policy makers, as well as farmers.

Table 1. Meteorological parameters for the last five year (2007-11)

Meteorological parameters		January				
		2011	2010	2009	2008	2007
Rainfall (mm)		0	2.2	2.0	0	0.0
No. of rainy days		0	0	0	0	0
Mean max. temp. (°C)		20.7	21.0	24.0	23.0	24.1
Mean min. temp. (°C)		3.2	6	6.9	4.9	5.9
Mean wind velocity (km hr^{-1})		2.1	2	0.5	0.9	1.8
Av. daily bright sunshine (hrs)		7.6	6.8	6.7	5.1	8.8
Av. daily evaporation (mm)		2.8	2.2	2.1	2.4	2.8
Relative humidity	07.19 hrs	92.8	93	94	82	84
	14.19 hrs	44.3	53	46	28	29

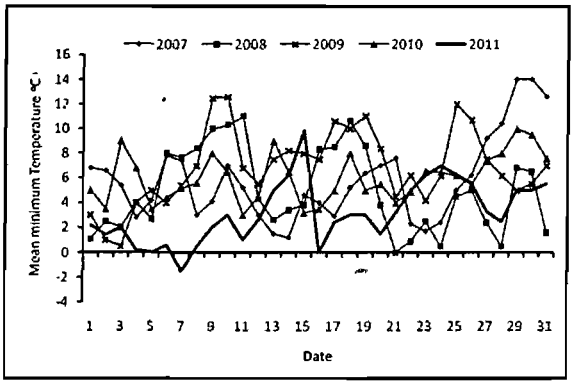

Fig. 1. Variation in mean minimum temperature for the month of January during last five years

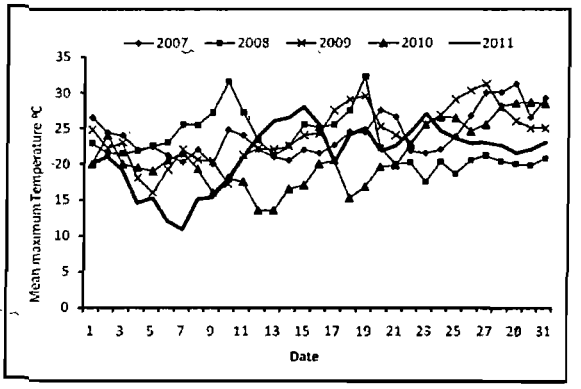

Fig. 2. Variation in mean maximum temperature for the month of January during last five years

Formulation and Evaluation of Cheaper and Balanced Concentrate Mixture Containing *Prosopis juliflora* Pods in Lactating Tharparkar Cattle – Before Sale/Commercial Production

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A cheap and balanced concentrate animal feed mixture for arid region was prepared utilizing the locally available feed resources. It was prepared by simply mixing the ground feed ingredients including *Prosopis juliflora* pods powder (PJPP), Tumba *(Citrullus colocynthis)* seed cake, Guar *(Cyamopsis tetragonaloba)* korma, Til *(Sesamum indicum)* seed cake, Wheat bran, Maize grain common salt, mineral mixture as per requirement, with a spade, and filled in gunny bags for storage. The balanced concentrate mixture prepared had 20% crude protein and 73% total digestible nutrient (TDN) and costs Rs.9.5 per kg. Farmers readily accept this process technology since it is easy to process, requires minimum labour and energy inputs and raw ingredients are easily available at livestock owners' doorstep. To reduce cost of cattle production, feeding trial and digestibility trial of this cheaper concentrate mixture was conducted on lactating Tharparkar cattle at Research cum Demonstration Unit of Tharparkar cattle, KVK, CAZRI, Jodhpur.

