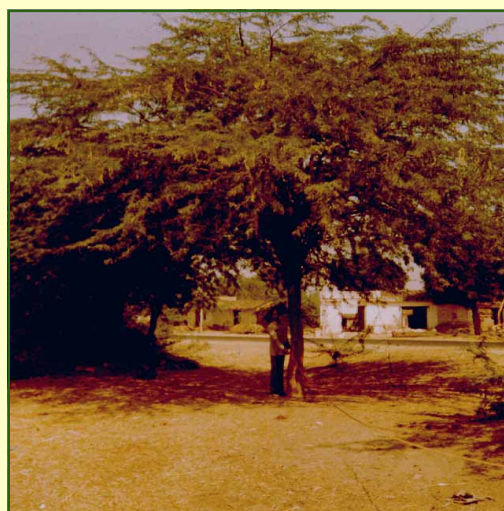


Managing *Prosopis juliflora* (Vilayati babul)



A Technical Manual

INTRODUCTION

India covers an area of 3.29 million km². Of this total, 51% is characterised as arable land, 16% as forest, 4% as permanent pasture and other grazing land, and 29% as degraded land unsuitable for cultivation. The eco-climate of the country varies from extreme arid to super humid. The arid and semi-arid regions together constitute over 40% of the country's total land surface and are spread over ten States (Table 1). The climatic conditions in these areas do not support much growth and regeneration of plant species. Consequently, the vegetation is quite sparse. The forest cover in arid and semi-arid tracts of India varies from 1 to 10%. Furthermore, the forests in these regions are not species rich.

Table 1. Extent of arid and semi-arid regions in India.

State	Percentage of total land area	
	Arid	Semi-arid
Andhra Pradesh	7	14
Gujarat	20	9
Haryana	4	3
Karnataka	3	15
Madhya Pradesh	0	6
Maharashtra	<1	20
Punjab	5	3
Rajasthan	61	13
Tamil Nadu	0	10
Uttar Pradesh	0	7

From time immemorial, human populations in arid and semi-arid regions have used the forest/woody resources freely for subsistence agriculture and for other small-scale economic activities like iron working and carpentry. Trees in the farming systems of arid and semi-arid tracts supply considerable amounts of timber, fuel and fodder. However, with ever increasing human and livestock population pressure during the last half century, deforestation has reached an alarming stage. This state of affairs has created a wide gap between the demand and supply of forest products. For example, the availability

of fuelwood from legitimate resources in India during 1980 was 17 million m³ against the actual demand of 184 million m³. The demand is expected to increase to 225 million m³ by the year 2001. Since wood remains the main source of cooking fuel for about 70% of the population, it is obvious that much of the wood comes from illegitimate felling and cutting of trees. Though this trend is similar for the entire country, it is particularly so in arid and semi-arid regions.

Since colonial times, planners, policy makers and forestry experts have given much emphasis to introducing fast growing and well adapted exotic woody species from iso-climatic regions of the world into arid and semi-arid India. Some of these exhibited remarkable adaptability and growth in their new habitats. *Prosopis juliflora* (Swartz) DC is one of these species that has performed much better than many native woody species. At the moment, *P. juliflora* provides approximately 75% of the fuelwood needs of rural people in arid and semi-arid regions of India. The species has become naturalised and has spread over the greater part of north-west, central, west and south India.

With its tremendous ability to adapt to arid and semi-arid environments, and its fast growth and multiple utility, it has long been recognised by foresters as a versatile species for afforestation. However, rural people in arid and semi-arid regions of India are a little apprehensive of this species as (i) they consider that the species adversely affects crop growth and production; (ii) there is a fear that it may become a weed; and (iii) the thorny stems and branches of the species often cause injury to humans and animals, and hinder agricultural operations.

Whatever advantages and disadvantages may be associated with the species, *P. juliflora* has become a prominent woody species in agro-ecosystems of arid and semi-arid regions of India. The species is used widely in plantation forestry activities in wastelands, village common lands, grazing lands, along railway lines and roads, canal and village pond banks, and degraded forested lands. Moreover, natural regeneration is profuse throughout the entire arid and semi-arid regions of the country.

Although *P. juliflora* is of great importance to most rural communities in arid and semi-arid tracts of India, its full potential in the rural forestry sector has not been realised to the extent that it deserves. In particular there is a need to increase the level of information related to plantation,

management and utility of this multipurpose species among rural communities and developmental agencies such as state forest departments, agriculture departments, district rural developmental agencies and non-governmental organisations.

