

**Anogeissus latifolia** : Anogeissus latifolia is a tree that grows up to 33 meters high. The leaves are elliptic-obtuse, entire, rounded at both ends. The flowers are greenish yellow, with minute globular heads on short stalks axillary. The fruits are small, yellowish brown or reddish brown, glossy, beaks, wings, and a top seed. Its seed is wedge-shaped.

**Common Name-** Axle-wood tree, gum ghatti, Indian gum, Dhaura, Dhausa, Dhau, Dhawra, Dhow, Bakla, Dindal, Dinduga, Vellay naga, Chiriman.

**Distribution-** In the Himalayas, Axle-wood of the tree is located at altitudes up to 1300 m. On deep soils it can become a great tree, with bole to 15 m long. The leaves are fed to silkworms. The species is native to the semi-arid areas of India. It is hardy, drought easily damaged by fire. Mentioned as an agroforestry species possible.

**Environmental requirements:** Environmental requirements: Altitude: 1200 m Mean annual temperature: 44 ° C. Average annual rainfall: 625-2250 mm Soil type: Found on a variety of soil types but prefers deep alluvial soils. Does not tolerate water logging.

**Phenology:** In India, A. latifolia is leafless in February-May Flowering: June to September depending on the locality, and the ripe fruits are present from December to March. Leaf flushing begins in the dry season, reaching a peak time before the rains start.

**Silvicultural traits:** **Silvicultural characters:** The tree is definitely an applicant if the light seedlings and saplings can withstand some shade. The tree is fairly drought resistant. The plants, however, get killed year after year in dry localities, but have good recuperative powers. It is not very soft gel. It coppices well and tadpoles, but a large seasonal variability is exhibited in the coppicing and pruning. It is susceptible to fire damage and navigation.

**Natural regeneration:** Natural regeneration: Natural regeneration of A. latifolia occurs through seed and coppice. Requirements for the establishment of natural regeneration is sufficient light, moisture, good drainage and the lack of thick weeds or in growth. Coppicing is invoked to regenerate the natural stands of coppice shoots grow quickly. Dilution of coppice shoots is necessary, as the number of coppice growth is usually produced by more than two.

**Artificial reproduction:** Artificial reproduction: not much work has been done on the artificial reproduction of this species. It can be raised by planting nursery raised plants or strains.

**Nursery techniques:** Nursery techniques: stem, usually with 22 cm and the root portion of 5 cm of shooting are prepared from plants two years old. After preparation of jute are wrapped in a damp cloth to prevent drying. The strains are refreshed before planting to remove any dried bits of the shoot and root.

**Planting techniques and maintenance:** Planting and maintenance techniques: Planting is done in July and August after the onset of monsoon rains. Planting seedlings or stem is in pits of size 30 cm 3 pits dug in advance at a spacing of 3 \* 3m. Although the use of bare seed for planting, the seedlings must be torn from the nursery beds with balls of earth, carefully wrapped and transported and planted.

Good rainfall after planting ensures good survival rate. Planting operations should be suspended if no rain is expected for a few days of planting. Bush cutting and weeding are necessary to prevent the removal of seedlings. The planting areas are in need of protection against pests and fire.

**Silvicultural treatment:** It worked only as a component of mixed forest species coppice under standards. However, this tree often cut in the interest of the most valuable species such as teak and sal in the slaughter of selection and breeding. Short rotation coppice method is adopted for the harvest of young tender leaves and shoots are rich in tannin. Seeds are sown densely on raised beds, the soil being mixed with large amounts of coarse sand. The bed is well shaded and 45 cm above the ground. Germination is fairly rapid. The plants are highly susceptible to insect attack. The development of plants is very slow.

**Rotation and performance:** This is a slow growing tree species, even slower in drier locations. Growth in the phase of saplings and pole is relatively faster than in the seedling stage. Stem sections show approximately four rings per cm radius. The harvest of coppice growth rate exhibits faster than seedlings. Once established in natural forests under some form of coppice management, meaning average annual increase of about 1.5 m 3 per ha per year.

**Uses:** It is one of the most useful trees in India. Its leaves contain large amounts of tannins, and are used in India for tanning. The tree is the source of Indian gum, also known as gum ghatti, which is used for the printing of banners and other uses. The leaves are also fed by moth *Antheraea paphia* producing silk Tussah (Tussah), a type of wild silk of commercial importance. Used in the treatment of snake bites and scorpion stings in India. Apiculture: The flowers are an important source of pollen for bees.

**Pests and diseases:** The sapwood is susceptible to *Lyctus*. *Sarcinelli apocynacearum*, *S. combratcearum*, *Tripospermum caseariae* and *T. lougurensis* ectoparasites are fungi associated with living leaves. The two dead and dying trees are attacked by stem borers, and *Olenecamptus anogeissi* *Olenecamptus indianus*.

**Reference** <http://08hachi.blogspot.com/2011/09/axle-wood-anogeissus-latifolia.html?m=1>

### **Botanical name : *Madhuca latifolia***

Family : Sapotaceae

**Distribution:** The tree grows throughout the greater part of India except the temperate and arid areas and southern parts of the India peninsula. It is a common tree of the deciduous forests of Madhya Pradesh, Maharashtra, Gujarat, Central India, Indian peninsula, Chota Nagpur, Orissa and is characteristic of dry plains. It is extensively cultivated near villages because of its multi utility, Two varieties, viz., var. *longifolia* and var. *latifolia* are recognized. The former grows in South India and the latter in North India.

### **Environmental requirement**

Climate and Temperature

It is a tree of dry tropical and subtropical climate. In its natural habitat, the absolute maximum shade temperature varies from about 41°C to 48°C, the absolute minimum temperature from about 10°C to 8°C.

Rainfall

The normal annual rainfall from about 750 to 1875 mm. The mean relative humidity in its natural range varies from about 40 to 80% in January and from about 60 to 90% in July.

Soil

The tree grows on a wide variety of soils, but prefers sandy soils. It grows well in alluvial soils of the Indo-Gangetic plains. In Sal forests, it is found growing on high clay and even calcareous soils.

### **Phenology**

Flowering takes place during March-April. Fleshy corolla falls off before or with the appearance of new leaves. About 10 year old trees start flowering. One to two good seed years may be expected every three years.

### **Silvicultural Characters**

It is a strong light demander and get suppressed under shade. The trees coppices well if felled in hot season. It has better taproot system.

Climate and Soil

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### **Nursery Techniques**

Ripe fruits are collected by shaking the branches. Fruits are rubbed and washed to obtain clean seeds. About 450 seeds weigh one kg. Fresh seeds have high germination capacity, which however is soon lost on storage. Fungi and insects readily attach the seeds.

Fresh seeds are sown at a depth of about 1.5 to 2.5 cm. One-month-old seedlings are transplanted in nursery beds. Late transplanting gives poor results. Spacing in transplant beds is 30 x 15 cm; shading the seedling is necessary, One-year-old seedlings are used for planting in main field. Seedlings can also be containerized. In that case, one-month-old seedlings are pricked into containers. Shading is necessary.

### **Planting**

Planting is one in 30 cm<sup>3</sup> pits at a spacing of 4x 4 m. Planting of stumps is done in crow bar holes or 30 cm<sup>3</sup> pits

### **Utilization**

Leaves are used as fodder. Flowers and fruits can also be fed to cattle. Leaves contain crude protein 9.8%, crude fibre 20.3%; N free extract 60.7%; ether extract 4.1%; total ash 7.8%, calcium 1.6%, phosphorus 0.2%. Seeds contain 39% oil which is used for cooking and soap making. Seed cake is also fed to cattle. It also makes a good manure. It contains (on dry matter basis), the following : crude protein 19.4%, ether extract 12.0%; crude fibre 62.2%, total ash 6.4%; calcium 0.2%, phosphorus 0.8%; digestible crude protein-8.0% total digestible nutrients 60%. Flower can also be fed to livestock to replace cereal concentrates. A fully developed tree can produce upto 90 kg of flowers in a year. The chemical composition (in per cent) of the flowers is crude protein 8.0; ether extract 1.4; crude fibre 30.4; N free extract 52.4; total carbohydrate 83.8; total ash 7.8; calcium 0.22; phosphorus 0.16. The protein content is comparable to that of rice and the total carbohydrate to that of maize and oats as also the availability of total digestible nutrients. Flowers are used by the tribals as a source of alcohol.

#### **Reference**

[http://agritech.tnau.ac.in/bio-fuels/Biofuel\\_Mahua.html](http://agritech.tnau.ac.in/bio-fuels/Biofuel_Mahua.html)

#### **Melia Dubia**

Meliaceae

Vernacular Names

Assamese: Dingkurlong, Bengali: Ghora-nim, Gujarathi: Kadu-kajar Hindi: Ghora nim, Kannada: Kad bevu, Betta bevu; Karibvam, Heb-bevu, Malayalam:Malavembu, Aryaveppu; Malaveppu; Valiyaveppu; Kattuveppu, Marathi: Kuriaput, Oriya: Maha- limbu, Batra, Tamil: Malay vembu; Masaveppu, Telugu: Munnatikaraka, Urdu: Labshi

Distribution

The species is found distributed in Very Moist Teak forests (3B/C1a), Secondary Moist deciduous forests (3C/2S1) and Dry Mixed Moist deciduous forests (5B/C2) of India.

#### **Description**

Natural Distribution of Melia dubia in India

Melia dubia is a large deciduous perennial tree growing from 6 to 30 metres in height. Bark is smooth, greenish when young, turning dark brown when mature and fissures with age forming large rectangular flakes. Wood trunk has few or no branches arising from about 8 m. Young branchlets are scurfy-tomentose, terete, turning glabrous on maturity into branchlets. Leaves are compound, bipinnate to tripinnate, imparipinnate, alternate, spiral, crowded, pulvinate; rachis terete, long stalked upto one meter in length; petiolule 0.3-1.2 cm; pinnae 3-8 pairs; leaflets 2-5 pairs on each pinnae, opposite, 4.5-9 x 2-4 cm, ovate-elliptic, apex acuminate, base cuneate or attenuate, asymmetric, margin crenate, coriaceous, glabrous when mature; midrib raised above; secondary nerves ca. 10 pairs, gradually curved; tertiary nerves broadly reticulate. The leaves are shed in December and flush of new leaves are found in February-March along with the flowers.