Twelve (12) lactating Tharparkar cattle were randomly divided into three groups of 4 each forming (T1), (T2) and (T3) groups. T1 group cattle were maintained on standard palleted concentrate feeding during morning and evening as per requirement with six (6) hour grazing on Cenchrus ciliaris dominated pasture and water ad libitum. T2 and T3 groups' cattle were fed as per requirement with cheaper balanced concentrate mixture along with roughage-massor *(Lens esculentus)* straw. The major observations recorded were monthly live body weights, daily concentrate feed intake, blood parameters- haematological and biochemical, daily milk yield with quality analysis at weekly interval for fat and SNF and health check by veterinarian. The initial live body weights (kg) of T1,T2 and T3 group was 330.6±15.32, 384.75±29.51, 352.75±16.45 and final weights were 315.58±10.96, 369.26±14.11, 344.0±30.51 respectively. Most of the animals in all the three groups had parturition in-between November 2009 to March 2010; however, they maintained their live body weights and their body weights are comparable among the groups in a given period of time.

The fat and SNF% of milk of all three groups T1, T2 and T3 showed no significant difference in quality. The fat percentage in T1, T2 and T3 ranged from 3.13± 0.23 to 4.58±0.13; 3.4±0.01 to 5.8±0.97; 3.08±0.32 to 4.80±0.12, respectively whereas

SNF% ranged from 7.96±0.15 to 9.76±0.19; 7.71±0.75 to 9.90±0.07; 7.93±0.15 to 9.73±0.14 in T1 T2 and T3 groups, respectively. They varied with the stages of production and season.

Blood was collected at monthly intervals from all experimental animals in the morning before feeding from the neck by jugular vein puncture. Blood was examined for haemoglobin (gm%) and then plasma was separated for biochemical parameters i.e., glucose, total protein, albumin, blood urea nitrogen, cholesterol, creatinine, calcium and inorganic phosphorus. All these blood parameters were in normal range and showed non significant difference between T1, T2 and T3 groups. The blood study showed that animals had normal body functions and lactating Tharparkar cattle maintained normal health. The average milk yield of T1, T2 and T3 groups were calculated and was 19% higher in T3 than T2 and differs significantly. During the experiment calving Interval of animals of T1 and T2 had non significant difference, while T3 had significantly longer calving interval than T1 and T2 groups. Digestibility trial was conducted for T2 and T3 groups' animals after the year long feeding trial. The data of dry matter consumption of all the animals in the feeding trails were pooled and palatability scores were calculated as dry matter intake (DMI) which was noted as 2.85 and 3.0 kg per 100 kg body weight for control and treatment groups respectively. The average water intake-animal^{-1} day^{-1} of T1 and T2 were 45.0±0.38 and 44.0±0.77 liters respectively. The study showed non-significant difference of water intake between the groups. The digestibility coefficient of nutrients was comparable between the groups.

The scientifically formulated cheap and balanced concentrate ration reduces cost of milk production and showed comparable digestibility of this ration with fairly good nutritive value. The milk yield of cattle fed on *Prosopis juliflora* pods containing concentrate mixture was significantly increased; however the calving interval of this group was also extended. The result showed that inclusion of *Prosopis juliflora* pods in concentrate mixture had no adverse effect on health, reproduction and production. It can hence be concluded that this process technology of hand mixing feed ingredients involving minimum labour, machine, electricity and energy inputs utilizing *Prosopis juliflora* pods is quite feasible for livestock owners' to economize livestock production.

Prosopis juliflora: A Social Asset for the Rural People and Ecological Threat to the Forests in Southern Districts of Tamil Nadu

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Prosopis juliflora (Seemai Karuvel), an evergreen species, native to the South and Central America and the Caribbean, is a fast growing, tolerant to arid conditions and saline soil was introduced in India during the 1870s' to meet the fuel wood demand and in Tamil Nadu the 1960s', particularly in the composite south districts viz., Ramanathapuram and Tirunelveli. Presently in Ramanathapuram district alone, it has commanded an area of about 52,000 hectares. Due to the fast growth, multi stem, higher calorific value it is still considered as potential fuel wood by rural folk but the environmentalists express concern that it has impacted the eco-systems, particularly the marine eco-system like the dry evergreen forests of Point Calimere Sanctuary.

