Babul *(Acacia nilotica)*

Knowing the Species

The genus *Acacia* belongs to family Mimosaceae. *Acacia* Willd is a very large genus containing trees, shrubs and climbers. *Acacia nilotica* (linn), Willd ex del is known in India as babul, kikar, babur (Hindi). It is a moderate sized tree with a spreading crown. It is indigenous to the Indian Sub-continent as also in Tropical Africa, Burma, Sri Lanka, Saudi Arabia, Egypt and in West and East Sudan. In India, natural babul forests are generally found in Maharashtra, Gujarat, Andhra Pradesh, Rajesthan, Haryana and Karnataka. However, scattered trees in groups occur naturally and also widely planted in almost all states and Union territories except north-eastern states, Kashmir and Kerala. *A. nilotica* is truly a multipurpose tree. Its timber is valued by rural folks, its leaves and pod are used as fodder and gum has a number of uses. It tolerates extremes of temperature and moisture. It is suited for planting on marginal lands and can survive both drought and flooded conditions.

Classification

Acacia nilotica is a complex species and has number of sub-species. Presently, 9 sub-species are known. These sub-species have been differentiated mainly on the basis of the shape, size and degree of pubescence of the branches, characteristics of pods, the habitat of the tree and the shape of the crown. The important features and distribution of different sub-species are given below:

- ***Acacia nilotica* sub-species *nilotica***
  The branchlets of this sub-species are generally glabrous to sub-glabrous or rarely pubescent. The arrangement of pods is necklace like, regularly constricted between the seeds having a smooth surface devoid of hair.

- ***Acacia nilotica* sub-species indica**
  The young branchlets of this sub-species may vary from sub-glabrous to thinly pubescent. Pods are arranged necklace like, narrowly clogged between the seeds and are densely white-tomentose.

- ***Acacia nilotica* sub-species *cupressiformis***
  This sub-species bears a characteristic crown which make it conspicuous and identifiable from other sub-species of *Acacia nilotica*. The tree has a narrow erect cypress like crown. The branches tend to go upwards and make a narrow angle with the main stem.

- ***Acacia nilotica* sub-species *tomentosa***
  The young branchlets of this species are densely white tomentose. The pods are arranged in the form of a necklace, slightly constricted between the seeds.

- ***Acacia nilotica sub*-species *adstringens***
  The young branchlets in this sub-species are very hairy or tomentose and only rarely pubescent. The arrangement of the pods differ with other species. They are not necklage like, margins distinctly and often irregularly crenate and its width varies from 1.2-2.2 cm. The surface of the pod is densely tomentose.

- ***Acacia nilotica sub*-species *subalata***
  The branches are densely pubescent to sub tomentos*e*. The pods are not necklace like. They are oblong with their margins flattened, straight or sometimes slightly crenate, usually 1.5-2.5 cm wide, densely and persistently subtomentose all over. The sub-species *subalata* is close to *adstringens* but it differs in having longer indumentum on the branchlets.

- ***Acacia nilotica* sub-*species kraussiana***
  The branches of this sub species are generally more or less densely pubescent. The pods are not necklace like. They are oblong, with margins more or less superficially crenate. The seeds of this sub-species are initially glabrescent and become hairless and shining black when dry.

- ***Acacia nilotica sub*-species *leiocarpa***
  The young branchlets of this sub-species are glabrous and some times puberlous. Pods are not necklace like. They are oblong with straight margins or rarely crenate, hairless, narrow, 1-1.3 cm wide.

- ***Acacia nilotica sub*-species *hemispherica***
  The tree of this sub-species have a hemispherical shaped crown; trunk is not clearly demarcated and the branchlets are for some time pubescent. The pods are not arranged in the form of a necklace, but oblong with straight margins to slightly crenate, 1.1 – 1.3 cm wide, with very short simple puberulence.

Natural Habitat in India

The following sub-species of *Acacia nilotica* are reported to occur in India.

1. *Acacia nilotica* sub-species *indica*
2. *Acacia nilotica* sub-species *adstringens*
3. *Acacia nilotica* sub-species *cupressiformis*
4. *Acacia nilotica* sub-species *subalata*

Distribution

Andhra Pradesh

In Andhra Pradesh, the species is common in the Telangana region in the districts of Warangal, Khammam, Hyderabad and other adjoining districts. It commonly occurs in farmlands, wastelands, pastures, etc. This species has also been introduced in other parts of Andhra under various schemes of social forestry programmes. The species is almost absent along coastal Andhra Pradesh.

Bihar

In Bihar, the species occurs in southern and western Bihar, particularly in the Chota Nagpur area. The species is commonly raised in plantations of agroforestry and social forestry. The species does not occur in the high rainfall region of eastern Bihar.

Gujarat

The species is almost common throughout Gujarat but is absent in coastal areas. It grows luxuriantly in Banaskantha, Mehsana, Swabarkantha, Khera, Baroda, Ahemadabad, Surat and Rajkot districts. The species has been widely planted in social forestry plantations on community and forest lands. The farmers also prefer this species on field bunds and in other agroforestry associations. This species has been popular in plantations of village woodlots.

Haryana

In Haryana, this species grows widely in irrigated as well as unirrigated farm lands, village lands and other waste lands except in the hilly parts of in Yamunanagar and Ambala districts. This species is capable of tolerating waterlogging, salinity and alkalinity thus has been widely planted on waste lands. The species is preferred for raising in village woodlots.

Himachal Pradesh

Acacia nilotica occurs in Himachal Pradesh in the plains, adjoining Punjab and Haryana particularly in the district of Una, Nurpur, Sirmur and Bilaspur. It is common on agricultural fields. It is completely absent in the hills.