#### **Flowers**

The flowers are borne on the terminal panicles in the upper axil and are shorter than the leaves. The flowers are numerous star shaped, greenish white in colour. The petals are hairy. The tree flowers during January to April when the trees shed their leaves and fruits ripen during November to February in the next year.

#### **Fruit and seed description**

Fruits – Fruits ripen from October to February. The fruit is drupaceous, ovoid or ellipsoid about 1.5 cm long, smooth, shining and yellowish when ripe. Immature fruits are green in colour, mature fruits yellow which turn brown. The average size of the fruit is 3.0 x 2.0 cm with about 250-300 fruits per kilogram. Samples with 500 fruits per kg have also been observed. A single tree can produce 15 – 20 kg of fruits.

Seeds – Each endocarp has five locules housing 1-5 seeds per fruit. The seeds are enclosed in a stony endocarp, pointed smooth and black. Locule filling varies from 0 - 5. Isolated tree collections have been observed to show poor filling while fruits collected from plantations raised from different sources have high levels of seed filling. The seeds have an average size of 1.5 cm x 0.5 cm. 100 seed weight is about 150 g.

It is best to adopt ground collection in Melia than obtain fruits by climbing and / or shaking the fruiting branches. The ground can be cleared off and a tarpaulin spread under the tree. Care should be taken to collect only the ripe yellow or brown fruits. Green fruits indicate immaturity and should not be collected.

#### **Processing and handling**

After collection the fruits can be transported to the place of processing in gunny bags or bamboo baskets. Ripe yellow fruits can be depulped easily if the fruits undergo fermentation and heating as the pulp is difficult to remove. Under natural conditions, ground fallen fruits are eaten by goats / deer which depulp the fruits and spit out the stony endocarp. The pulp can be softened by allowing the fruits to ferment which can be hastened by soaking the fruits in water which is slightly acidified (to pH 5.5-5.6) or in lime water (Dilute calcium hydroxide solution). Once fermented, the fruits are macerated in bamboo baskets and thoroughly washed under running water so that even a small quantity of pulp is not adhered to the seeds. Sand can be used as an abrasive to remove the pulp thoroughly.

#### **Storage and viability**

The drupes thus extracted have to be sun-dried for ten days in shade. Cleaned and dried drupes can then be stored in gunny bags or sealed tins for one to two years without losing viability. The drupes stored for over a year show improved germination over fresh ones. No instances of pest incidence have been observed in the fresh or stored drupes of *M. dubia*. If the pulp is not thoroughly removed, the drupes are susceptible to fungal infestation. This can be overcome using Captan or Bavistin (@ 4 g/kg seeds).

#### **Seed processing and pretreatments**

Reports state very poor germination in *Melia*. The highest recorded germination in the species is 15-20 per cent. Various pretreatments like hot-water soaking (60-70°C), boiling water treatment (100°C), roasting drupes at 60°C for 5-10 minutes, storing of drupes in farmyard manure, treatment with concentrated sulphuric acid (H<sub>2</sub>SO<sub>4</sub>), drupes collected from the spittings of goats, soaking of drupes in cow-dung slurry for two to fifteen days, cutting the hard endocarp of drupes and soaking drupes in cold water for a week have been suggested to improve the germination rate of *M. dubia*. However, studies at IFGTB reveal germination as high as 75 per cent without any pretreatment. The drupes should be graded in water to remove floating drupes prior to sowing. The major constraints in germination identified in the species at IFGTB are the source of collection, time and medium of sowing.

#### **Nursery**

Seed sowing: Cleaned and dried drupes should be sown in the open raised nursery beds, in drilled lines, 5 cm apart. About 6-7 kg of dried drupes containing about 1500 numbers are required for one standard nursery bed (10 x 1 m). The drupes sown need to be watered regularly. At places where daytime temperature is not very high, or where nursery beds are in shade, the bed should be covered with a tarpaulin sheet to retain temperature in the medium.

#### **Nursery pests and control**

Red spider mite: The mites occur in groups beneath the leaves and feed on the epidermal tissues. Chlorosis can be easily located on the adaxial side in infested seedlings. Low to medium level infestation was found during June to July and November to December. Application of Derrimax 0.3 ml/lit of water can control the mites.

Ascortis selenaria defoliator: A polyphagous defoliator attacks *Melia* seedlings during the rainy season- June to July and November to December. The main host is *Prosopis juliflora*. It also occurs in *Peltophorum ferrugineum*, *Santalum album*, *Delonix regia* etc. At low infestation level, handpicking of caterpillars can be done to manage the pest. Adults are usually attracted to light and therefore light traps can be installed for a week after the first showers. At high infestation level Methyl parathion (2 ml/lit) can control the pest.

Mealy bug: Occasional incidence of mealy bugs was noticed at low levels in seedlings. Application of Neem oil or tobacco extract directed towards the underside of the leaves controlled the scales.

Leaf miners: Leaf miners also damage the leaves in nursery seedlings at very low levels.

In seedbeds, collar rot and seedling web blight by *Rhizoctonia solani*, leaf spots caused by *Colletotrichum dematium* (Pers. ex Fr.) Grov. and *Cylindrocladium ilicicola* (Hawley) Boedijn & Reitsma are the diseases recorded on *M. dubia* in nursery. The symptoms produced by both the pathogens are almost similar; disease appears as small pin prick lesions, pale brown in colour, later spreading to form circular necrotic lesions. The infection spreads to the entire leaf lamina in case the attack is severe. Premature defoliation is noticed in container seedlings. Both the foliage diseases can be controlled by the application of Carbendazim (@ 0.1% a.i.) as foliar spray at fortnightly interval as well as soil drench at weekly interval.

Both the pests and diseases incidence are serious, causing heavy mortality to the species, and hence require to be monitored closely.

### **Pricking and maintenance of seedlings**

The seedlings in the nursery bed, by about one month, can be pricked and polypotted. Care should be taken at the time of transplantation as the species is very sensitive to transplantation shock. The potted seedlings can be maintained in the shaded nursery with regular watering for normally 3-4 months. It is better to shift them to outdoor conditions at the end of six months, as further retaining them in shade hampers their growth.

### **Plantation methods**

Growth requirements: *Melia dubia* is fast-growing and possesses strong potential as a reforestation and agroforestry species. The species grows well in temperature ranges of 30-45 °C at an altitude of 650 – 1800 m. The species requires a mean annual rainfall of 750 – 2500 mm. It grows in well drained red, red loam and black loam soils with pH ranging from 5.5 to 7.0 and depth 50-150 cm, requires moderate soil fertility and can come up in soils with salinity of <4 dS/m.

**Silvicultural characteristics:** The tree is a heavy light demander, requiring full overhead light for development. Young plants are easily browsed, and hence care should be taken during the first year of planting. It is an excellent coppicer, coppicing profusely from large stumps, however, younger stems or stumps of one to two year old trees yield only a few coppice shoots. It produces root suckers freely. The species is susceptible to the attack of mealy bug, which attacks stumps and destroys the young coppice.

### **Out-planting of seedlings**

The species performs best in wide spacing of 5 x 5 m in staggered rows, though lesser spacings of 4 x 4 and 3 x 3 are also adopted. Planting should be done prior to the rains. Pit size of 60 cm x 60 cm x 60 cm is essential. Irrigation is essential during the first two years, devoid of which the species does not survive even in good sites. Fertilization during the first two years hastens growth.

### **Plantation pests and diseases**

No major incidences of pests are noticed in the plantations of *M. dubia*. However, a few diseases like stem canker and gummosis result in damage to the clean bole affecting its market value.

### **Timber characteristics**

The wood is moderately hard and 450 kg/m<sup>3</sup> in weight. The sapwood is grey or pinkish- white with a yellowish tinge and the heartwood is light red in colour. It is straight grained and coarse textured. The wood is easy to saw, machines satisfactorily and can be finished into a smooth surface. It is only moderately durable, that too under cover. Wall-boards, door panels, furniture, agricultural implements and floorings are also made with the wood. It has been identified as the best raw material for plywood, as both face and core veneer. It can also be used for match industries, packing cases and as a paper pulp for production of paper. It has been identified as a high calorific value species, hence is deployed in energy plantations. Timber is highly useful and it seems very suitable for agriculture implements, plywood, boxes and packaging purpose. It is used for cabinet making and in construction because of its resistance to termites. Due to the light weight, it is widely used for making catamarans (kattumarams) also.

### **Other uses**

#### **Unrefined pulp**

1.7 49.2 5.2 540 2.4 82 83.4 48.4 8.9

#### **Refined pulp**

1.42 86 10.1 300 5.8 80 79.2 38.5 9.2

(APA, 2010)

Extracts from the tree are medicinal and the leaves are lopped as fodder. The seeds are reported to contain linoleic and oleic acids (65-82%) and they also yield greenish- yellow butter oil, not utilized now but with potential in preparation of soap and hair oil. The bitter principle of the fruit is a remedy for colic, half a fruit being the dose for an adult. The fruit is used as an anthelmintic. The juice of the green fruit, with a third of its weight of sulphur and an equal quantity of curd heated together in a copper pot, is used as an application to scabies, and to sores infested with maggots.

### **Growth statistics**

Growth statistics vary from region to region depending on site and environmental factors. The general observation is that if plantations are established with better spacing in favourable conditions, growth rate is high. The irrigated plantations attain GBH of 82 cm while under rainfed conditions, the GBH is 48 cm at the fifth year. The tree generally branches after attaining a height of 12 – 13 m

## **Economics**

4 year Old Trial – Irrigated Girth 67cm, Height 14 m Clean bole 10 m

The information provided in this section has been obtained from Hunsur Plywood Works Pvt. Ltd., Hunsur, Karnataka based on the growth performance of the species planted by the concern in 1995 and evaluated at the end of 15 years. Ten trees were selected and harvested. The trees had an average bole length of 8.90 m and a girth of about 100 cm producing approximately 0.425 cu.m. (15 Cft) per tree. These logs can be used for core veneer by peeling and logs of smaller sizes can also be utilized. Trees with a minimum of 16 inches (40 cm) girth are saleable at the rate of Rs 2000 per tonne for match industry.