This technical manual on *Prosopis juliflora* provides basic information and guidance to rural people and to those who instruct farmers and land managers on the use of this species in various environments and agricultural settings. The manual aims to (i) provide techniques for nursery production, out-planting, plantation care and management of the species, and (ii) guide the users regarding utilisation of the species. The techniques described may also be suitable for management and processing of other tree species with similar characteristics.

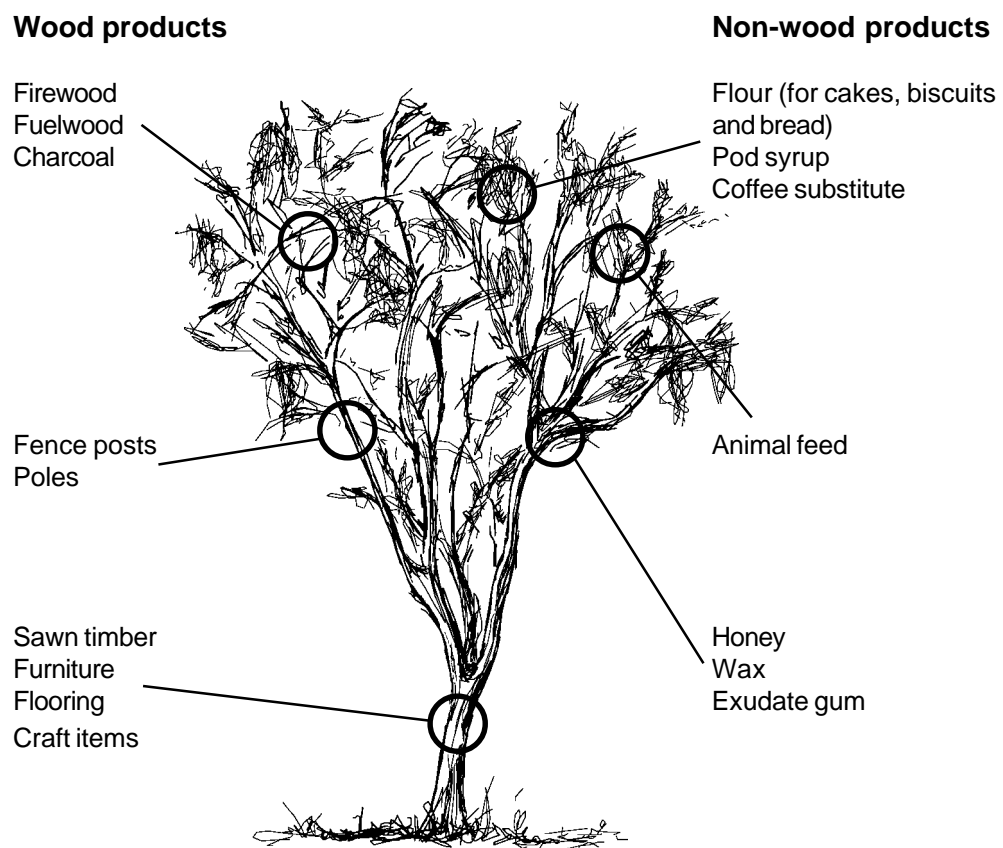


Figure 1. Successfully marketed *P. juliflora* and *P. pallida* tree products.

I. DISTRIBUTION OF *PROSOPIS*

The history of the first introduction of *Prosopis juliflora* into India is about 130 years old. Introduction of the species was first seriously attempted in 1870. Owing to its fast growth and drought hardiness, the species has since been introduced in many other parts of India from the north-west to extreme southern parts. The species proved its potential as a versatile plantation forestry species from the very first introduction and has been grown in highly saline areas, alkaline soils, coastal areas, sand dunes of the Thar desert, in ravines of many north, central and south Indian rivers, and in dry and degraded grasslands.

P. juliflora has become an acclimatised exotic in large parts of arid and semi-arid tropical India (Figure 2). It is found especially in areas with 150-750 mm mean annual rainfall and maximum shade temperatures of 40-45°C. From north-west to south, the species is distributed from the States of Punjab to Tamil Nadu, and in an east-west direction, it is found from Kutchh region of Gujarat State to drier parts of Orissa. The States where it mainly occurs are: Andhra Pradesh, Delhi, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Tamil Nadu and Uttar Pradesh. The domain of the species in arid and semi-arid tropical regions is mostly in plains and valleys but in many places it grows at altitudes of up to 1200 m above mean sea level.