It is true to state that this species provide livelihood support to the southern Tamil Nadu district rural poor due to the secure employment by goat rearing, grazing, felling of *Prosopis* coppices shoots, fuel wood collection and selling, charcoal making, and its related activities. Due to the above potentials of this species, people of that region allowing this tree to colonize itself in the wastelands/vacant lands. So, management plans are required for this region to exploit this species up to its potential and control its invasion in to precise ecosystems.

Some of the Advantages and Disadvantages of *Prosopis juliflora* in Arid Rajasthan

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Prosopis juliflora was introduced in arid Rajasthan in 1913 by the ruler of then the princely state of Marwar with the objective to increase greenery and biomass particularly on degraded and wastelands of arid zone. During about last 100 years, the species has been naturalised in arid zone and found every where including sand dunes, eroded hills, river beds, saline terrains, etc.

The species is thorny in nature and its leaves are in general not edible to animals providing self protection properties to this species. In general, the plant is bushy in nature and its drooping canopy sweeps the ground therefore, it does not allow growing other plants in its vicinity. The pods are edible to animals. Grazing animals consume all most all the ripen pods found on the ground and helping in the propagation of this species by droppings their excreta during movement on the grazing lands. Presently, the species is increasing its own through grazing animals at a very faster rate particularly on grazing land, Orans, Gauchars, forest land, along the road sides, etc.

It is very hardy and fast growing species has high regeneration ability also. It is producing lot of biomass being used for bio-fuel and charcoal production. It has become an integral part of socio-economic and cultural web and a source of livelihood support for resource poor families in arid Rajasthan. It is being established by farmers on farm boundaries to develop bio-fencing to protect their crops by stray animals and also from wind strokes.

Its wide spread on grazing lands has synchronised the grazing resources therefore aversively affecting animal health and production. It has become an alternate host of several pests of crop plants particularly white fly, which is causing threat to successful crop production.

Now, there is a need to develop utilization aspect of tender pods of *P. juliflora* like Sangri and Ker. Also there is a need to develop thorn less Prosopis species.

Prosopis juliflora: A Useful Tree in Dryland Ecosystems

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Prosopis juliflora (Sw.) (Mimosaceae) commonly known as mesquite is a shrub or small tree. Perennial deciduous thorny shrub or small tree, to 12 m tall; trunk to 1.2 m in diameter, bark thick, brown or blackish, shallowly fissured; leaves compound, commonly many more than 9 pairs, the leaflets mostly 5-10 mm long, linear-oblong, glabrous, often hairy, commonly rounded at the apex; stipular spines, if any, yellowish, often stout; flowers perfect, greenish-yellow, sweet-scented, spikelike; corolla deeply lobate. Pods several-seeded, strongly compressed when young, thick at maturity, more or less constricted between the seeds, 10-25 cm long, brown or yellowish, 10-30 seeded. Seed compressed and oval or elliptic, 2.5-7 mm long, brown It has become *Prosopis* species form a major component in dryland ecosystems in the Americas, Africa and Asia as it is fast growing, hardy and drought-resistant tree with remarkable coppicing power.

Probably ranging from Tropical Thorn to Dry through Subtropical Thorn to Dry Forest Life Zones (with little frost), mesquite is reported to tolerate annual precipitation of 1.5 to 16.7 dm, annual temperature of 20.3 to 28.5°C, and pH around neutral.

Mesquite pods are among the earliest known foods of prehistoric man in the new world. Today flour products made from the pods are popular, although only sporadically prepared, mostly by Amerindians. Pods are made into gruels, sometimes fermented to make a mesquite wine. The leaves can be used for forage. Providing good bee pasturage also, nectar from mesquite yields a superior honey. The wood is used for parquet floors, furniture, and turnery items, fencepost, pilings, as a substrate for producing single-cell protein, but most of all for fuel. Toasted seeds are added to coffee. Bark, rich in tannin, is used for roofing in Colombia. The gum forms adhesive mucilage, used as an emulsifying agent. Gum is used in confectionary and mending pottery. Roots contain 6-7% tannin, which can be used for dying.