Area of the plantation Species planted

Spacing

Total trees planted (Block) Per cent survival

Average height of the plantation Average girth of the plantation Average yield per tree#

Average value per tree

Current value of the plantation\*

1 Acre (0.40 ha) Melia dubia

6 x 6 m

108

90

7.84 m

96 cm

15 Cft. (0.425 cum)

280 x 15 = 4200/- 4200 x 97 = 4,07,400/-

Total expenditure for plantation (includes establishment, weeding, manuring, watering) upto maturity 6000/-

Market value of timber (current price)

Rs. 280/- per cuft (boles with length >8.5 m and GBH 115 cm fetch higher prices)

Net profit 4,01,400/-

\* Cost of land not included. #Only clear bole is taken into account. Lops and tops are not accounted for.

This performance of the species can be expected only under good maintenance and controlled irrigation upto atleast six years. Unattended plantations with weed growth, poor soil conditions, water logging, etc., do not produce logs of the desired size. If bund planting is taken up in a single row about 60 trees can be planted at 5 m spacing which will fetch an income of about Rs.2 lakhs in the sixth year, as trees planted along bunds have been recorded to put on girth faster than the block planted material.

If the plantation is maintained for 30 years, the logs fetch higher prices (Rs. 650/- per cft ) as the utility value of the wood is increased. The logs can be used for face veneer and the process is more akin to splitting for which larger sized logs are required.

Problems in identification of Melia dubia and Melia azaderach

It has been observed that there is a mix up of two species of the family of Meliaceae namely Melia dubia and Melia azaderach. The latter is planted as an avenue tree and does not possess the traits desirable for plywood. But identification of the species has posed problems and farmers are able to distinguish the species only at the end of one year. Described below is a pictorial difference of the two species which would facilitate the public to identify the two species.

### **Reference:**

[https://www.researchgate.net/profile/Rekha\\_Warrier3/publication/282005705\\_Melia\\_dubia/links/560124b308ae07629e52ba3e/Melia-dubia.pdf?origin=publication\\_detail](https://www.researchgate.net/profile/Rekha_Warrier3/publication/282005705_Melia_dubia/links/560124b308ae07629e52ba3e/Melia-dubia.pdf?origin=publication_detail)

### ***Tecomella undulata***

Common names (Synonyms): Hindi- Roheda, Rohida Marathi- Raktrohida, Rakhtroda; Sanskrit- Chalachhada, Dahimacchada, Dadimapuspaka; English- Marwar Teak, Desert Teak, Honey Tree Geographical sources: India, UAE, Pakistan

**Distribution** of *Tecomella undulata* is restricted to the drier parts of the Arabia, southern Pakistan and northwest India up to an elevation of 1200 meter. In India, it occurs naturally in Rajasthan, Gujarat, Punjab, Haryana and Maharashtra. In Pakistan it is found in Sind and Baluchistan. It is also distributed in sub-Himalayan tract from Gonda (UP), eastward to Bengal, Sikkim and Assam west, in Andaman and western ghat.

In India the species is mainly found in western parts of Rajasthan such as Barmer, Jaisalmer, Jodhpur, Pali, Ajmer, Nagpur, Bikaner, Churu and Sikar districts. In Gujarat it is found in North region. In other states its population is scanty and very rare.

It may grow as high as 12 meters with a girth up to 2.4 meters. The species has been identified as an important for environmental conservation in arid zones as a stabilizer of shifting sand dunes, providing shelter for wild life. It is a very useful species for afforestation of the drier tracts due to its drought and fire-resistant properties.

#### **Morphological features:**

The wood is grayish or yellowish brown, close grained and mould with light streaks and is tough, strong and durable. The heartwood contains a good amount of lophol which is toxic and responsible for the fungus and termites resisting property of wood.

Bark of young plant is soft and greenish brown and hard and dark brown in old tree. Its bark is up to 8 mm. thick in fully matured tree. The bark of young branches is employed for the treatment of syphilis and eczema. Preliminary investigations have shown that the bark possess mild relaxant, cardiogenic and cholestatic activity.

Leaves are 4-8 × 1- 1.25 cm. narrowly oblong or linear oblong, simple, obtuse, margin undulate, membranous, dark green, glabrous above and petiole. Leaves of this plant have heavy edges. Flowers are pale yellow or deep orange-red, showy, large, 6.5 - 7.5 cm. long in corymbs racemes, arranged in few flowered from short lateral branches. The tree looks beautiful when in full bloom from March to April.

Fruit is capsule, slightly curved. Seeds of *Tecomella undulata* are winged. It has been reported that soil under tree *Tecomella undulata* has appreciably higher concentration of various macro and micro nutrient elements.

The plant prefers subtropical climate having medium to light soil.

#### **Propagation**

*Tecomella undulata* is propagated conventionally mainly from seeds. Since, the tree is very slow growing and no suitable method for vegetative propagation for rapid multiplication of elite trees is available (Bhansali 1993) therefore, seeds of better quality trees are of prime importance for extensive plantation (Jindal and Bhansali 1997). Seeds of *Tecomella* are available from April to June and at times only unripe/over ripe capsules are available (Jindal et al. 1987a). Jindal et al. (1990) studied the effect of fruit ripening and seed storage on germination and seedling characteristics of *Tecomella*. Hypocotyl length was maximum in seeds collected from burst capsules collected during April therefore collection of ripe fruits in the month of April were best suited for germination compared to unripe fruits, or ripe fruits collected in the month of June. They also reported a loss in seed viability with time; freshly harvested seeds showed 82 % germination in wet paper lined petriplates at room temperature (35 °C) while 2 year old seeds had only 15.5 % viability. Storage was also reported to have an effect on seedling vigour besides % germination. Decrease in radical and hypocotyl length was recorded with increase in seed age. Seed dormancy was not encountered during the study as the freshly harvested seeds germinated well.

They suggested a need for exploring alternative methods of seed storage instead of seed storage in gunny bags as practiced by the State Forest Department. Nirmala and Radhakrishnan (1995) studied the pod morphological characters and assessed the stage of pod harvest for seed collection. They reported that a colour change of the pod from yellow to brown could be taken as a reliable index for pod harvest. Fresh seeds were readily germinable and seeds from the apical and middle regions of the pod produced greater seedling vigour than seeds from the distal region.

Later, Jindal and Pancholy (1994) studied the effects of different storage containers on seed germination and seedling characteristics. They observed that after 16 months of storage, the seed viability ranged from 27.1 % in paper bags to 30.0 % in cloth bag, 57.1 % in tins and 64.3 % in polythene bags. Germinative Energy Index (GEI) i.e. the percentage of seeds which have germinated up to the time when the number of seeds germinating per day has reached to peak, also followed a similar trend. They concluded that seeds with low moisture content can be maintained for longer periods at room temperature if stored in air tight containers. Jindal and Bhansali (1997) studied the effect of plant growth regulators (PGRs) (IAA, BAP, Kn, GA<sub>3</sub>), a systemic fungicide (bavistin) and extracts of abnormal plant growths (witchbroom diseased tissues of *Salvadora oleoides* Decne,

insect induced gall tissues of *Zizyphus nummularia* (Burm.f.) Wight et Arn. and *P. cineraria* (L.) Druce) on seed germination and seedling characteristics of Rohida. Bavistin (250 ppm) showed the most pronounced and explicit effect on germination (93.3 %) and GEI (67.3 %) while significant delay in germination was observed with growth regulators. Interestingly, the plant extracts of abnormal growth enhanced the general growth of seedlings, and maximum beneficial effect (2.5 %) was observed in the treatments of *Zizyphus* gall tissues.

Sheikh (1981) suggested that *T. undulata* can be successfully planted in areas receiving an average rainfall of 350 mm/year and mulching with pebbles up to 1 m from the plants significantly increased their height. Further, Sheikh (1986) observed that *T. undulata* survived well when planted at 30 cm depth compared to 18 cm depth. Mulching caused dramatic improvement in the growth of *T. undulata* and contributed to 90 % survival (Gupta and Singh 1997) while addition of 5 g P<sub>2</sub>O<sub>5</sub> per tree caused 11–13 % increase in height, girth and crown spread (Gupta et al. 1996). Application of nitrogen fertilizer alone did not influence the growth of *T. undulata*, however, phosphorus increased height and diameter (Dutta et al. 1997). Jaimini and Tikka (2001) studied the survival, growth and biomass production of fifteen multipurpose species under rainfed conditions and reported that the survival rate of rohida was 92.70 %, however, its growth was very slow.

## Reference

Kalia R K, Sharma R, Rai M K and Bhatt RK. 2014. Understanding *Tecomella undulata*: an endangered pharmaceutically important timber species of hot arid regions. *Genetic Resources and Crop Evolution*. 61(7):1397-1421.

## *Schleichera oleosa*

**Introduction:** *Schleichera oleosa* (Lour.) Oken. is a monotypic genus belonging to family Sapindaceae (soapberry) the same family to which the popular fruit 'Litchi' belongs. The synonym of this plant are *Pistacia oleosa* Lour. *Schleichera trijuga* Willd., *Cussambium oleosum* Kuntze., *Melicocca trijuga* Juss. The generic name of kusum, *Schleichera* is derived after the Swiss botanist J.C. Schleicher who first described the tree. The species name *oleosa* is derived from the Latin word 'oleosa' meaning oil, as the seed kernel are rich in oil. Synonymously the tree is also referred as *Schleichera trijuga* Willd., the word *trijuga* stands for 'three pairs', based on the presence of three pair of leaflets in a leaf. Kusum is a large forest tree with dense green foliage. Leaves pinnate with three pairs of leaflets. Inflorescence raceme. Flowers white and fruits small. The fruits are berry shaped, globose or ovoid with a hard skin. The seeds are brown, irregular elliptic, slightly compressed oily and enclosed in a succulent aril. The oil content of the seed is around 59-72% with yellowish green color.