Box 1. The potential for *Prosopis*.

Salt affected lands in India account for ten million hectares (ha). Thirteen million ha of wastelands in arid and semi-arid tracts can support plantations of drought hardy woody species. Thus, 23 million ha are readily available for plantations of *P. juliflora*. Considering an average production (a conservative estimate) of about 3 m³ per ha, the annual production could be approximately 70 million m³, which represents about 250% of the current annual production of fuelwood from forest resources in the country.

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. However, in Kerala, and

also in Bihar and Orissa, farmers use the species as a live fence around fields and farms.

The most abundant distribution of this species is found in the Kutchh 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. Block plantations of the species are very few but the species is planted systematically along road sides, railway lines, canal banks, village pond sides, village common lands and farm boundaries.

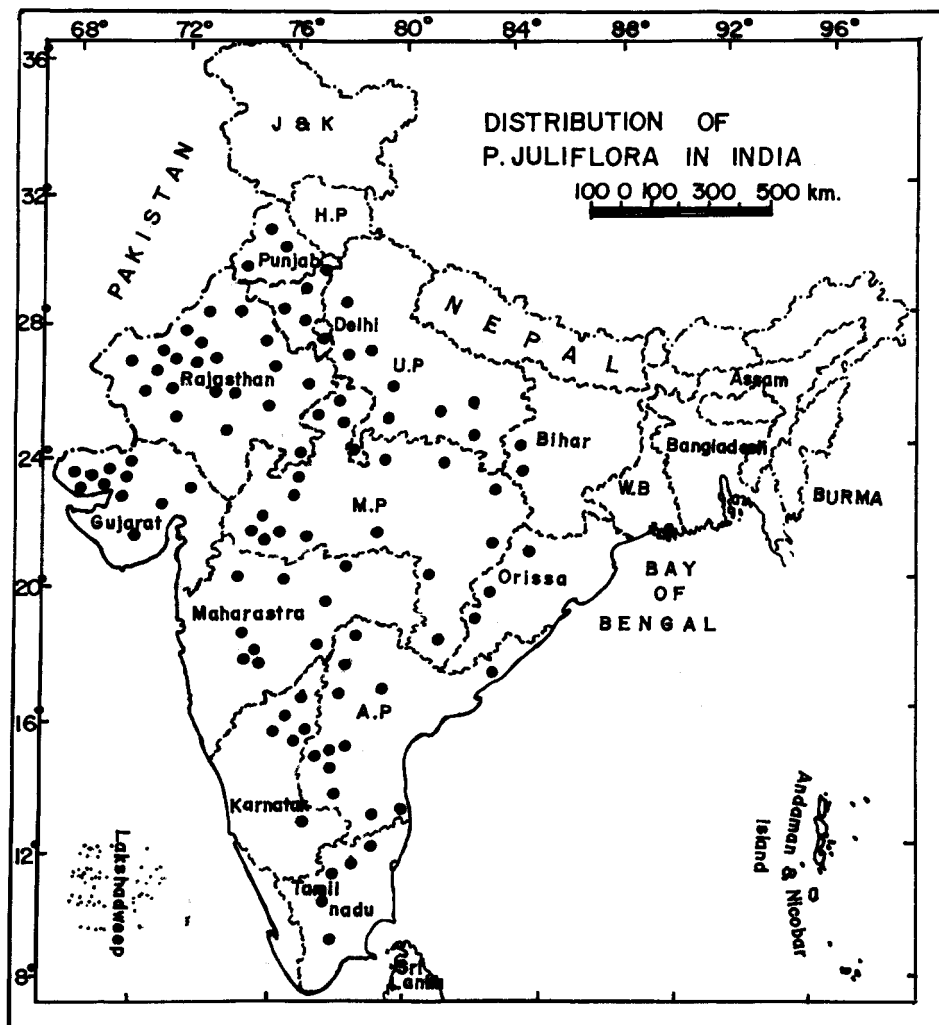


Figure 2. Distribution of *P. juliflora* in India.

Box 2. *Prosopis* advancement in Kutchh.