Jammu and Kashmir

In Jammu and Kashmir, the species occurs only in the plains in Jammu district adjoining Punjab. Farmers prefer to grow. *A. nilotica* trees on their fields.

Karnataka

This species occurs in Karnataka particularly, in its northern part in the districts of Bellary, Gulbarga, Kolar, Bangalore, Mysore and Coorg. This species has been widely planted on tank foreshores and roadsides.

Kerala

This species occurs only in Travancore district in low altitude dry forests where it attains larger dimensions. It grows to a height of 9 meters with diameter above 30 cm at breast height.

Madhya Pradesh

The species is gregarious in Western Madhya Pradesh in Indore, Dewas, Ratlam, Dhar, Mandsaur, Ujjain and other districts which have preponderance of black cotton soils. It also occurs in northern Madhya Pradesh in the districts of Tikamgarh, Satna, Rewa and Chhatarpur. The species grows only around homesteads, along roads and field bunds and is generally absent from forests. The eastern part of Madhya Pradesh which receives higher rainfall has the preponderance of *Acacia nilotica* particularly on the field bunds specifically in Raipur, Raigarh and Bilaspur districts. In social forestry plantations, the species has been widely planted along road sides, canal sides, village and community forests.

Maharashtra

In Maharashtra, the species occurs widely in the rain shadow region of Western Maharashtra and Vidharbha region. In Vidharbha region, it particularly occurs in Amaravati, Akola, Yavatmal, Wardha and Nagpur districts. In Western Maharashtra, it is found in Pune, Satara, Sangli, Ahemednagar and Sholapur districts. It is reported that *Acacia nilotica* is common in Sholapur districts throughout the undulating plateau of this region. It also occurs in erstwhile Marathwada region in Aurangabad, Jalna, Beed, Parbhani and Nanded districts. The species

is almost absent along coastal areas. It occurs mostly on agricultural land in black cotton soil along nala banks.

Orissa
In Orissa, *Acacia nilotica* is distributed mainly in the western part which adjoins Madhya Pradesh. The species is not gregarious in forest areas but has been introduced in semi-arid areas in degraded forests and road side plantations, particularly in Sambalpur and adjoining districts.

Punjab
In Punjab, this species has been widely planted in strips along road and canal side plantations. It occurs naturally in pockets in riverain sites along Siwalik hills.

Rajasthan
In Rajasthan, this species occurs in most part of the state but it avoids extreme arid conditions. The species is abundant in northern Rajasthan, particularly in the districts of Jaipur, Bharatpur, Alwar, Sawai Madhopur, Dausa, Kota and Bundi and adjoining areas, where rainfall is comparatively better.

Tamil Nadu
In Tamil Nadu, the species grows widely in the districts of Salem, Erode, Dharmapuri and Coimbatore. It is absent in coastal districts and higher hills. The species has been widely planted in tank foreshore plantations under social forestry programmes.

Uttar Pradesh
In Uttar Pradesh, it grows in the plains. It completely avoids hills and frosty localities. It is planted along road sides, canal sides and railway lines. It has also been raised in community and forest lands under social forestry plantations. Under agroforestry, it grows on field bunds as scattered trees in both irrigated and unirrigated conditions. The species is common in whole of the Gangetic plains.

Soil
Acacia nilotica mainly occurs in plains on flat or gently undulating ground and ravines. It grows best on the alluvial soils in riverain areas subject to periodic inundations.

It flourishes even in alkaline soils. A considerable amount of moisture in the soil is essential for its success. Even the existence saline water in the sub-soil is not injurious.

Climate
This species occurs in tropical and sub-tropical regions of India. In its natural range the absolute maximum shade temperature varies from 40^0C to 47.5^0C. The average annual rainfall in its normal habitat varies from 200 to 1270 mm. The tree normally tolerates temperature range varying from 4^0C to 47^0C. For good development the optimum lower limit of rainfall is about 600 mm.

Light
Acacia nilotica is a strong light demander and is intolerant of suppression.

Frost
It is a frost tender species. In severe frost, small seedlings as well as large trees are affected.

Drought

The species is drought resistant. Tree species growing in the forest usually live under fluctuating water regime i.e., abundant water supply to extreme drought. The extent of growth loss due to water stress has not been estimated.

Growth Characteristics

A. nilotica is an evergreen, usually moderate sized (height varying form 2.5 m to 25 m) tree. In favourable localities, it attains a height of 15-25 metre and girth of 2.4-3.0 metres. In unfavourable localities, it is a stunted, shruby or a straggling tree. It is almost evergreen tree with a short, thick and cylindrical trunk. The tree has a very clear bole upto a height of 5-6.5 metres. In difficult sites, it seldom grows more than 10 metres. The clean bole in such cases is not more than 3-4 metres.

The spines are stipular, paired, straight (directed downward) 1 to 8 cm long and straight, often white. Leaves are bipinnately compound with 3-9 pairs of sessile pinnae and leaflets mostly in 12-27 pairs per pinna. Leaflets 1 to 7 mm long and 0.5 to 1.5 mm wide. It produces bright or golden yellow flowers, in globose heads with sweet scented flowers on axillary peduncles of 1.2 to 4.5 cm length.

As a Plantation Tree

A. nilotica grows quickly, coppices readily and is a source of fixing nitrogen, improving soil fertility and its leaves and pods are widely used as fodder. Leaves contain about 7-15% crude protein, 20.1-33.3% crude fibre, 1.2-2.6% calcium and 0.1-0.2% phosphorus. In dry areas it is heavily browsed by camel and goats. The tree provides shade and shelters and is an excellent soil binder, which makes it useful in soil conservation works. The species has been groun under various conditions covering arid, semi-moist, irrigated farmlands, etc. Babul is basically a household tree and is the best friend of the farmers. It is grown around houses, wells, compounds, on farm lands and other available places in the private holdings. It is grown in homestead plantations because every part of this tree finds one use or the other by the farmers. Babul can be seen in agroforestry plantations right from the foot hills of the Himalayas in the north to Tamil Nadu in the South, from Rajasthan in the west to the West Bengal in the east.