Fast-growing, drought resistant, and with remarkable coppicing power, *Prosopis* is a natural fuelwood candidate. With specific gravity 0.70 or higher, the wood has been termed "wooden anthracite", because of its high heat content, burning slowly and evenly and holding heat well. This species provides >90% of the fuelwood in some Indian villages. Although no direct data on N-fixation of *Prosopis* are available, however, tree legumes (exclusive of Caesalpiniaceae) can fix between 155 and 580 kg ha^{-1} yr^{-1}. Soils under the crowns of legumes in the desert usually have 10 times more N (0.3%) than those under non nitrogen fixers (0-03%).

Per 100 g, the flower is reported to contain (ZMB): 21.0 g protein, 3.2 g fat, 65.8 g total carbohydrate, 15.5 g fiber, 10.0 g ash, 1,310 mg Ca, and 400 mg *Prosopis* Leaves contain 19.0 g protein, 2.9 g fat, 69.6 g total carbohydrate, total carbohydrate, 21.6 g fiber, 8.5 g ash, 2,080 mg Ca, and 220 g P. Fruits contain 13.9 g protein, 3.0 g fat, 78.3 g total carbohydrate, 27.7 g fiber, and 4.8 g ash. Seeds contain (ZMB) 65.2 g protein, 7.8 g fat, 21.8 g total carbohydrate, 2.8 g fiber, and 5.2 g ash. Another analysis of the fruit shows 14.35% water (hygroscopic), 1.64% oil, 16.36% starch, 30.25% glucose, 0.85% nitrogenous material, 5.81% tannin-like material, 3.5% mineral salts, and 27.24% cellulose. Mesquite gum readily hydrolyses with dilute sulfuric acid to yield L-arabinose and D-galactose and 4-o-methyl-D-glucuronic acid at 4:2:1. Owing to the high content of arabinose, the gum is an excellent source of sugar. Roots contain 6.7% tannin, bark 3-8.4%, and dry wood 0.9%. The alkaloids 5-hydroxytryptamine and tryptamine are reported from this species.

The juice used in folk remedies for cancerous condition called "superfluous flesh." Mesquite is a folk remedy for catarrh, colds, diarrhea, dysentery, excrescences, eyes, flu, headcold, hoarseness, inflammation, itch, measles, pinkeye, stomachache, sore throat, and wounds. Aqueous and alcoholic extracts are markedly antibacterial.

Many alkaloids such as *juliflorine*, *julifloricine*, *julifloridine*, *juliprosine*, *juliprosinine*, *juliflorinine*, *3'-oxojuliprosopine*, *sceojuliprosopinol*, *3-oxojuliprosine* and *3'-oxo-juliprosine* have been isolated and their growth inhibitory activity has been reported against fungal diseases of crop plants. *julifloravizole* a novel alkaloid from leaves of *P. juliflora* was reported broad spectrum antifungal activity against species of *Fusarium*, *Drechslera* and *Alternaria*. Considering the availability of many biologically important alkaloids in the leaves of *P. juliflora*, the pooled alkaloid extract could be used against important phytopathogen.

Prosopis juliflora - A Tree for Prosperity of Arid Lands

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Prosopis juliflora, an evergreen multipurpose exotic tree species of family leguminosae has adapted to diverse habitat and spreading fast country wide, despite the factors like climate change. It is also proving the theory of survival of the fittest. The *Prosopis juliflora* once introduced at the time of drought is now considered as invasive, is an issue of benefit or detriment. The studies in some arid regions of Rajasthan however reveals that *P. juliflora* is a life-line and supporting livelihood not only for the rural masses especially the people below poverty line but also a tree sustaining vast biodiversity in desert and saline arid wastelands. It is in fact a boon to the arid environment. *P. juliflora* has a variance in size of inflorescence and also deviation in other growth parameters of tree including density and diversity of plant and animal association at different place.