The State Forest Department of Gujarat initially planted exclusively *P. juliflora* on about 31,550 ha of Banni grasslands of Kutchh to check the advancement of Rann. The prevailing conditions in Banni, including successive droughts, increasing salinity and excessive grazing pressure, provided a highly suitable environment for the growth and spread of the hardy *P. juliflora*, which is today a dominant species of the vegetation complex. In fact, it ranks first in terms of distribution, abundance and aggressive encroachment of rangelands. It has been reported that the area under *P. juliflora* has increased from 378 to 684 km² (an 81% increase) in 12 years (i.e. 1980-1992). Analysis of remote sensing data clearly stated that the species is expanding in the Banni area at a rate of about 25 km² per year.

P. juliflora occurs most frequently as bushy thickets, and dominates wastelands and degraded grazing lands, around river beds, roads, railway lines, canals and other fallow lands. Farmers do not allow the species to grow on cultivable land because of its strong and sharply pointed thorns and also because of their apprehension that the species adversely affects crop growth and production.

In addition to *P. juliflora*, a few other exotic *Prosopis* species, mainly of Latin American origin, *P. alba*, *P. chilensis*, *P. glandulosa*, *P. flexuosa*, *P. nigra*, and *P. pallida* have also been introduced into India. However, the history of introduction of these species is only a few decades old. To date, most planting of these species is still at an experimental stage in the premises of research and development institutions. This manual deals mainly with *P. juliflora* but, when this species was introduced, many seeds of other exotic *Prosopis* species like *P. chilensis*, *P. alba* and *P. pallida* were mixed in the seed lots. On close examination of *P. juliflora* stands, from north-west to extreme southern parts of India, one can find the individuals of other exotic *Prosopis* species scattered here and there along with *P. juliflora*. As the taxonomy of the genus *Prosopis* is very complex and confusing, an understanding of at least basic structural features of the various species to differentiate them is required. However, it is beyond doubt that, today, *P. juliflora* is amongst the most widely distributed woody species in India.

II. THE INTRODUCED *PROSOPIS* SPECIES

This section aims to provide users with a brief guide to the genus *Prosopis* and especially *Prosopis juliflora* for correct identification. The distinctive features of some important introduced *Prosopis* species in India are described.

The genus *Prosopis* is widespread and consists of 44 species, mostly thorny trees and shrubs. The area covered by the genus spreads over dry tropical and sub-tropical regions of America, Africa and Asia. In India, besides the introduced *P. juliflora*, the most commonly occurring *Prosopis* species is *P. cineraria*, which is indigenous to Indian sub-continent.

To recognise the different introduced exotic *Prosopis* species in India, features have been identified by studying samples from several plants for each species. However, these features are intended only as a guide, as variations are encountered among individuals. Therefore, to identify a species, samples from several individual plants should be studied and compared with identification features of each species.



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Figure 3. *P. juliflora* near a household in a village.

A. *Prosopis juliflora* (Swartz) DC

Common names: Mesquite and honey mesquite (English-USA), algarrobo (Spanish-Latin America), vilayati babool (Hindi), vilayati khejra (Hindi, especially Haryana), vilayati kikar (Marathi), angrezi bawaliya (Marwari), gando baval (Gujarati), belari jari (Tamil).

Features

In areas where it is widespread, *P. juliflora* commonly takes the form of a spreading shrub. This is due to the fact that people cut the plant for fuelwood as soon as it reaches 1-1.5 m high and new coppice shoots emerge in the subsequent growing season. However, the tree form is also common (Figure 3).

The species seeds prolifically and has tremendous regeneration capacity, and can withstand droughts even at seedling stage. Where most other species fail to withstand drought and environmental harshness, *P. juliflora* can successfully establish and colonise wastelands and other similar habitats.

Stems and leaves

In India, the shrubby thicket form with spreading branches is common. The stem height of these shrubs varies but generally ranges between 1 and 3 m. The tree form varies from 4-12 m or sometimes even more (especially in valleys, areas with more moisture and also in well protected areas). The clear bole length of tree forms range from 1-3.5 m. The tree bark is 2-3 cm thick, grey or dark purple with a blackish tinge, splitting off in long strips. Branches have thorns which are usually paired, straight and up to 5 cm long. The branchlets are zig-zag, cylindrical, green and spiny with persistent, green foliage. These are typical features of shrubby thicket forms. The dark purple wood is very hard.