## Phenology

Kusum is a slow growing large deciduous tree approximately 20–30 m tall and a crown spread of approximately 2–4 m diameter. The bark of the tree is usually grey in colour with reddish wood inside. The kusum tree sheds leaf during the month of December to February; remains leafless for a short period of time before the new purple to red coloured leaves emerge and gradually turns green with time. Kusum flowers are usually devoid of petals. The shape of the fruit is ellipsoid to sub-globular berry and the base of the fruit is narrowed and apex pointed. The fruits are hard-crustaceous and smooth or slightly spiny. Inside, the fruit contains one seed or sometimes two. The seeds are rich in oil.

Racemes of greenish yellow flowers appear along with new leaves in March-April.

**Fruiting :** Fruit ripen in June-July and quickly falls on the ground.

**Morphology of the Fruit / Seed :** Fruit 2.5 to 3 cms long, globose or ovoid, 1-3 celled, more or less abruptly tapering to a point, dry indehiscent. Seeds 1.5 cm long, smooth, brown, enclosed in a succulent aril having an acid taste.

**Seed Collection and Storage :** Ripe fruits are collected in July-August, dried and trashed to separate the seeds. Stored in gunny bags after smearing with ash for about 6 months without any deterioration. It is locally known as kusum. The other common names are kusum, kusumb, kosumb, koshamara, Celone oak, kosamara, lac tree,



honey tree, gum lac tree, macassar oil tree, sukoshka, skrataka, jatudruma, koshamra, jantu vriksha and kshudra maukkuli etc. It occurs in the Indian sub continent and south east asia. There are many trees that are grown for multiple products. They are known as multipurpose trees (MPTS), a term widely used in agro- forestry. Kusum is also one among the multipurpose trees which has been proved to be useful in numerous ways from times immemorial.

**Nursery Technique :**Seed is sown in polybags in July to August directly since seeds do not withstand the transplanting well because of very fast growth of tap root. The planting out in the field can be taken up after the second rains. The seeds are the major source of propagation and are viable mostly if sown freshly after collection. Proper drying and storage of seeds in airtight containers may allow germination of seeds up to 1–2 years. On prolonged storage the viability of seeds is lost drastically. Apart from seedlings, kusum trees are naturally produced in forests from root suckers (adventitious shoot developed from roots). Artificially kusum trees can be propagated through vegetative method of air-layering (artificial induction of roots from the wound on a shoot and detaching the explant from the mother plant to produce a plantlet). The stumps prepared from the 1–2 years old seedlings, root suckers or air-layers are transplanted in the field in the holes dug approximately 30 cm deep and wide.

**Pests and Diseases:** Although biologically lac insect is the natural pest of kusum, the economic importance of the lac resin secreted by these insects has turned out to be beneficial to human beings. Thus, lac insects are deliberately inoculated on kusum trees and reared with proper management practices. Other insect pests that cause damage to kusum tree include leaf defoliators, stem borers and sap suckers.

The seeds are often attacked by a red bug known as *Serinetha* augur. The stem blight, yellow cork rot, white spongy rot and white fibrous rot are few important fungal diseases of kusum causing serious damage to the trunk and root. The pests and diseases of kusum are managed either through mechanical means or through insecticide/fungicide spray.

#### **Uses**

The wood is suitable as firewood and makes excellent charcoal.

Pressed oil cakes from kusum tree are rich source of crude protein, carbohydrate, fibre and other minerals and serves as nutritive cattle feed.

The oil extracted from the seed, called as kusum oil is used for culinary and lighting purposes.

The kusum oil is being used to cure itching, acne, burn and other skin problems.

The oil is used in rheumatism by external massage.

Kusum oil is used in hair dressing as well as for promoting hair growth.

The pinkish-brown heart wood is very hard, durable and excellent to make pestles, cartwheels, axles, ploughs, tool handles and rollers of sugar mills and oil presses.

Kusum plant is known for lac cultivation. It is one of the major host plant commercially exploited for cultivation of the Indian lac insect (*Kerria lacca*). It supports the kusmi strain of lac insect, which produces good quality, natural, biodegradable and commercially important, light coloured lac resin of demand by lac industry, thus fetching high remunerative prices to lac.

The seeds of kusum are a very rich source of oil (60-72%) for industrial implications. The seed oil called kusum oil is an important component of the Makassar oil used for hair dressing and cooling bath oil.

Kusum oil is used in textile industry for batik applications and also for making soap.

The bark of kusum tree produces tannins and dyes that are occasionally used in small-scale industries like tanning in leather industry.

Young leaves and shoots-raw cooked in soups or steamed and served with rice. The ripe fruit is eaten raw which has a pleasant acid flavor. The unripe fruits are pickled.

An oil obtained from the seed called macassar oil, is some times used for culinary purposes. It contains cyanogenic compounds, which may cause giddiness and should be removed if the oil is used for human consumption.

The kusum tree is also grown as an avenue tree or wayside tree. The tree is utilized for multifarious purposes and is a boon for a subsistence farmer.

The extended foliage and canopy of the kusum tree provides good shade and is therefore, suitable for mixed farming with other heat susceptible economic plants.

Industrial uses of plant parts: The seeds of kusum are a very rich source of oil (60–70%) for industrial applications. The seed oil called ‘kusum oil’ is an important component of the Macassar oil used for hairdressing and cooling bath oil. Kusum oil is used in textile industry for batik applications and also for making soap. Pressed oil cakes from kusum are a rich source of crude protein, carbohydrate, fibre and other minerals and serve as nutritive cattle feed. The bark of kusum tree produces tannins and dyes that are occasionally used in small-scale industries like tanning in leather industry.

**Medicinal uses:** Different plant parts of kusum are used in traditional medicine. The seed oil is used by the local vaids for curing skin diseases like scabies, itching and acne. The bark decoction is also used against skin inflammations and ulcers. The decoction is also infused for curing malaria. The bark of kusum is often used to control tissue swelling by vaids. The bark is known to contain medically important compounds like lupeol used in preparing analgesics and anti-tumorous agents like betulin and betulinic acids. The fine powder obtained by grinding the seeds is applied on the wounds of cattle to prevent flies and maggots.

**Other uses:** The arillodes of the ripened fruits are acidic blended with slight sweetness and are eaten raw, whereas the unripe fruits are used for preparing pickles. The cooked young leaves serve as a culinary dish for poor villagers. Leaves, twigs and seed cakes are excellent source of fodder for cattle. The kusum seed oil consists of cyanogenic compounds and is not suitable for human consumption causing giddiness unless the compounds are removed. However, the seed oil is used for lighting purpose by the poor tribal people. The wood is a source of firewood and charcoal while the hard heartwood is used for making cartwheels, axles, ploughs, rollers of sugar mills, oil press and other agricultural implements.

The major use of kusum tree is for cultivation of lac. However, other uses of kusum tree are currently underexploited but hold promise to benefit human life in many spheres. Planting of kusum in suitable areas needs to be promoted in view of its advantages as MPT. There is tendency to prefer quick-growing trees in the afforestation programmes, which may not always be advantageous or even eco-friendly in the long run. The role of kusum plantations can mainly be envisaged in terms of economic benefits to the resource- constrained farmers dwelling around forest areas.

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## Butea monosperma

### Fabaceae - Papilionoideae

Local names: English (flame-of-the-forest, bastard teak); Hindi (chichra tesu, polak, tella moduga, dhak, palas, desuka jhad, khankrei, chalcha)

**Botanic description:** *Butea monosperma* is a small to medium-sized deciduous tree, 5-15 (max. 20) m tall, up to 43 cm dbh; trunk usually crooked and tortuous, with rough greyish-brown, fibrous bark showing a reddish exudate; branchlets densely pubescent. Leaves trifoliate; petiole 7.5-20 cm long with small stipules; leaflets more or less leathery, lateral ones obliquely ovate, terminal one rhomboid- obovate, 12-27 x 10-26 cm, obtuse, rounded or emarginate at apex, rounded to cuneate at base, with 7-8 pairs of lateral veins, stipellate.

Flowers in racemes, 5-40 cm long, near the top on usually leafless branchlets; calyx with campanulate tube and 4 short lobes; corolla 5-7 cm long, standard, wings and keel recurved, all about the same length, bright orange-red, more rarely yellow, very densely pubescent.

Fruit an indehiscent pod, (min. 9) 17-24 x (min. 3) 4-6 cm, stalked, covered with short brown hairs, pale yellowish-brown or grey when ripe, in the lower part flat, with a single seed near the apex. Seed ellipsoid, flattened, about 3 cm long.

## **BIOLOGY**

Leaves are shed during the dry season. At the beginning of the rainy season, the leafless tree flowers abundantly and is very conspicuous in the forest. At the end of the flowering period, new leaves develop, which are initially a pale bronze-tinged green. Birds are the chief pollinators.

**Ecology:** *B. monosperma* is a tree of tropical and subtropical climate. Found throughout the drier parts of India, often gregarious in forests, open grasslands and wastelands. It is a characteristic tree of the plains, often forming pure patches in grazing grounds and other open places, escaping extermination owing to its resistance to browsing and its ability to reproduce from seed and root suckers. In its native habitat, most of the rain is received during the monsoon season, while the autumn and summer months are generally dry. The tree is very drought resistant and frost hardy, although the leaves turn white and fall off.

**Biophysical limits:** Altitude: Up to 1 500 m, Mean annual temperature: -4 -49 deg. C, Mean annual rainfall: 450-4500 mm

**Soil type:** It grows on a wide variety of soils including shallow, gravelly sites, black cotton soil, clay loams, and even saline or waterlogged soils. Seedlings thrive best on a rich loamy soil with pH 6-7 under high temperature and relative humidity.

### **Documented species distribution**

Native: Cambodia, India, Indonesia, Japan, Laos, Myanmar, Nepal, Sri Lanka, Thailand, Vietnam

Exotic: China, Papua New Guinea

### **Products**

**Fodder:** In India, young leaves are good fodder, eaten mainly by buffaloes. Though the leaves are fairly rich in nutrients, digestibility values are low, comparable only to those of straws.

**Fuel:** Wood makes a fuel of moderate quality. Leaves are sometimes used as a fuel. The wood is burnt for gunpowder charcoal.