In the preliminary studies made so far on associated floral diversity and density of *P. juliflora* in orans, gochars, reserved forest lands, saline lands, wastelands, water bodies and agriculture fields, 12 tree species and 11 other plant species were found associated with it. Among the faunal diversity component, five groups of faunal elements including annelids, soil arthropods and entomofaunal invertebrates and three major groups of vertebrates were found associated with *P. juliflora* in Rajasthan. The present paper discusses the importance of *P. juliflora* in harbouring biodiversity, thriving well in degraded community lands and as a source of livelihood. *P. juliflora* should be looked as a species for the future prosperity of arid lands as it still opens avenues for research, improving environment of saline wasteland; supporting livelihood and bio-resource and a tree for producing bio-energy. With the increase in number of bio-fuel plants in Rajasthan, large scale biomass of *P. juliflora* will be required and hence a site specific management programme needs to be developed so as to meet the future requirement.

Prosopis juliflora: A Valuable Shrub for Arid and Semi-arid Regions

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Prosopis juliflora (Sw.) DC (Vilayati Babool), member of Mimosaceae family, native to South America, Central America and the Caribbean, is a perennial deciduous thorny shrub with fast growing, hardy, drought-resistant and remarkable coppicing power. 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 and semi-arid zone and survived where other tree species have failed. Today it is the tree species utilized for its each and every part in various ways on a commercial basis in arid and semi-arid regions. *Prosopis* pods contain: protein, 16.5%; fat, 4.2%; carbohydrate, 57%; fibre, 16.8%; ash, 5.4%; calcium, 0.33%; phosphorus, 0.44% 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. *Prosopis* pods are a good source of livestock fodder feed in drought prone areas which is cheaper, more nutritious and locally available fodder resource. Fruit pods are high in sugar & protein and are a rich food source for man and beast. Roasted pods provide substitute for coffee powder. *Prosopis* exudate gum is comparable to gum arabic. Nectar from *P. juliflora* yields a superior honey. The wood is used most of all for fuel but also for parquet floors, furniture, turnery items, fencepost, pilings, etc. Its larger branches and trunks yield a high quality timber, comparable in colour, finish and physical attributes to Indian rosewood and other commercial hardwoods. Writing and printing papers could be produced from *Prosopis juliflora* logs having 30 to 50 cm in girth with 50% cellulose and 30% lignin. *Prosopis juliflora* is hardest of the hard woods (density more than 300 kg m^3 and specific gravity 0.70) and most suitable for charcoal making and electricity generation. *Prosopis* bark extract is used as an antiseptic on wounds, and gum is used to treat eye infections. Considering the availability of many biologically important alkaloids in the leaves of *P. juliflora*, the pooled alkaloid extract could be used against important phytopathogen. Although no direct data on N-fixation of *Prosopis* are available, however, tree legumes (exclusive of Caesalpiniaceae) fix N between 155 and 580 kg ha^{-1} yr^{-1}. Soils under the crowns of legumes in the desert usually have 10 times more N (0.3%) than those under non nitrogen fixers (0-03%). Organic acid produced from litter of *P. juliflora* facilitate dissolution of precipitated calcium carbonate already present in sodic soils. Thus, help in reclamation of the sodic soil. Due to fast growing nature and higher biomass production potential, a considerable quantity of carbon could be sequestered in

woody biomass of *Prosopis juliflora*. The tree has played a pivotal role in combating desertification and drought through its intensive plantation on refractory areas to enhance their ecostability. 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. There are a much more possibilities to explore the feasibility of obtaining various new products and services from *P. juliflora*.

NOTES