Leaves cluster on short shoots along the branches. They are bipinnate, with 13-25 pairs of obliquely oblong, dark green leaflets per pinna (Figure 5). The leaflets are generally 5-24 mm long, 1.5-5.2 mm wide and spaced along the rachis usually at a greater distance apart than their width.

Flowers

Inflorescence is an axillary spike, 8-10 cm long and bearing greenish-white flowers that turn light yellow when mature. Plants start flowering at three or four years of age. The calyx is five-toothed, campamelate, one mm long. The corolla is pentamerous free, tomentose, on the inner surface towards apex. There are five stamens which are 3-6 mm long. The plant flowers three times a year, in August-September, November-December and February-March. Trees usually start flowering earlier in the south than in the north. The fruits or pods from August-September flowering mature by early November and those from November-December flowering ripen by late February to early March. The pods from February-March flowering mature by early May. Thus the plant appears to be flowering almost any time of the year except from hot summer (May) to mid rainy season (August).

Pods and seeds

The pods are usually flattened and straight, but incurved at the apex. Some pods may be sickle shaped. In general, pods are 6-30 cm long, 5-16 mm wide and 4-9 mm thick. With age, the pods swell and become pulpy and yellowish brown in colour. The prominent outline of seeds in immature green pods is no longer discernible in mature pods. The endocarp may have up to 29 rounded, rectangular segments, each carrying a seed. The seeds are hard, flattened, 7 x 4 mm in size and ovoid, and have shiny yellowish brown colour.

B. *Prosopis pallida* (Humboldt & Bonpland ex Willdenow) HBK

P. pallida is native to Peru, Colombia and Ecuador and was introduced systematically in India only two decades ago. However, a few plants are found in old and dense *P. juliflora* thickets in arid regions of India. Seeds of this species may also have been mixed in with *P. juliflora* seed lots during introduction. At Jodhpur (Rajasthan), it was first systematically introduced in 1985 in an experimental plantation and a second experimental plantation was established in 1991. Other experimental plantations of the species are located at Karnal (Haryana), Lucknow (UP) and Phaltan (Maharashtra). The species is a valuable shade tree in dry areas and its pods are used for forage.

Common names: Algarroba, algaroba, huarango (Spanish-Latin America), Peruvian *Prosopis* (English). In India those who can differentiate introduced *Prosopis* species call it thornless vilayati babool.

Features

It appears that *P. pallida* has the best tree form among the introduced *Prosopis* species in India. In a decade-old plantation at Jodhpur, some individuals have attained a height of 10 m. The collar diameter is on average 20 cm. The species is a prolific pod/seed bearer.

Stems and leaves

The plant is reported to assume a height of 8-20 m with a trunk of 60 cm in diameter in favourable and protected sites. The majority of accessions introduced in India are not armed with spines and, therefore, are often referred to as thornless exotic vilayati babool. In other types, branches have paired and axillary spines which are less than 4 cm long. In India, they are less than 1 cm long, but thorns are not common in any plantations of the species raised so far.

Leaves and leaflets of *P. pallida* are much smaller than those of *P. juliflora*. There are up to 4 pairs of pinnae per leaf (Figure 6), but in the majority of cases only one pinnae is observed. The pinnae are 1.5-6.2 cm long with a cup shaped gland at the junction with the petiole. There are 6-15 pairs leaflets per pinna. The leaflets are arranged very close on the rachis but they do not touch at any point. Leaflets are oblong to ovate and 2.4-8 mm in length and 1.2-4 mm in width.

Pods are straw-yellowish in colour. They are straight or curved and resemble *P. juliflora* pods but they are relatively thicker. They are 9-24 cm long, 1-1.4 cm broad and 5-9 mm thick. The segments of the pods are broader than they are long. There are up to 28 oblong seeds in each pod. Seeds are brown in colour and their length is about 6 mm (Figure 4).



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Figure 4. *Prosopis pallida* showing position of seed.