**Fibre:** A coarse fibrous material obtained from the inner bark is used for cordage, caulking the seams of boats and making paper.

**Timber:** The soft and not durable wood is light, about 570 kg/m<sup>3</sup> air dry, white or yellowish-brown when fresh, but often turning greyish because of susceptibility to sap stain. It is not of great value but is sometimes used for utensils.

**Gum or resin:** A red exudate is obtained from the bark, hardening into a gum known as 'butea gum' or 'Bengal kino'. It can be used as a dye and as tannin.

**Tannin or dyestuff:** A bright yellow to deep orange-red dye, known as butein, prepared from the flowers is used especially for dyeing silk and sometimes for cotton. This dye is used by Hindus to mark the forehead. The bark is used for tanning.

**Lipids:** The seeds yield a clear oil.

**Poison:** Seeds show bactericidal and fungicidal activities.

**Medicine:** The flowers are useful in the treatment of liver disorders and seeds act as an anthelmintic. An astringent gum oozing from the cut stem has medicinal properties as a powerful astringent and is applied in cases of diarrhoea.

**Other products:** In India, the tree is an important host for the lac insect (*Laccifer lacca*), which produces shellac. Of all the lac trees, it yields the most lac stick per hectare.

### **Services**

**Erosion control:** In India, farmers frequently use *B. monosperma* to stabilize field bunds.

**Ornamental:** *B. monosperma* is planted as an ornamental because it flowers with a profusion of bright orange, rarely sulphur-coloured flowers

### **Tree management**

*B. monosperma* is moderate in its demand for light. Although it can withstand some shade, dense shade suppresses its growth. The trees pollard and coppice well and produce root suckers freely. They can also withstand heavy annual lopping. Well suited for silvopasture at wide spacing (10-15 m) in extensive tracts of

grassland (for example, in central and western India, where it is managed by repeated coppicing on a roughly 5-year rotation). Coppice shoots are also cropped in intermediate years for the larger leaves. Under dryland conditions and in its natural habitat, coppice management yields roughly 100 kg/tree of air-dry fuelwood every 5 years. If allowed to grow, trees attain a height of 3- 5 m and dbh of 15-20 cm in 10 years. Plantations can be established on irrigated as well as rainfed land.

### **Germplasm management**

Seed storage behaviour is orthodox; no loss in viability during 2 years of hermetic storage at room temperature. There are approximately 500-1500 seeds/kg.

### **Pests and diseases**

Seedlings and saplings are browsed and damaged by cattle. Rats and porcupines feed on fleshy roots, killing the sapling. Insect pests attack different parts of the tree. Several defoliators belonging to the families Arctiidae, Eucosmidae, Lasiocampidae, Lymantriidae, Noctuidae, Notodontidae, Pieridae, and Sphingidae have been recorded. Insects of the family Coccidae feed on the sap. The larvae of some insects of the family Lycaenidae feed on the flowers.

Xanthomonas buteae causes black leaf spots, which in severe infection cover the entire leaf surface and cause premature defoliation. Phomopsis buteae and Pseudodiplodia buteae have also been recorded on the leaves.

### **Reference**

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### ***Bombax ceiba***

*Bombax ceiba* Linn.

(Synonymous: *Bombax malabaricum* DC.

*Salmalia malabarica* (DC.) Schott & Endl.)

Local name: Semal

Sanskrit name: Salmali

Common Name: Silk cotton tree

### **Growth Habit:**

Semal is called Kings of the Forest due to their massive size and showy flowers. It is a large deciduous tree with a straight cylindrical stem and

horizontally spreading branches in whorls. This horizontally branching system in whorls, large size and the buttress at the base are the first seen characteristics to distinguish the species in the forest. The tree reaches up to 40 meter in height and 2 meter in diameter with the clear bole of 24-30 meter. Large trees are invariably buttressed at the base. Stem buttresses at the base and go up to 5-6 meter in height.

### **Morphology:**

The young stem and branches are covered with sharp, straight, stout prickles up to 1.2 cm long with woody conical bases.

Bark: Bark of Semal looks pale ashy to silver grey, 1.8 -2.5 cm thick, smooth up to middle age, becoming rough with irregular vertical cracks on older trees.

Leaves:

Semal tree has the compound leaves

which is palmate in appearance. It is

exactly appears as the palms appear in

man. It is digitate, large, spreading,

glabrous which has common petiole, and the size of leaf is 15-30 cm long. One leaf is composed of several leaflets. Five leaflets are common in one leaf but sometimes up to the seven leaflets could be found. The size of

leaflets varies from 10 to 20 cm. generally the leaflets found in the centre are longer as in the fingers in palm. The leaflets are lanceolate, acuminate, more or less coriaceous and entirely glabrous.

Flowers :

The bright red flowers, which appear in January to March, are large and conspicuous on the leafless trees. It presents a strikingly remarkable sight in winter and spring when the usually bare branches are covered with large, fleshy, red flowers. Birds are attracted to them, and are probably responsible for their pollination. These flowers form a scarlet carpet on the ground for few weeks (2-3 weeks) after dropping.

The flower of Semal are very showy, attractive and visible from long distances also. Because of its beautiful and attractive flowers, people like to plant it as the ornamental plant in the botanical garden, garden or as the avenue species. Flowers are numerous, large, 10-12.5 cm across. It clustered towards the ends of branches at the time of flowering. It has the thick, fleshy and cup shaped Sepals. It bears generally 5 petals in one flower which are 7.5-15 cm long oblong, recurved above, and fleshy, of bright crimson (rarely yellow or orange) colour.

Capsule: The pods are about 10-18 cm in length, oblong-oval in shape, locucially 5 valved; valves woody, downy outside, lined with silky hairs within.

Seeds:

Within the capsule it has many seeds which are obovoid, smooth, 6-9 mm long in size. These seeds are oily and surrounded by a thick mass of long silky hairs or floss, hence easily blown about by wind.

#### **General distribution:**

Semal is widely distributed in Indian subcontinent except extremely arid regions ascending up to 1200 meters and occasionally up to 1500 meters.

In Nepal, it is found from Terai (70 m) up to about

1300 meters.

It seeks moist, protected valleys preferably flat ground near stream banks where it is often gregarious. Though typical of the alluvial Savanna type of forests, it also grows sporadically in mixed deciduous forests in the lower valleys

and in the Sal (*Shorea robusta*) forest. Though it is generally scarce in the hills, it is very common in the Bhabar and Terai tracts (tropics) of Nepal and India especially in the open grazing grounds in miscellaneous forests. It is often found growing in association with Sal (*Shorea robusta*).

It is often only tree species left in villages in the Terai.

Although it has a very wide range of distribution, it is nowhere very common, usually occurring scattered in mixed deciduous forests. Occasionally, it tends to be gregarious on alluvial soils near river banks and grassy savanna lands. It also occurs in India, Sri Lanka, Pakistan, Bangladesh, Myanmar, Java, Sumatra and Northern Australia.

#### **Site factors:**

Climate:

Semal occurs in regions showing a wide range of temperature and rainfall but thrives best in a comparatively moist tropical climate. In the natural habitat, excluding the places where it is found up to 1200 m elevation in the hills, the absolute maximum temperature varies from 37.5 to 50 degree Celsius and the absolute minimum from minus 2.5 to 17.5 degree Celsius. The mean daily maximum temperature in May, which is generally the hottest summer month, varies from 30 ° C -42°C; the mean daily minimum temperature in January, which is coldest

month of the year, varies from 4.4°C to 23.9°C. grows in regions with an annual rainfall ranging from 750-4570 mm or more, showing best development in place with a high rainfall well distributed throughout the year. In its habitat, frost is not uncommon, particularly in the low lying areas.

#### Topography:

Semal prefers valleys and flat or undulating ground with deep soil. It can also grow on well drained hill slopes. It is almost gregarious on flat alluvial ground in grasslands near river banks.

#### Geology / Soil:

Semal is distributed widely throughout the Indian subcontinent; its occurrence in a particular locality is governed more by edaphic rather than by climatic factors. It prefers a deep sandy loam soil derived from granite. It is rather scarce on quartzite, schist and khondalite soils. It occurs extensively on deep alluvial soil along stream banks in Terai region of Nepal and generally avoids clayey and marshy soils. It grows even on badly drained sites but the growth is comparatively slow and the development poor, the trees remaining stunted, with tapering boles.

Semal occurs mostly in the alluvial savanna forests and is also quite common both in dry mixed deciduous and moist deciduous forest. Though primarily a seral species, it is commonly dispersed in the climax type of vegetation as well. Some believe that the species possesses evergreen characters and shade tolerance in early years. Due to this any seeds falling in the soil under an evergreen canopy are also able to grow as healthy seedlings even faster than the seedlings growing in open where even in the first year it is characteristically deciduous. Once the tree grows above the top canopy level of the evergreen forests it becomes strongly deciduous and thus is able to exist in harmony with strong light demanding species in the top canopy of the evergreen forests.

#### Phenology

In some cases particularly in dry situations, the leaves turn yellow and commence to fall at the beginning of December, the tree being leafless by the end of that month when other trees, particularly in moist situations, may remain in full leaf till March or may never be entirely leafless. The new leaves appear on March-April.

The large, round, dark brown buds become visible in the month of December. The showy scarlet flowers appear in February-March and are conspicuous on the trees which are usually leafless at the time of flowering but if in leaf their flowers are, as a rule, not so numerous. The trees when in full bloom, flowering was observed from far, and presents a striking blaze of crimson.

The nectars in Semal flowers attract birds and insects which act as pollinating agents. Birds, particularly the clumsy crows, are rather wasteful in their pollination habits as, in feeding upon the floral nectar; they often knock the flowers off their brittle bases. The carpets of floral debris that one commonly sees on the ground below a Semal tree in bloom consists of whole flowers also, besides other remains. Squirrels, deer and other mammals, however greedily feed upon this floral litter.