Taungya plantation of *Acacia nilotica* started in Berar area and the plantations raised in the past have been successful to a large extent. However, the system has been given up recently. In Uttar Pradesh, in some of the districts like Saharanpur, Gonda, etc. *A. nilotica* plantations have been raised in the past. In Tamil Nadu, *A. nilotica* has been grown as taungya plantation successfully with a variety of agricultural crops.

Babul is a common agroforestry tree species for large part of India, particularly for alluvial plains and Indian peninsular region. The species is specifically suitable for growing in arid and semi-arid climates. However, it avoids extreme arid conditions. In Rajasthan, *A. nilotica* is a popular species in the northern and central regions. In these areas, two sub-species namely, *indica* and *cupressiformis* are common. *A. nilotica* sub-species *cuppressiformis* is preferred on agricultural cropland because of its narrow crown.

In Indo-Gangetic plains, the species is equally popular in irrigated and un-irrigated agricultural lands. However, it has shown better results in comparison to other species in

terms of productivity and economic returns in un-irrigated croplands and wastelands. The species is grown in wheat and rice zone, with equal ease.

Utilization of the Species

Almost every part of the babul tree is utilized for some purpose. The sap wood of babul is sharply demarcated from the heart wood and is white, whitish, turning pale yellow on exposure. The heart wood is pinkish brown and turns reddish brown on ageing. The wood is strong and durable. It is used for various constructional purposes.

Physical Properties of the Wood

The wood is very heavy, strong, very tough and extremely hard wood. The average weight is about 785 kg/m^3 at 12 per cent moisture content. It is somewhat coarse-textured and has inter-locked grains. The wood is dull and somewhat rough without any characteristic odour or taste. The strength properties of wood are given in table 1.

Table 1. Mechanical properties of *Acacia nilotica*

Properties	Babul		Teak	
	Green	Air dry	Green	Air dry
Moisture content per cent	70.00	12.00	76.6	12
Static Bending				
(a) Fibre stress at elastic limit (kg/sq cm)	421	487	509	651
(b) Modulus of rupture(kg/cm^2)	776	894	841	959
(c) Modulus of elasticity (1000 kg/sq cm)	977	1128	1097	1196
Impact bending				
(a) Fibre stress at elastic limit (kg/sq cm)	1085	1306	1085	1121
(b) Maximum height of drof in impact binding (cm)	130	104	91	71
(c) Modulus of elasticity (kg/sq cm)	108400	140100	160600	166800
Compression parallel to grain (kg/sq cm)				
(a) Compressive stress at	207	260	311	376
(b) Maxi. Crushing stress	354	536	415	532
(c) Modulus of elasticity	101800	118000	129800	137400
Compression perpendicular to grain (kg/sq cm)				
(a) Compressive stress at elastic limit	91	124	86	101
Hardness-load in kg to embed 1.128 cm diameter ball to half diameter				
(a) Radial	720	824	557	502
(b) Tangential	755	855	551	524
(c) End	671	915	486	488
Shear paralled to grain (kg/sq cm)				
(a) Radial	119	168	90	97
(b) Tangential	143	192	100	108

Tension perpendicular to grain (kg/sq cm)				
(a) Radial	89	71	68	58
(b) Tangential	107	93	79	66

Working and Finishing Properties

It is an easy wood to convert and resaw when green, but it becomes harder and tougher when seasoned. It works well by hand machines and finishes to a good surface. Its working quality index based on quality of worked surface and ease of working is 84 compared to 100 for teak.

Timber

The wood is widely used for construction as posts, rafters, beams and in door frames. It is one of the most favoured timbers for all types of agricultural implements like ploughs, harrows, crushers and rice pounders, and is extensively used in card building, for yokes, shafts, wheels and body work.

Babul wood is also recommended for certain types of sports and athletic goods like clubs, wall bars, parallel bars, etc.

Fuelwood

As a fuelwood, it is an excellent material and is also made into charcoal. Its charcoal is considered to be superior to charcoal from other species.

Pulp and Paper

The wood from Acacias is good for paper and pulp making. It is reported that, rayon and paper pulp properties from *A. nilotica* compare favourably with those of *Dendrocalamus strictus* and *Eucalyptus hybrid*. However, since babul wood is highly valued for agricultural implements and house construction it is rarely available for pulp making.

Tanning Material

Bark: The bark is obtained mainly as a by-product when trees are felled for timber or fuel. It is separated by beating the logs with wooden mallets and the strips obtained are dried in the open chipped into smaller pieces and sent to tanneries without grading. The proportion of bark to wood is roughly 1:5 by weight. A 15 year old plantation of about 620 trees per hectare may yield about 5 tonnes of bark per hectare.

Pods: The whole pod of babul contains about 12-19 per cent tannin and that removed of seeds 18-27 per cent tannin.

Gum

The gum obtained from *A. nilotica* is known as “Indian Gum Arabic”. It is generally considered inferior to the true Gum Arabic obtained from *A. senegal* in medicinal properties.

Medicinal Uses

The leaves, bark, gum and pods of *A. nilotica* are used for medicinal purposes. The tender growing tops and leaves are used as a douche in cases of gonorrhoea, dropsy and leucorrhea. Pulp of leaves, decoction of bark and the gum are prescribed in diarrhoea, dysentery and diabetes. A paste made of the burnt leaves with coconut oil makes a very efficacious ointment

in cases of itch. The leaves and the gum are used for gargling for relaxing sore throat and spongy gums. Decoction of leaves is also used as wash for bleeding ulcers and wounds.