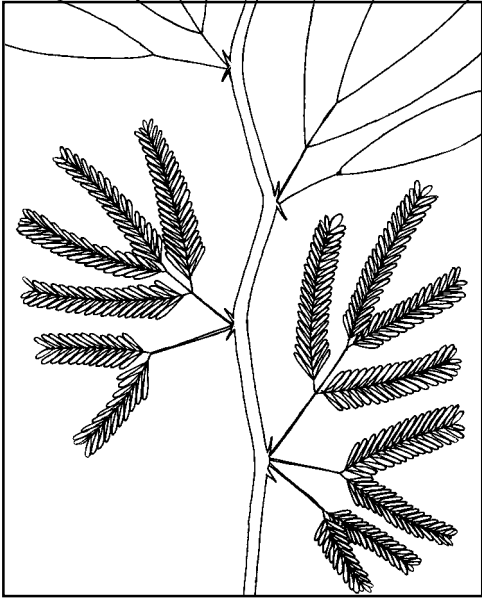


Figure 5. *Prosopis juliflora* (x 0.3).

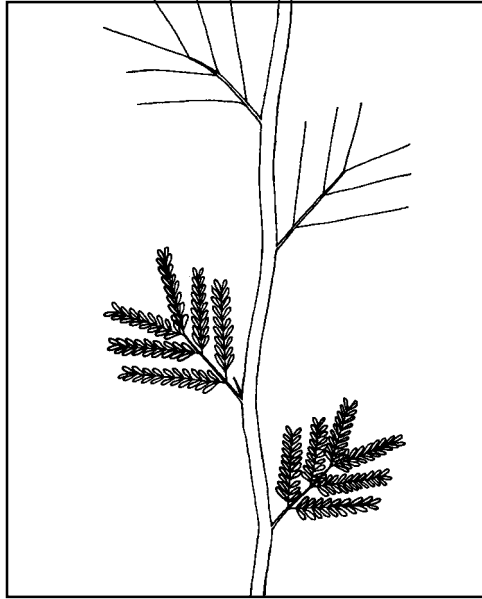


Figure 6. *Prosopis pallida* (x 0.3).

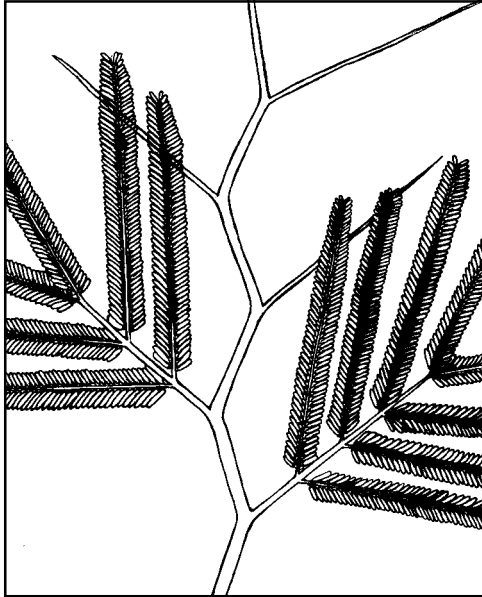


Figure 7. *Prosopis alba* (x 0.3).



Figure 8. *Prosopis chilensis* (x 0.3).

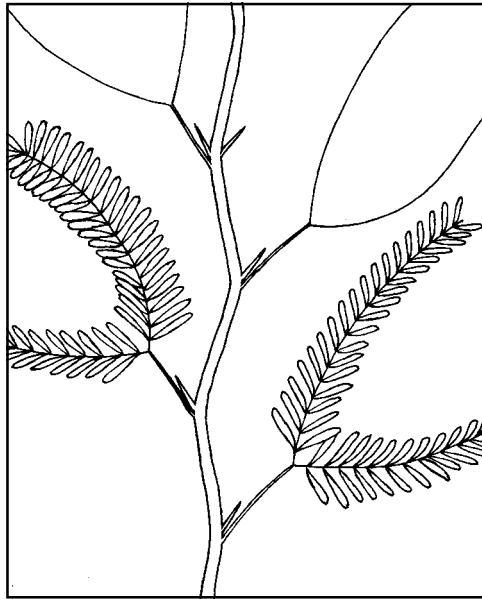


Figure 9. *Prosopis glandulosa* (x 0.3).