The fruits develop very rapidly, sometimes reaching a length of 7.5 cm while there are still flowers on the tree; they ripen from March to May. The fruits open usually while still on the tree, but sometimes after falling. The seeds which are numerous, surrounded by masses of white silky hairs, and are thus easily blown about by the wind. Strong dry winds are frequently prevalent at the time the fruits open and where Semal trees are numerous, the air is full of flecks of silk cotton, which are blown far and wide, bearing the seeds with them.

#### Germination and seedling stages:

The germination is epigeous; the testa splits and the radicle emerge from the narrow end of the seeds and descends. The hypocotyl elongates, arching at first, and in straightening, carries above ground the cotyledons, which are much crumpled in the seed but soon expand. The root is tap roots. The primary root long, at first thin, afterwards thickening greatly becoming fleshy, tapering upwards and downwards from the fleshy part, at first white, afterwards yellow or light brown, lateral roots few or moderately numerous, chiefly upper part of main root.

Seedlings are subject to the attacks of various animals; rabbits nibble the stem, rats gnaw the taproot, and pigs and porcupines grub up the roots.

The growth of seedlings during the first season is slower than it is subsequently. In Dehardun (India), seedlings attained a height of 8-15 cm by the end of the first growth season, while those which are regularly weeded and watered grew rapidly during the second season, some reaching a height up to 1.7 m by the end of the season: in more tropical climates, the growth is very much faster. On stiff soil and on other unfavourable ground, the seedlings remain small for two or three years or more, growing only a few centimeters.

In dry localities, they may die back annually for a few years before establishing themselves and commencing upward growths. The Bombax is frost sensitive and shows the die back in seedlings.

#### **Silvicultural characteristics:**

Semal is a strong light demander. It resists slight frost, but is affected by severe frosts in hills. Growing as it does in savanna tracts; it is subject to severe burning: in the seedling and sapling stages, it is repeatedly burnt back, but has good power of recovery from the base, and once it is established, its thick bark enables it to resist damage by fire better than most species. It coppices in its early years but cannot later. It also produces root suckers, but these survive only if the parent trees are small. Many of them tend to die after 2-3 years. It suffers from grazing and, in its young stages, benefits much from the protection of thorny bushes because these thorny bushes protect them from grazing.

#### **Regeneration: natural regeneration:**

Semal seeds freely every year and the seeds get widely dispersed by wind. Natural regeneration establishes itself under favourable conditions freely on new alluvial flats, savanna and open spaces. In Nepal and north India, it is one of the first trees to appear on alluvial ground in the process of natural succession of vegetation, after the stage in which the land is occupied predominantly by *Dalbergia sissoo* and *Acacia catechu*. During early stage, the thorny shrub such as *Zizyphus mauritiana* protects it from grazing. In heavily grazed areas, the saplings establish themselves freely under the protection of dense clumps of *Zizyphus mauritiana*, *Zizyphus xylopyrus* and other thorny shrubs, or in the tussocks of coarse grass where they are out of reach of cattle.

#### **Artificial regeneration:**

The seeds are collected locally from Mid March to Mid May. The capsules or seed pods are knocked off from the tree when they are just about to open and placed in the sun under wire netting and they soon burst.

Seeds are separated from floss by putting them in a gunny bag and thrashing with a stick until the seeds get separated.

The weight of 100 dry capsules is about 2 Kg of which the floss constitutes about 0.57 kg and the seeds 0.45 Kg. The seed weight varies from 21,430 to 38,500 per Kg. Germinative capacity has been found to vary from 14-75%. The seed is viable for two years. It can be stored in sealed tins for 1 or 2 years with only slight decrease in germinated capacity. Viability of seeds stored in gunny bags decrease considerably at the end of first year. Semal seed does not require pre treatment before they are sowing. Experiments show that the untreated seeds germinate (63%) better than cold water treated seeds (60%).

#### **Nursery Technique:**

Semal is eminently suitable for afforestation of new ground and of grasslands in the riverain tracts, on soil consisting of alluvium in mixture with silt or sand by any of the methods described here:

The seed is sown in nursery in May or June 5 cm x 23 cm and regularly watered till the monsoon starts. Seedlings should be shaded from the afternoon sun during hot weather. They are suitable for stump planting when one year old. Also 1-2 years old stock is used for entire planting. Semal can be raised by direct sowing, entire planting as well as stump planting. But trial shows that the sowing has very few success story and other methods are successful.

#### **Plantations technique:**

Direct sowing:

For direct sowing, the seeds may be sown in raised patches of loose mineral soil at 3.7x3.7 m spacing just before or at the commencement of the rains using 3-6 seeds per patch. If spaced 7.4 m x 7.4 m, other species could also be grown in between to form a mixture which helps in minimizing the damage from shoot borers.

**Entire planting:**

Entire planting has been found successful in the regions with comparatively high rainfall. Tall 1 to 2 years old plants are used to plantations after pruning all leaves except the young ones at the tip. If planting out is done in rainy seasons and there is a good spell of rain afterwards, the plants get established quickly and are able to withstand competition from grass and other weeds successfully.

**Stump planting:**

For stump planting, stumps are prepared from 1 to 2 years old nursery raised seedlings, keeping only 4 cm of shoot and 30 cm of root and pruning all side roots. The stump diameter at the collar may be 8-20 mm. Bigger stumps, 2-5 cm in diameter and 60 cm in length, are reported to have given better results than small results in Bengal. The appropriate time is just after the outbreak of monsoons. Planting can be done in pits of 30 cm x 30 cm filled with well worked soil. The soil around the stumps should be compacted and water should not be allowed to stagnate around it.

**Tending operations:**

**Weeding:** Semal is a rapid grower and requires little weeding after the first 1 or 2 years. Sometime climber cutting is also done with weeding. Weeding lowers the competition and provides loose soil to expand their roots. After 2-3 years pruning is required.

**Thinning:** Semal being a strong light demander requires full growing space throughout its life for proper development. Hence thinning is necessary in plantations and has to be done in two or more stages 6.7m x 6.7m during the rotation. Where the initial spacing of 6.7 m x 6.7 m (225 plants/ha) is considered suitable for plantations, it is considered best to thin to a final crop spacing of 13.4 m x 13.4m i.e. 55 plants per hectare. This conclusion is based on the fact that trees with a breast height girth of 1.8 m (which is the exploitable size) will have a crown spread of 12-15 meter.

**Management and silvicultural systems:**

If grown pure, Semal in the final crop would have to be very widely spaced and the resulting yield would be very small, considering the crown size and the characteristic branching habit of this species. Pure crops of Semal may be undesirable for any of the following reasons:

Deterioration of soil conditions, Epidemic attacks of insects, fungi or Loranthus, Poorer growth form and Low production. Natural growth of Semal has been worked under the selection system with an exploitable diameter limit and a felling cycle which varies from place to place. In some places, it has been worked under the clear felling system followed by concentrated artificial regeneration adopted with a rotation of 20-30 years and exploitable diameter of 57 to 61 cm.

**Injuries and protection:**

**Insects:**

Large number of insects and larvae found, but only the *Tonica nevirana* is dangerous. This shoot borer attacks seedlings and destroys shoots and often killing the plants.

In April May, the fallen seeds on the ground are attacked by the mature and wingless young Semal bug (*Dysdercus cingulatus*). They suck out the juice from seeds, and the seed loses their germination capacity.

**Fungi:**

Semal is not known to suffer from any serious fungal disease; however *Ganoderma lucidum*, root rot fungus has been noticed in Taungya plantations.

**Animals:**

Porcupines, rats, deer, mice etc eat and gnaw its seedlings.

Mostly the natural methods are applied for the protection however some pests and insecticides can be applied in plantations.

**Utilization:**

Physical and mechanical properties of wood:

The wood is usually white or pale pink, turning pale yellowish brown on exposure. There is usually no color differentiation between heartwood and sapwood. The wood is very soft and light. The wood density is 373 kg



/m<sup>3</sup> (at 12% moisture content). It is straight-grained, even and very coarse textured with large open pores. Growth rings are not always distinct to the eye, but clearly visible under the hand lens.

It is easy to saw and work but its surface remains rough after planing due to its large pores. It does not crack while nailing. It can be peeled on a rotary lathe and made into plywood veneers.

As the wood is liable to rapid decay due to fungus and insects attack and also sap stain, it must be promptly converted and dried by air or preferably kiln seasoning. It is easy timber for kiln seasoning which takes about 4-5 days.

The untreated wood is highly perishable. It can, however, readily be treated with preservatives and penetrations is usually complete, even with even with an open tank treatment. It is extremely durable under water.

#### **Present day uses:**

Semal timber is in great demand as matchwood. In India, almost the entire annual yield of standing trees is reserved for matchwood industry. Semal has the reputation to be linked with the pioneer industry of Nepal. The first modern industry established (1942), was the "Juddha Match Industry" which was largely based on Semal tree. But with the decline of Semal availability, lots of match factories shifted towards the waxed paper stick or already closed up.

It is used to make plywood, being eminently suitable for light plywood containers not requiring high strength properties. It is also used for packing cases, boarding (especially in ceilings), planking (especially in dug outs for Katha manufacture), shingles, toys, scabbards, coffins, brush handles, inside partitions of Opium chests and as well curbs. It is also considered as the "Wood wools" which is used as valuable packing material. The floss from Semal seeds is the silk cotton or Indian Kapok of commerce. It is used for the manufacture of life saving appliances, for stuffing cushions and pillows, upholstery, wadded cloth quilts, as insulating materials for refrigerators and as packing.

The floss of Semal is popularly known as Indian Kapok. It is light, buoyant, soft, strong, elastic, resistant, water repellent and suitable for stuffing lifebelts, mattresses, instruments, laces, etc.

In Nepal, Semal is being used in construction of boats, boatyards and canoe. In famous tourist lakes of Pokhara valley, the semal boat is used for the fishing, boating and other purposes however the life expectancy of the boat is far less 2-3 years only. It is made with the view of cheap in constructions. (<http://www.fao.org/docrep/field/003/13251e/13251e05.htm>)

Among traditional healers of Chhattisgarh, the Semal tree as medicinal plant holds a reputed position. Its one to two years old roots are known as Semal Musli. Like other Musli viz. Safed Musli, Kali Musli etc. Semal musli is also used very frequently by the healers. There is good demand of Semal Musli in national and international drug markets.