Food

The seed of babul are eaten roasted or raw in time of acute scarcity in Rajasthan. Air dry seeds contain moisture 8.83%; crude protein 26.4%; eather extract 3.3% and free extract 62.9%; crude fibre 2.7%; total ash 4.7%. The other elements in seed are calcium 673.0; phosphorus, 420.0; iron 4.9; Niacin, 3.17; ascorbic acid 4.51; Thiamin 0.24, mg/100 gm.

Dye Stuffs

Dye stuffs from *A. nilotica* is prepared by boiling the pods, leaves, bark in varying proportion and occasional additions of wood extract. Variety of colours from yellow, to black through brown can be obtained by varying proportion of leaves, pods bark and wood extract.

Fencing Material

Thorny branches of babul are useful as fencing material. The spines are also used as fishing hooks and as a substitute for pin. The trees are also planted closely along the field boundary as live fence.

Avenue Tree

Babul is useful as a hardy avenue tree, where selection of species is difficult. It is also used as a live-hedge fence round circular trenches for planting other important avenue trees.

Perhaps, there is no single Indian tree as useful to the largest proportion of rural population in multifarious ways. Due to its sparse crown it casts a very light shade and is not detrimental to crops grown under it. It is also a known nitrogen fixer. This is the reason why in dry hot parts of India, it is grown on the embankments of fields. It has an important role to play in social forestry of future.

Natural Regeneration

A. nilotica can regenerate naturally. Large natural wood lands of *A. nilotica* are not common. The species occurs in patches, usually, in wastelands and common grazing lands. The ripe pods of *A. nilotica* fall on the ground in summer months. Seeds are separated from the pod due to sun drying and are dispersed by wind and animals. Natural regeneration occurs mainly through seeds and some times through seedling coppice. Adequate moisture is necessary for germination. Germination starts in the early monsoon period and continues for sometime. One of the problems in natural regeneration is damping-off of young seedlings. During germination, insects may damage the radicle.

A. nilotica seeds may become dormant and dormancy is due to hard seed coat. In dormant condition, seed is viable but fails to germinate even though external conditions are suitable. Seeds of *A. nilotica* may remain dormant for one to two years or more.

Animals are the best source for dissemination of seeds. Pods of *A. nilotica* are eaten by animals like goat, sheep, cattle and rats but these seeds are not digested by animals. The

gastric enzymes in the stomach act upon these seeds, before they come out with the excreta. These seeds easily germinate, thus seed germination is greatly stimulated by animals.

Coppicing

In some areas, particularly, in states of Andhra Pradesh, Karnataka, Tamil Nadu and in the districts of Guntur, Anantpur, Bellary, Chingleput and Doab, babul has been coppicing well. In these areas, coppice can be relied on as one of the means of regeneration. In India, in low rainfall areas, it does not coppice. When trees are young and small in size, coppicing vigour is more.

The important factors which influence successful natural regeneration are:

Moisture

Sufficient moisture is necessary to soften the seed coat. This may take quite some time. Abundant moisture is observed in riverain tracts where abundant regeneration come up on fresh alluvial deposits.

However, regeneration of young seedling is destroyed in flooded areas. Excessive moisture causes damping-off in seedlings. Seedlings are also damaged when buried under thick deposits of silt in riverain tracts.

In southern parts of India, natural regeneration of *A. nilotica* plentiful in tank beds, while it is absent or negligible on the upper reaches.

Plentiful regeneration occurs where the ground is annually inundated. It is observed that *A. nilotica* can withstand high degree of salinity. It tolerance salinity as hig as 10 mmhos per cm and it can also withstand tannery waste water.

In areas affected by drought, the natural regeneration is extremely low. In such regions, seeds germinate but fail to establish and are killed due to lack of moisture. Seedlings which survive in drought have slow growth rate.

Light

Adequate light is an essential factor for the germination and establishment of seedlings. *A nilotica* is a strong light demander. Seed germination is considerably retarded under dense shade. If the seed germinates under shade, the development of seedlings is not proper and they cannot establish. Fresh light is not a problem for babul because a patchy overhead shade makes plenty of light available.

Soil

A. nilotica has a long tap root system. Loose and deep soils facilitate the development of the root system. Root of *A. nilotica* easily takes up moisture from loose soil, the development of tap root is more rapid in deep soil. Adequate drainage and aeration in soil are the most important factors for establishment of seedlings. In the presence of compact soil and insufficient aeration, seedlings are unable to establish.

Fire and grazing render the soil more compact, impervious and less fertile. Seeds do not germinate in heavily burnt or excessively grazed soils.

It is noticed that *A. nilotica* grows well on moderately calcareous sodic soils and gives better performance on alluvial soils.

It has been observed that natural regeneration comes up easily on ploughed land and new embankments. On hard and unworked soils, natural regeneration is scanty. Natural regeneration has been plentiful in deep black cotton soil within its zone of distribution. These soils retain moisture at some depth, which the roots of babul are capable of absorbing. The germination and growth of seedlings is better in areas where moisture is substantial. Therefore natural regeneration is usually plentiful in depressions and along the streams or nala banks.

Weeds and Grasses

Weeds and grasses influence the establishment of seedlings. In presence of weeds and grasses, seedling fail to establish because weeds and grasses compete with seedlings for moisture and light. Weeding is necessary to eliminate competition and to obtain good growth. Weeding should be continued till the trees are capable of withstanding competition from weeds and grasses.