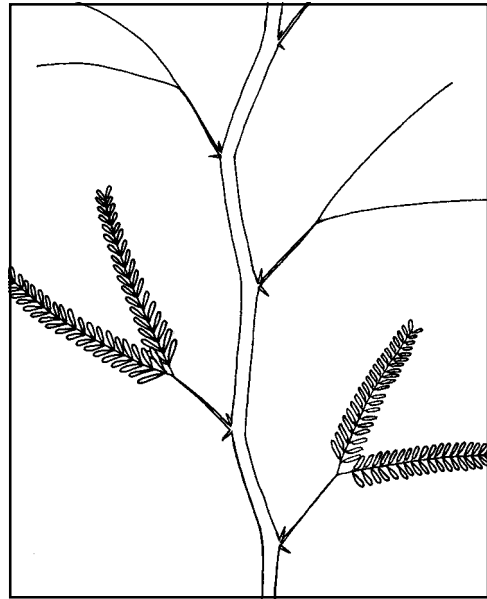


Figure 10. *Prosopis flexuosa* (x 0.3).

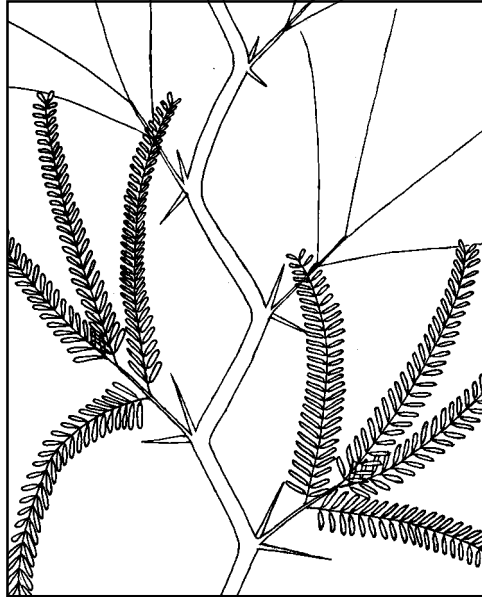


Figure 11. *Prosopis nigra* (x 0.3).

C. *Prosopis alba* (Grisebach)

Common names	Algarrobo blanco (Spanish Latin America), alba (India).
Form and size	Tree form, 7-15 m high and 45-48 cm diameter.
Leaves	Leaflets are much smaller than that of <i>P. juliflora</i> , with many more pinnae. 3-4 pairs pinnae per leaf.
Spines	Hardened stipules, paired, small and scarce and found only in strong shoots. Spineless trees have been found.
Pods	Sickle or ring shaped, straw-yellow in colour, linear and compressed with parallel margins. 10-23 cm long, 8-20 mm wide and 4-5 mm thick, with 12-30 endocarp segments that are more broad than long.
Comments	Pods are sweet and make excellent livestock food.

P. alba was introduced to India in Jodhpur (Rajasthan) in the early 1980s. It has also been introduced to other areas such as Karnal (Haryana), Lucknow (UP) and Phaltan (Maharashtra). The species is not widespread, however it is gradually occupying space in arid and semi-arid tracts of Rajasthan, Gujarat, Maharashtra and UP through systematic plantations by the forest departments of respective states (Figure 7).

D. *Prosopis chilensis* (Molina) Stuntz emend. Burkart

Common names	Algarrobo blanco (Spanish Latin America), vilayati babool (Hindi). Vilayati babool is used to describe both <i>P. juliflora</i> and <i>P. chilensis</i> in India.
Form and size	Tree form in protected sites. Bushy unless managed. 5-11 m high
Leaves	Leaflets are much larger, more widely spaced and on a longer rachis than <i>P. juliflora</i> . Normally only 1 pair pinnae per leaf.
Branches	Flexuous, knotty and partly spinous
Spines	Spines Paired and axillary, and some reach 6-7 cm in length, but not all nodes.
Pods	Straight or sickle shaped, flattened and linear. 10-16 cm long, 1-0.5 cm broad and 0.4-0.5 cm thick with parallel margins.
Comments	Trees are sometimes deciduous. Pods are excellent fodder and timber is excellent as construction material.

P. chilensis is often found in association with *P. juliflora*. This may be because some seeds of *P. chilensis* were mixed with the seeds of *P. juliflora* during its introduction. In the last two decades, a few plantations of *P. chilensis* have been raised at Jodhpur (Rajasthan), Lucknow (UP), Karnal (Haryana) and Phaltan (Maharashtra) (Figure 8). The name *P. chilensis* has often been misused to describe *P. juliflora* (Swartz) DC.