Like other Musli, it is also used as aphrodisiac. Roots are aphrodisiac, cardiac and astringent The bark exudes "Mocha ras (juice)" used for medicinal proposes.

The gum is stimulant, tonic, demulcent, anti dysenteric, analgesic and useful in giardiasis and diarrhea. Seed oil is used in the manufacture of soaps and lubrication substances.

Semal, one of the most sturdy and splendid of ornamental trees planted in Botanical gardens, gardens and avenues.

#### **Ecological importance of semal:**

Since the Semal trees is very large and tall, it becomes the favorite roosting and resting sites for the large birds especially the vultures, eagles and bats. Vultures prefer to live in the Semal tree. In Hindu custom, vulture is considered as the symbols of ill-fate, hence people do not like to keep the Semal tree in the vicinity. Also the Semal tree has been exploited heavily due to its commercial uses. Because of this, the availability of Semal trees has declined sharply. That ultimately assists in marginalizing the vulture population.

#### **Reference**

[https://www.doc-developpement-durable.org/file/Arbres-Bois-de-Rapport-Reforestation/FICHES\\_ARBRES/Bombax%20ceiba/A%20brief%20introduction%20to%20Bombax%20ceiba%20Linn\\_Forestry%20Nepal.pdf](https://www.doc-developpement-durable.org/file/Arbres-Bois-de-Rapport-Reforestation/FICHES_ARBRES/Bombax%20ceiba/A%20brief%20introduction%20to%20Bombax%20ceiba%20Linn_Forestry%20Nepal.pdf)

### ***Mitragyna parviflora***

*Mitragyna parvifolia*, (Roxb.) Korth

(Syn. *Stephegyne parviflora*)

Family : Rubiaceae

commonly known as: kaim, water kadamba • Bengali: ধারাকদম্বাharakadam, গুলকিদম্বাgulikadam • Gujarati: કલમ kalam • Hindi: गुरी guri, कैम kaim

Native to: India

Medium size deciduous tree; leaves opposite, oblong-ovate, obovate, ovoid to almost orbicular, 6-12 cm long; stipules large, oblong or elliptic, glabrous above, hairy beneath along veins; petiole 5-18 mm long; flowers cream coloured or greenish, in globose 8-15 mm across heads on up to 12 mm long peduncle, head singly or in cluster of up to 5, each subtended by two bract-like leaves; calyx lobes minute with ciliate margin; corolla with 4-6 mm long tube, lobes half as long, throat hairy inside; style filiform, stigma mitriform (headgear); fruiting head dry with aggregation of capsules.

#### **Reference**

<http://tropical.theferns.info/viewtropical.php?id=Mitragyna+parvifolia>

### ***Grevillea robusta***

*Grevillea robusta* A. Cunn. ex R.Br., commonly known as Silky Oak or Silver Oak, has gained widespread popularity in warm temperate, subtropical and tropical highland regions of many countries, originally as a shade tree for tea and coffee and more recently as an agroforestry tree for small farms. It provides economically valuable products including timber, poles, firewood and leaf mulch; it is easy to propagate and establish and is relatively free of pests and diseases; its proteoid roots help it grow in low-fertility soils; it does not compete strongly with adjacent crops; and it tolerates heavy pruning of its roots and branches. With its fern-like pinnate leaves and prominent attractive orange flowering display, it is also popular as an ornamental.

#### **Botany**

*Grevillea robusta* is the largest species in the genus *Grevillea*, in the plant family Proteaceae. It has no recognized subspecies or varieties, and no hybrids with other species have been recorded (McGillivray and Makinson, 1993). It is an erect single-stemmed tree typically reaching an adult size of 20–30 m in height and 80 cm in diameter in its natural range. The crown is conical and symmetrical with major branches spaced at intervals of about 1 m and projecting upwards at an angle of 45°. Bark on the trunk is dark gray and furrowed into a lace-like pattern. The fern-like foliage of this species is very distinctive. Leaves are 10–34 cm long and 9–15 cm wide, variably pinnate to bipinnate, with a smooth green upper surface and hairy silvery undersurface. Petioles are 1.5–6.5 cm long.

The bright orange flowers, about 2 cm in length, are borne in numerous pairs along the flower spikes, on pedicels 1.5 cm long. Fruits are two-seeded follicles 2 cm in length, with a slender persistent style. Seeds are winged, 13–19 mm long x 8-10 mm wide and 0.8–0.9 mm thick, with a papery wing around the brown, ovate central seed body.

#### **Distribution**

The natural habitat of *G. robusta* is in northern New South Wales and southern Queensland, Australia, where it occurs from the east coast to as far west as the Bunya Mountains, Queensland, up to an altitude of 1120 m (Harwood, 1992a).

*Grevillea robusta* has been introduced to warm temperate, subtropical and tropical highland regions around the world commencing in the mid to late 19th century and is widely planted in India, Sri Lanka, Central and South America and many countries in Africa (Harwood, 1989).

#### **Environmental amplitude**

The natural distribution is in the warm humid to warm sub-humid climatic zones. However, the species has performed well when introduced to a much wider range of climates. In its native range mean annual precipitation is 700-2000 mm and mean annual temperature is 15-20°C.

Towards the hotter extremes of the tolerated temperature range, the dry season should be no longer than 4 months for good growth. *Grevillea robusta* performs poorly in lowland tropical environments where mean annual temperature exceeds 23°C, and very wet locations where annual rainfall exceeds 2000 mm.

*Grevillea robusta* has some resistance to frost. During the winter months in temperate latitudes, it can survive temperatures down to minus 8°C with little or no damage, but milder frosts of only minus 2°C or so will cause damage during the growing season. Low-intensity ground fires will kill seedlings and young trees. It cannot withstand severe gales or persistent strong winds without damage to the branches.

*Grevillea robusta* prefers rather fertile soils such as those derived from river alluvia or basalts but will grow on shallower less fertile soils derived from sedimentary material. The pH range for good growth is around 4.5 to 7.5. Best growth is obtained on sandy loam, loam and clay loam textures. Heavy clay soils and prolonged waterlogging are not tolerated.

#### **Uses**

**Wood.** The air-dry density of heartwood is 550–650 kg m<sup>-3</sup>, that of sapwood and branches is lower. The heartwood is pale pink on cutting, darkening to red-brown after drying, while the sapwood is cream colored. The sawn timber is of medium strength and is used for furniture, packing cases, flooring, paneling, plywood and the manufacture of small wooden items such as pencils (Bolza and Keating, 1972; Skolmen, 1974). The wood produces short-fiber pulp of acceptable quality (Ghosh, 1972) but has not been used for pulp production on a commercial scale. The branches and twigs are used for firewood and charcoal. Poles are used for house construction in rural areas, scaffolding and rafters (Spiers and Stewart, 1992).

**Agroforestry-** *Grevillea robusta* is one of the most important trees for agroforestry in the tropical highlands of Eastern and Central Africa. It is commonly planted as a boundary tree around the perimeter of small farms, in a single row at 2–2.5 m spacing. It is also planted in rows between small fields, and as scattered individuals over crops such as coffee and maize. In addition to their use as a soil mulch, the leaves of *G. robusta* are used by some farmers in the Embu district of Kenya as a fodder supplement for cattle in the dry season when other fodder sources are scarce (Spiers and Stewart, 1992). They are also used as bedding in livestock stalls.

#### **Silviculture**

**Silvicultural characteristics.** *Grevillea robusta* grows well in row plantings and as scattered trees over food and cash crops in warm temperate and subtropical climates. Recent studies on root architecture and water uptake indicate that *G. robusta* is relatively deep-rooted and thus may compete less with crop roots than do other trees (Howard et al., 1996). It tolerates repeated heavy pruning and pollarding, enabling farmers to regulate the degree of competition with adjacent crops.

**Propagation.** Propagation is usually from seed. There are about 40,000 viable seeds/kg. Seed will retain viability for at least five years if dried to below 8% moisture content and stored in a dry, cool (20°C or lower) environment (Jones, 1967; B.V. Gunn, CSIRO Forestry and Forest Products, pers. comm. 1998). No pretreatment is required for germination. Seedlings are pricked out when their second leaf-pair starts to develop, into tubes or plastic bags filled with a fertile loamy potting mix. Seedlings are grown for around 4–6 months in the nursery until planting out at a height of 20–40 cm during the rainy season. Cuttings can be easily struck using shoots of seedlings or saplings (Swain, 1928), which can also be air-layered.

**Establishment.** As the species is usually planted in rows or small woodlots, or as scattered individual trees, mechanical site preparation is seldom used. Some control of competing vegetation is required for the first 1–2 years after planting. This is normally achieved by several rounds of manual weeding. Fertilizer is seldom applied: 50 g per tree of an NPK fertilizer (12:12:12) applied shortly after planting would be appropriate for infertile soils.

**Management.** When planted in woodlots (2.5 m x 2.5 m) and line plantings (2–2.5 m between trees), thinning of inferior trees is often carried out at age of around 4–5 years to yield poles and firewood for local use or sale. Farmers in the African highlands commonly harvest branches by high pruning and pollarding every 3–4 years from age 4–6 years onwards (Poulsen, 1983; Spiers and Stewart, 1992). Some African farmers prune the surface roots of *G. robusta* by digging with a hoe at a distance of around 30 cm around the trunks of trees growing in and around fields, to reduce competition with adjacent crops.

**Growth and yield.** When grown at close spacings in plantations and woodlots, the growth rate of the species is relatively modest. For example, the estimated mean annual wood yield in tropical highlands is only some 10–12 m<sup>3</sup>ha<sup>-1</sup> over 10–15-year rotations at recommended stocking of 800–1200 trees/ha (Pandey, 1987). *Grevillea robusta* is therefore not a high priority plantation timber species.

When it is planted singly or in lines, annual growth rates of 2 m (height) and 2 cm (diameter) over the first 5 years are commonly achieved in a number of countries where climate and soils are suitable.

*Grevillea robusta* coppices well after being cut back to ground level at ages of up to two years, but coppicing ability declines sharply thereafter, so management on a coppicing rotation is not feasible.