Seedlings of A. nilotica are sensitive to suppression. In a group the seedlings having poor and stunted growth are suppressed and killed. Several shrubs and herbs such as Lantana camara, Cassia tora and others form a dense ground cover which effectively prevents natural regeneration.

Grazing

Grazing is a serious problem in obtaining successful regeneration. Livestock damage the seedlings, particularly, goats and camels browse and destroy young seedlings. Sheep and goats are dangerous because of their preference for woody plants over herbaceous ones. Damage by trampling is also serious in most areas. Young tender plants are easily browsed by all categories of livestock. The grazers usually resort to lopping for pods which affects the seed production and consequently natural regeneration. The grazing and browsing of tall trees by camels also affects growth of trees. At places, where grazing and lopping are severe, natural regeneration of babul forests is completely absent.

Therefore, for protection of naturally regenerated plants, it is necessary to control grazing by effective fencing.

Fire

A. nilotica is a fire tender species. The seedlings and saplings are seriously damaged by fire. Serious fire hazards often result in areas with a good growth of underground grasses and herbs like *Cassia tora*. The species is fire tender, particularly in young stages. Fires affect various soil properties, which consequently lead to poor establishment and poor growth of seedlings.

Artificial Regeneration and Its Calender

Artificial regeneration involves seed collection, proper seed storage, seed treatment, nursery and planting practices, tending and maintenance, etc. Direct sowing of babul is successful and is the common method for raising this species. Sowing of babul in combination with field crops has been practiced since time immemorial. However, nowadays nursery raised polypot plants are used as a common method for raising this species.

Fruits

Abundant fruits are produced almost every year during April and May. The pods are indehiscent and show considerable variation in colour and shape from dark brown to grey and straight to curved, glabrous to velvety in texture. The pods are thick but compressed having 6 to 16 seeds per pod. Seeds lie transverse to the long axis of the pod.

Seed Collection

A. nilotica seeds are available in abundance and can be collected using one of the following options:

- From natural fruit fall
- From standing trees
- From felled trees
- From animal pens

Seed

Seeds are dark, black-brown in colour, smooth, compressed, 7-8 mm in diameter with a hard seed coat. Considerable variation exists in seed quality from one origin to another. Seeds from moist localities are generally bigger as compared to seeds from dry locality. Seed weight studies indicate a variation for 5500-11,600 seeds/kg.

Seed storage: Seeds can be stored in gunny bags, tins or baskets. Seeds must be stored in cool and dry place with good air circulation. If seeds are to be stored for a long time, they need to be completely air dried and kept in air tight containers.

Treatments of Seeds: The seeds coat of babul seeds is very hard and impermeable. It requires pretreatment to hasten germination. *A. nilotica* seeds can be pretreated by one of the four methods described below:

(i) Immersion in cold water for 48 hours,

(ii) Immersion in hot water (80^0C) for 30 minutes. The water is heated till the temperature rises up to 80^0C. The container containing hot water is removed from the heat and seeds are immersed in the water for 30 minutes. After treating with hot water the seeds are soaked in ordinary water for 24 hours prior to sowing.

(iii) Soaking in sulphuric acid (90%) for 10 to 30 minutes. Seeds after soaking in the sulphuric acid are removed, washed and dried prior to sowing.

(iv) Seeds collected from goat/sheep pens do not need any further treatment. When, seeds are required to be sown immediately after collection, this is probably the best and convenient method. Animals may be fed with *A. nilotica* pods for this purpose.

Out of the above treatments the hot water treatment is safe, quick and effective and thus recommended.

Nursery Practices

Sowing and germination: The treated seeds are sown in nursery beds either by broadcast sowing or by dibbling method. However, the dibbling , method is preferred. *A nilotica* is seldom raised in nursery beds. It is generally raised in polythene containers. Two or three treated seeds are sown in each bag, about 1.5 cm deep during February-March i.e. about 5 months before transplanting in the field. The soil mixture used in polythene bags consist of soil and compost in 2:1 ratio. Germination commences one to three weeks after sowing and is mostly completed in a months time. The germination of the seed is epigeal. The radicle emerges and descends.

Vegetative Propagation

Vegetative propagation in *A. nilotica* is successful under mist chamber conditions. Success is reported in case of rooting of stem cuttings treated with indole acetic acid and indole butyric acid. Tissue culture propagation of *A. nilotica* has been successful with callus formation only.

Irrigation in the Nursery

Watering in the nursery is done frequently, till the seed germination terminates. After germination, 2-3 waterings a week are sufficient. Watering is one of the most important operation which decides the success of failures of seedlings in the plantation. Excessive watering results in production of pampered seedlings, which fail when planted out under difficult conditions. Therefore, watering in the nursery has to be planned most judiciously. The number of waterings and the quantity of water required per plant or per bed depends upon the locality and season.

Weeding

Young seedlings have to be weeded regularly for 2-3 months. During weeding, excess seedlings are removed so as to leave only one seedling in each polypot.

Shade

In the early stage, shade is provided for the proper development of seedlings. It is reported that shade increases the germination percentage. Shade is required during winter when there is a danger of frost and during summer when the temperature is too high.

Hardening of the Seedlings

Hardening is a necessary process for seedlings developed in the nursery. Seedlings are kept in the nursery under constant care for some time while they develop. The good seedlings are selected and placed in separate beds, where they are given less water and exposed to the sun gradually to condition them for planting out.

Planting Practices

Size and quality of planting stock

Seedlings attain a height of 30 to 40 cm in a period of 6 months. Experience indicates that medium sized stock, between 30 to 40 cm tall with a woody root collar, has a better survival rate. The seedlings should be transplanted at this stage when the root shoot ratio is optimum. Further growth of shoots leads to imbalance in root shoot ratio

and a large number of casualities of planting out. Mortality in plantation is high for undersized and weak seedlings. Grading of seedlings is, therefore, important.