E. *Prosopis glandulosa* (Torrey)

Common names	Honey mesquite (English-USA), bilayati kikar (Punjabi).
Form and size	Shrubby, but good management can produce a tree form. 3-9 m high.
Leaves	Leaflets are large and widely spaced, similar to <i>P. chilensis</i> .
Spines	Axillary and 1-4.5 cm long. Usually the spines are solitary but in some individuals are paired.
Pods	Curved or straight. Linear, flat. Yellow. 8-20 cm long, 0.9-1.4 cm broad and 0.4-0.7 cm thick. Similar to <i>P. juliflora</i> .
Comments	Good fodder and fuelwood. Excellent source of nectar for honey bees. Trees are deciduous.

P. glandulosa was introduced to India in the early 1890s. Experimental plantations of the species exist at Jodhpur (Rajasthan), Phaltan (Maharashtra) and Lucknow (UP) (Figure 9). Natural stands are found in Punjab and Haryana, particularly in association with *P. juliflora*.

F. *Prosopis flexuosa* (DC)

Common names	Algarroba (Spanish-Chile), lamaro (Spanish-Argentina).
Form and size	Erect shrub form, but in protected sites, with proper management it can also take a tree form. Shrub 3-5m high. Tree 10 m high.
Leaves	Leaflets are smaller than those of <i>P. juliflora</i> . There is one pair of pinna per leaf.
Branches	Zig-zag appearance. Drooping ultimate branchlets.
Spines	Spines are small or absent. White with yellowish tinge or yellow. Axillary and paired. 3-5 cm long.
Pods	Often nearly straight but sometimes arched. Yellow with black-violet tinge. Pod pulp is very sweet. 5-28 cm long and 0.7-1.2 cm broad with undulating margin.
Comments	Trees are deciduous. Good fodder (pods), fuel and flooring in houses.

P. flexuosa is commonly found in northern Chile. Its introduction to India is very recent. It was introduced to Jodhpur and Karnal in the early 1990s (Figure 10).

G. *Prosopis nigra* (Grisebach) Hieronymus

Common names	Algarrabo negro (Spanish-Argentina), kala vilayati kikar (Hindi).
Form and size	Tree form. 4-10 m. Stem has persistent fissured dark bark.
Leaves	Leaflets are small and similar to <i>P. flexuosa</i> . There are normally 2 pairs of pinnae per leaf which are much longer than other species.
Branches	Flexuous and erect long shoots are quite spiny. Ultimate branchlets are downward arching and almost spineless.
Spines	0.4-3.4 cm.
Pods	Mature pods are yellow with slightly violet tinge. Thick and fleshy. 10-15 cm long and 0.5-0.9 cm broad.
Comments	Valuable timber tree. Pods are very sweet.

P. nigra is native to Bolivia, Argentina and Paraguay. It was introduced to India only fifteen years ago (Figure 11).

III. POD COLLECTION, STORAGE AND SEED EXTRACTION

The methodologies described in this section from pod collection to clean seed extraction are simple and practical. A nursery grower, whether he/she is a farmer, a nursery manager of an established nursery belonging to a Government Department, NGO or private company, or even a novice in the field, can easily obtain good quality seeds if the procedures are followed step by step. Knowledge and experience of these methodologies form the sound foundation of raising quality stock of the species in the nurseries.

This section deals with *P. juliflora*, but the same methods can also be used with seed of other introduced *Prosopis* species.

A. Collection of pods for seeds

Although pods appear continuously from November to May, the plant canopy is fully laden with ripe pods from November to December and from March to May (Figure 12 and Figure 13).

Collection of pods from trees

If pods are to be used for planting, they should be collected from trees that have been identified for desirable traits such as erect form, high pod production, spinelessness or very few spines. November to December and March to May are the best times for pod collection.

P. juliflora pods can be collected from trees by;

- manual shaking (pole and rope method)
- manual shaking and cutting-sawing method

Manual shaking is a useful method as the mature pods are easy to detach. In shrubby forms of the species this method is quite workable. However, branches cannot be shaken directly by hands as they contain numerous spines. Therefore, branches are shaken using a pole or a rope thrown over the branches.

In India, the most common method of collecting *P. juliflora* seed is a combination of manual shaking and cutting-sawing methods. A bamboo pole (6-8 m long) which is permanently fixed to a serrated



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Figure 12. Canopy of a *P. juliflora* tree laden with pods in December.



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Figure 13. A bunch of *P. juliflora* pods.