Direct sowing

This is the easiest and most common method for raising babul plantation in the field. Several methods have given satisfactory result. The successful ones are by broadcast sowing (seed rate 2.5 – 3 kg/ha), dibbling in lines, patches or mound sowing during June (seed rate 1 kg/ha).

Root system

A. nilotica species has a very long tap root system. As the growth advances, several lateral roots also develop at the end of the first season and after some time the tap root and lateral roots cannot be easily distinguished.

Seedlings of plantable size are graded in the nursery. The gradation depends to a large extent on local experience and the establishment of local standard. The main objectives of a grading system for planting stock are:

To eliminate seedlings with damaged or diseased tops or roots.

To eliminate seedlings below the minimum standard of size and root development.

Planting

Babul is planted in man made forests under several environmental conditions using different methods of establishment. The seedlings are generally planted in pits having the size of 30x30x30 cm. The most common spacing adopted for plantation is 4m x 4m. On road sides, deeper pits of the size of 45 x 45 x 45 cm are preferred. Mound planting is practiced where there is fear of water logging specially on dug up road sides. For proper growth and survival it is necessary to give one or two waterings after planting. This is specifically required in arid regions. Irrigation after planting is not a prerequisite in areas having sufficient soil moisture and precipitation. Higher survival rate and better rate of growth is reported when soil and water conservation measures are also adopted.

Cultural Operations and Its Calender

Weeding

Tending operations are necessary for the successful plantation of babul. In areas, where growth of grasses and understorey vegetation is dense, it is almost impossible to raise babul without proper weeding. In the first year of plantation, three weedings are usually necessary.

Mulching

When babul is grown in dry areas mulching is generally recommended in the first year. Mulching needs to be carried out during November-December for optimum results.

Cleaning and Thinning

When babul is planted by sowing or when natural regeneration is abundant, cleanings and thinnings become necessary. To assist the seedlings to develop into a vigorous and healthy

crop, it is necessary to carry out spacings, cleanings and thinnings annually for the first five years specially when regeneration is form direct seeding, natural or otherwise.

Pests and Diseases

A. nilotica is liable to be damaged by many groups of insect pests (*Coleoptera, Lepidoptera, Hemiptera* and *Orthoptera*) and diseases. *Celosterna scabrator* and *Oxyrachis tarandus* are reported to be the most notorious pests of *A. nilotica* in various localities. The mango mealy bug *Drosicha stebbingi*, primary pests of *Mangifera indica* also attack *A. nilotica*. Heavy infestation caused by the bug results in the death of shoots and twiges and deforms the growth of the saplings of *A. nilotica.* Almost all the stages of the plant are affected by different fungal pathogens. Among fungi members of *Deuteromycetes* are the most dominant group causing serious diseases of seeds. Various treatments are being used against the fungal infections present on or within the seed. Seed treatment with various fungicides, organomercury compounds, etc. are practiced for the effective control of seed-born and soil-born diseases. Different types of root diseases like root-rot, collar-rot, wilt; stem diseases like die-back, stem canker, heart rot; foliages diseases like leaf rust and leaf spot are caused by fungi like *Ganoderma lucidum, Polyporus gilvus, Botry-odiploidia theobramae, Fusarium sp., Fomes badius, Ravenlia acaciae arabicae, Cylindrosporium acaciae.* The important pests and diseases of *A. nilotica* with their nature of damage and control measures are summarized in Table 2 and 3.

Table 2. Major entomological problems and their control

Pest	Order	Family Damage	Tissue(s) of damage	Nature	Control measures
Araecerus suturalis (Adult)	Coleoptera	Anthribidae	Seed	Stored Seed	Insect pest feeding on the pods or seeds are controlled by spraying endosulfan or tetrachlorovinphos spray of malathion
Caryedon gonagra (Adult)	Coleoptera	Bruchidae	Seed	Stored Seed	-
Celosterna scabrator (Larvae)	Coleoptera	Crambycidae	Roots of young trees	Bore down wads, hol lowing	Root should be drenched with 0.3% emulsion of out the aldrin main root
Chrysobothris gardeni (Larvae)	Coleoptera	Buprestidae	Root	Bore in the root	Root should be drenched with 0.3% emulsion of aldrin.
Diapromorpha balteata (Adult)	-do-	Chrysomelidae	Foliage	Food on foilage	Broad spectrum insecticides, malathion, savin, endosulfan, monochrotophos

					(0.01-0.1%)
Sinosylon anale (Adult)	-do-	Bortrychidae	Shoots	Excavating tunnels in the trans-verse	Fumigants like petrol carbon disulphide mixture in an insectiplaincidal, emulsion like 0.1% endosulfan
Drosicha stebbingii	Hemiptera	Margardidae	Leaf, Shoot & Branches	Feeds at the sites of wounded older branches	-do-
Hamaspi doproctus cineres (Nymphs)	Hemiptera	Margarodidae	Leaves & Shoots	Feeds on sap of and shoot	Root should be drenched with 0.3% emulsion of aldrin, spraying of 0.1% carbaryl and 0.2% monochrotophos
Lacifer-laca (Nymphs)	-do-	Lacciferidae	Shoots	Feeds on sap of succulent shoots	-do-
Oxyrachis tarandus (Adult)	-do-	Membracidae	-do-	Lays its eggs in a slit on a shoot	-do-
Crypto phelebia illepida (larvae)	Lepidoptera	Tortricidae	Pods and seeds	Bore into the pods and seeds	Spraying of endosulfan or tetrachlorovin-phos
Casiala raptaria (Larvae)	-do-	Geometridae	Foliage	Foliage feeding	Spraying of malathion, savin, endosulphan, monochrotophos & rogor b/w 0.01 to 0.1%
Euprocitis lunata (Larvae)	-do-	Lymantriidae	-do-	-do-	-do-

Table 3. Major diseases and their control

Name of Pathogens	Class	Disease cause	Control measures
Ganoderma lucidum	Basidiomy Contina	Ganoderma root-rot	Site preparation: Clear felling removal of old stumps and residual roots and root lets
G. applanatum	-do-	Decay of Wood	-do-
Polyporus gilvus	-do-	Root-rot	Avoiding water logging Conditions and injury to plants
Botrydiplodia theobromae	Deutero	Collar-rot	Soil drenching with Carbendazing fungicides
B. theobromae	-do-	Die-back	Cu-based fungicides like Blitox (0.2%)
Rhizoctonia bataticola	-do-	Charcol	Sopraying with Dithane or Root-rot Bavistin (0.1%) fungicides
Fusarium sp.	-do-	Fusarium	Avoiding excessive water wilting

Growth Yield and Management of the Species

Natural Crop

The growth statistics of *A. nilotica* are available in some of the Working plans. These data are based on the analysis of sample plot data of Uttar Pradesh, Maharashtra and Madhya Pradesh. The growth data for the natural babul forests has been compiled and the summary of the same is reproduced in Table 4.

Table 4. Yield table of *Acacia nilotica*

Crop Age (Years)	5	10	15	20	25
Average age diameter (cm)	7.36	13.71	18.79	22.60	25.14
Maximum diameter (cm)	12.19	20.83	26.92	31.49	34.29
Main average height (m)	8.22	11.58	14.02	16.15	17.67
Crop top height (meters)	8.14	12.19	14.93	16.70	17.98
No. of trees/ha	538	246	155	120	99
Total volume (cu.m.)/ha	10.19	22.08	35.53	45.49	50.26
Thinning volume (cu.m)/ha	11.27	3.22	4.95	6.39	7.27
Final yield (cu.m)/ha	11.46	25.31	40.49	51.98	57.54
Accumulated yield of thinning (cu.m)/ha	1.27	4.50	9.45	15.85	23.13
Total yield(cu.m)/ha	11.46	26.58	44.99	61.44	73.39
M.A.I. (cu.m)/ha	2.29	2.66	2.99	3.07	2.93
C.A.I. (cu.m.)/ha	3.02	3.68	3.29	2.38	-

The figures are from actual measurement of trees in a crop of seedling origin in which all dead, dying and suppressed trees were removed initially and about 625 seedling per ha are retained. The plot is having ravines with loamy soil and occasional kankar pan formation. The growth figures as read from Age/height and Age/diameter curves are as follows (Table 5).

Table 5. Age/height and age/diameter relationship

Age in years	Average diameter at b.h. (in cms)	Average Height (in meters)
5	5.7	1.6
10	8.5	2.2
15	11.0	2.6
20	13.7	2.8
25	16.5	3.0

Babul is a fast growing tree when soil moisture is not a limiting factor such as on canal banks or tank fore-shore plantation. Rate of growth recorded for average plantation is given in Table 6.

Table 6. Tree growth data from canal bank plantation

Age (years)	Number of Trees (per ha)	Av. DBH (cm)	Av. Height (m)

10	246	13.7	11.6
15	155	18.8	14.0
20	120	22.6	16.1
25	99	25.1	17.7

Growth data for 11 years collected from a sample plot situated in Kamlodiya block of Udaipur range are as follows (Table 7):

Table 7. Height and diameter observations at Udaipur

Year of measurement	Age in years	Average D.B.H.(O.B.) (in cms)	Average height (in metres)
1957	6	6.0	2.35
1963	12	9.2	2.93
1968	17	10.7	3.65

Growth Data Compilation at FRI, Dehradun

At FRI, Dehradun yield table for *A. nilotica* has been prepared from the growth data collected from 11 sample plots (8 sample plots in Uttar Pradesh and 3 in Rajasthan) on the basis of tree model approach. The best site quality of the locality had H/H max = 1, where H = average height and H max = maximum height of the dominant trees. It was found that maximum basal area per ha is attained when BA/BA max equals one (where BA = average basal area and BA max = the basal area of the largest trees). Yield tables for 3 different sites have been calculated with the help of regressions (Table 8). Thinning yields have also been worked out by using growth curves.

The study reveals that in best localities, i.e. site quality I, there should be about 1196 trees in a plantation at 5 years of age of obtain maximum volume output from the site. The study also indicates the subsequent reduction in number of trees which should be applied during the course of management. Observations taken on the growth of babul trees indicates that the best growth is attained on canal bank plantations. In dry areas, the rate of growth is poor. Babul attains 10 to 12 m height at 25 years in dry tracts where it is capable of yielding mean annual increment of 3 to 4 m^3/ha.

Table 8. Yield of *Acacia nilotica*

Age	Dominant		Mean Diameter by basal area method	Number of trees / ha	Basal area /ha (in squ.m)	Total Volume/ha (in squ.m)	Volume thinned (in cube.m)	M.A.I. (in cube.m)
	Height (in meter)	Diameter (in cms)						
Height Ratio 1.0 (Good site quality)								
5	9.2	16.9	9.8	1196	9.07	36.8	6.83	7.33
10	13.8	21.8	16.0	691	13.89	88.42	12.82	9.53
15	16.2	24.4	19.8	514	15.88	120.75	13.88	9.36
20	17.7	26.3	22.7	417	16.97	143.94	15.38	8.87
25	18.7	27.8	25.2	354	17.67	162.61	-	8.46
Height Ratio 0.8 (Medium site quality)								
5	7.4	13.6	7.6	1473	6.71	20.83	4.17	4.17
10	11.1	18.7	12.8	872	11.18	55.40	6.91	5.96

15	12.0	21.3	15.9	660	13.11	77.36	7.72	5.90
20	14.1	23.3	18.3	541	14.20	92.83	7.86	5.58
25	15.0	24.8	20.3	462	14.91	104.35	-	5.24
Height Ratio 0.6 (Poor site quality)								
5	10.3	10.3	5.9	1487	4.07	9.18	1.1	31.84
10	8.3	15.0	9.8	1059	7.93	28.79	2.72	2.99
15	9.7	17.4	12.0	855	9.69	41.38	3.13	3.05
20	10.6	19.2	13.7	726	10.71	50.92	3.21	2.90
25	11.2	20.8	15.1	634	11.38	57.60	-	2.71

Economics of Planting the Species

Acacia nilotica is one of the most important multipurpose tree species. It is being introduced on a large scale under various components of social forestry programmes in many Indian states. It is a domestic tree and villagers like to plant it around their houses, wells, compounds and in the agricultural fields. Almost every part of the tree finds some use. The tree is highly versatile. It is capable of growing in a variety of soil conditions. The tree has been planted on a large scale along roads, rails and canals. It is also planted in degraded forest areas particularly near habitations. It also grows well in grasslands and pastures and is a good tree for silvi-pastural systems. The tree grows well in the tropical arid and semi-arid regions in India.

In social forestry programmes, *Acacia nilotica* has been grown mainly under the following components.

Strip Plantation

Babul plantation in strips along road, rail lines and canals has been taken up on a large scale in several states. These plantations are economically viable and have been financed by different agencies. The IRR for these plantations ranges between 10-25 per cent.

Village Woodlots

The species has been planted in village woodlots in several states. These plantations yield valuable products and are economically profitable. Near Ahmedabad, some village woodlot plantations are managed for the production of datun (sticks used for brushing teeth). Most village woodlots are managed in a rotation of 15-30 years for production of timber for local use.

Agroforestry Plantations

Babul can be seen in agroforestry plantations right from the foot hills of the Himalaya in the north to Tamil Nadu in the south, from Rajasthan in the west to West Bengal in the east.

In West Bengal, *A. nilotica* has been tried in mangrove areas and in silvipisciculture systems. It is reported that areas outside the National Park in Sunderban delta have been planted with several non mangrove species including *A. nilotica* and cultivation of fish is taken up in the areas enclosed with earthen embankments.

A. nilotica leaf litter decomposes easily and cycles organic matter in the soils where planted, qualifying the species for its suitability in agroforestry systems.

Rehabilitation of Degraded Forest

Babul has been planted on a large scale in several states for rehabilitation of degraded forest lands.

Reclamation of Wastelands

A. nilotica appears to be the most important species for afforestation of wastelands. The species is good for revegetating saline, alkaline, ravine and waterlogged areas. It is also good for black cotton soils.

Aerial Seeding

Aerial seeding is quoted as a promising, cheap and quick technique for regeneration. The efficiency of aerial seeding depends on species and site conditions. In India, aerial seeding of *A. nilotica* has been done on experimental basis in Chambal ravines in Uttar Pradesh, Rajasthan, West Bengal and Western Ghats of Maharashtra.

Harvesting and Its Calender

Babul forest are generally managed on a rotation of 30 to 40 years. Trees planted in agro-forestry plantations are generally harvested on shorter rotations. In forests, the trees are generally marked for felling during December-January and felling is carried out from February to April. The timber and firewood is sorted out and timber is generally transported to depots by April-May. Harvesting is completed by June before the onset of the monsoons.

Market and Marketable Products

Babul is a very useful species and yields several products. Timber, firewood, bark gum, fodder leaves and several other products availed from *A. nilotica* tree are marketed either locally or in urban centres. Timber is generally used for construction. It is one of the most favoured timber for agricultural implements like harrows, ploughs, bullock cart yokes, shafts and wheels etc. It is also considered to be a good timber for various class one type of tool handles. It is also used in several sports and athletic goods like clubs, wall bars, pebble bars, etc. The branches of the tree make excellent fuel wood. The calorific value of the sapwood is 4793 caloories/Kg and that of heartwood is 4946 calories/Kg and it also produces good quality charcoal. The wood obtained of *A. nilotica* is also used for paper and pulp making. The bark of the tree is separated from the logs and used extensively for tanning purposes in local tanneries. The average tannin content in bark is estimated at 12%, though sometimes it can be as high as 20%. Bark of older trees is richer in tannin content than the bark from young trees. The bark is used in tanning industries mainly located in northern India particularly in Kanpur. The leaves and pods are used as fodder by graziers locally. Pods are also used for tanning purposes. The gum obtained from *A. nilotica* is known as Indian gum arabica. Almost all the products obtained from *A. nilotica* are marketable.

The important markets (Mandis) of babul are mostly located in Maharashtra (Pune, Amrawati, Buldhana, Akola) and Tamilnadu (Guntur, Tinnovalle-Ramnad)

Source Institutions for Detailed Information

Detailed information about *A. nilotica* can be obtained from Institutes listed below:

a. Forest Research Institute, Dehradun

b. Arid Forest Research Institute, Jodhpur

c. Tropical Forest Research Institute, Jabalpur

d. Institute of Genetics and Tree Breeding, Coimbatore

Source: Indian Council of Forestry Research and Education, Dehradun. Babul (*Acacia nilotica*).Dehradun, Forest Research Institute. 33p.