### **Symbiosis**

The species does not form symbiotic associations with soil bacteria or mycorrhizal fungi, although it develops proteoid roots (sections of the secondary roots which develop as dense cylindrical clusters of rootlets, about 1 cm in diameter). These develop under conditions of low phosphorus availability are believed to enhance nutrient uptake. (Skene et al., 1996).

### **Reference**

<https://www.winrock.org/factnet-a-lasting-impact/fact-sheets/grevillea-robusta-a-versatile-and-popular-tree-for-farm-forestry/>

### ***Pongamia pinnata***

*Milletia pinnata*

Botanical Name : *Pongamia pinnata* (L), *Derris indica* (Lam.), *Pongamia glabra* Vent.

Family : Fabaceae (Papilionaceae)

### **Distribution**

This tree can be seen in the greater part of India in- the plains from Ravi eastwards growing along rivers and up creeks in the peninsula. It is found in Uttar-Pradesh, Bihar, Orissa, Madhya Pradesh, Andhra Pradesh, Karnataka, Tamil Nadu and Kerala. It also grows wild in the tidal and beach forests of Sunderbans and along stream banks as in the dunes of the seashore as in Andaman. It can also be seen as a cultivated species along canal banks, roadside avenues and along bunds.

### **Environmental requirement**

Temperature

In its natural habitat, the maximum temperature ranges from 27 to 38°C and the minimum 1 to 16°C.

Rainfall

*Pongamia* is native to humid and subtropical environments and thrives in areas having an annual rainfall at 500 - 2500 mm.

Topography

This species grows up to an elevation of 1200 m but in the Himalaya foothills is not found above 600 m.

Soil Requirement

*Pongamia* can grow on most soil types ranging from stony to sandy to clayey, including verticals. It does not do well on dry sands. It is highly tolerant to salinity. It is common along waterways or seashore with its roots in fresh or salt water. Highest growth rates are observed on well drained soil with assured moisture.

### **Phenology**

The tree exhibits considerable variation in its phenological habits. It is evergreen in favorable conditions and completely leafless, between March and May under adverse condition. Fresh leaves and flowers appear immediately. Flower appears from April to July. Pods appear from January to March. The tree starts flowering and setting pods from the 4 to 7 years.

### **Silvicultural Characters**

Light - It is a light demander but can tolerate shade.

Frost - Susceptible to severe frost

Drought - It is a drought hardy species to certain extent

Flood - It can also tolerate high moisture for a short period.

Coppicing - It is an excellent coppicer

Root suckers-It can also produce root suckers readily.

Pollarding - It can withstand pollarding.

### **Natural Regeneration**

It regenerates profusely from seeds in nature under frost condition. The tree naturally coppicing well and sends out root suckers in natural conditions.

### **Artificial Regeneration**

The tree is easily established by direct seedling or by planting nursery raised seedling or stump cuttings of 1 - 2 cm root - collar diameter. Propagation by branch cutting and root suckers is also possible. Fresh seeds yield

high germination. Tree will yield about 10-5.0 kg of seeds. About 1500-1700 seeds weigh are kilogram. Seeds require no treatment before sowing and will remain viable from one year if stored inside the pod in containers free from pest and disease attack.

#### **Nursery Practice**

Fresh seeds are sown directly in polybags of 20 x 15 cm filled with soil, sand and FYM in the ratio of 2:1:1. Seeds germinate, in 10-15 days. Seeds with unknown germination can be sown in mother beds and then transplanted into polybags after germination at 30 - 40 days. This will help to overcome empty polybags and get uniform seedlings in nursery.

#### **Planting**

Seedlings of six months to one year old are outplanted in the main field into pits of 30 cm<sup>3</sup> or 45 cm<sup>3</sup> at 3m x 3m or 5m x 5m spacing. Application of FYM 5 kg, DAP 25 g per pit will enhance growth and establishment.

#### **Maintenance and After Care**

**Watering** - In dry localities watering during the summer months for the first two years will give high survival percentage and good growth.

**Tending operation** - Weeding around the plant for the first three years will ensure good growth. As avenue or garden tree pruning have to be done to get a proper bole.

**Yield** - Mainly grow for its pod which yields oil of 20-25 per cent. A well grown up tree of 5-10 years can yield 10-50 kg of seeds per tree.

**Uses** - Wood is not considered as a quality timber. It is used for cabinet making, cart wheels, agricultural implements, and tool handles. The leaves contain 18% crude protein and is eaten by cattle and goats. Oil is used as fuel for cooking and lamps and also as a bio-diesel. The oil cake is used in poultry feed. Dried leaves are used as an insect repellent in stored grains.

#### **Reference**

[http://agritech.tnau.ac.in/bio-fuels/Biofuel\\_Pungam.html](http://agritech.tnau.ac.in/bio-fuels/Biofuel_Pungam.html)

### **Juniperus communis**

Plant profile

Family Cupressaceae

Ayurvedic name Vapusha, Hapusa

Unani name Abhal

Hindi name Aaraar, haubera, abhal

English name Common Juniper

Trade name Hauber

Parts used Berries, leaf, bark and wood

#### **Morphological Characteristics**

It is a dense sub-erect or prostrate perennial shrub growing up to 1.5 m height.

Leaves are 5-13 mm long, in whorls, linear, sharply pointed, spreading nearly at right angles from the branchlets, convex on the back, concave and glaucous bluish white on the upper surface, jointed at base and continued down the stem with a large gland on the decurrent portion.

#### **Floral Characteristics**

Flowers are dioecious, axillary, supported by small imbricating bracts.

The male cones ovoid, yellow; antheriferous, scales broad ovate and acuminate. Stamens are decussate or in three, connective enlarged ovate or peltate at the apex bearing 2-6 globose pollen sacs near the base.

Female flowers are in cones, composed of 2-6 opposite or ternate scales, usually not all fertile.

Ovules are 1-2 to each fertile scale. Fruit are 7.5-10.0 mm long, sub-globose, blue-black, glaucous berries tips of the scales visible at apex.

Seeds are 1-3 with a thick hard testa and often connate into a hard several-celled mass.

#### **Distribution**

Juniperus is a temperate species, which occurs in forests throughout Western Himalaya from Srinagar to Kumaon at 1700-4200 m MSL.

#### **Climate and Soil**

Sandy clay loam soil rich in humus is more suitable for this crop. It prefers temperate climate.

## Propagation Material

Plant can be multiplied through stem cuttings and seeds, however, meristems and stem-cuttings are ideal material as plants propagated from stem-cuttings grow faster than that of seedlings.

Agro-technique

## Nursery Technique

Raising Propagules : The right time for collection of seeds is October for raising seedlings of *J. communis*. Moreover, the rate of success of nursery using seeds is very poor. Hence, to multiply the plant through vegetative propagation is preferable. Stem cutting is suitable in May. Apical shoot (15cm) performs better root formation than the older part of the stem. Sand is most suitable medium for planting. In propagation chamber or polytunnel, the success rate of rooting is 40 to 57%. IBA 2500 ppm promotes rooting in maximum cuttings (80%) followed by IBA 3000 ppm (60%). Peeling of bark at the lower end of the cuttings improves the rate of success as compared to round or normal cut and crushing at the lower end. Normally, stem-cuttings take 60-70 days for rooting. The rooted stemcuttings should be hardened at least for 6 months before transplanting in field. In nursery, the stem-cuttings should be planted at 10cm X10cm spacing.

Propagule Rate and Pre-Treatment : About 10,000 saplings are required for one hectare land.

Planting in the Field

## Land Preparation and Manure Application :

July-August is the suitable period for planting rooted stem-cuttings or seedlings of plant in main field. It is not necessary to plough entire field for planting crop. The planting spots marked at desired space should be made weed free before making planting pits of dimension 45cm X 45cm X 45cm. Pits are filled with equal proportion of soil and sand. About 15 t/ha of Farm Yard Manure (FYM) should be applied as basal dose at the time of transplanting in main the field. In subsequent years, FYM @ 15 t/ha should be applied at the time of bud break in March-April, after winter dormancy.

Transplanting and Optimum Spacing : Sapling is planted at the centre of the pit and the soil is gently compressed after planting. The pits are made at a spacing of 1m x 1m accommodating 10,000 plants/ha. Plants should be watered lightly after the planting.

Intercropping System : Intercropping is not suitable for the crop.

Irrigation Practices : In the absence of rainfall, irrigation at weekly interval is essential for about a month after transplanting to ensure establishment of the saplings in field.

Weed Control : Hand weeding twice at monthly intervals during July-September provides effective weed control in the initial 2-3 years of the crop.

Disease and Pest Control : No disease or insect-pest has so far been noticed in this crop.

## Harvest Management

Crop Maturity and Harvesting : *J. communis* bears flowers / fruits after attaining the age of about five years. Fruits rip during September-October, hence it is the right time to harvest the fruits. Bark and leaf can also be collected during October.

Post-harvest Management : Bark, leaf and fruits can be air dried and stored at room temperature in a dry place.

Chemical Constituents : Plant contains 4-terpineol (18.14%), marpol (7.96%),  $\alpha$ -pinene (6.96%),  $\gamma$ terpinene (4.46%),  $\beta$ -fenchyl alcohol (1.53%) and oploponone (0.69%) are major constituents. As per literature, sabinene (48.8%),  $\alpha$ -pinene (6.2%) and endofenchyl acetate (5.8%) are major components of the essential oil from needles of *J.communis* growing in nature. Fruit yields 0.8 – 1.2% essential oil and 8% resin. It also contains the bitter substance juniperin.

**Yield** : Yield could not be recorded because of destructive methods for extracting leaf, bark and wood.

## Therapeutic Uses

Berries, wood and oil are used in folk remedies for cancer, indurations, polyps, swellings, tumors and warts. Its fruit and essential oil possess carminative, stimulant, deobstruent, diaphoretic, digestive and diuretic properties. They are useful in different forms of dropsies, either administered alone, or in combination with other diuretics. They are also used to treat mucous discharges in gonorrhoea, gleet and leucorrhoea; and some cutaneous diseases. The wood is sudorific in action.

## Reference

<https://vikaspedia.in/agriculture/crop-production/package-of-practices/medicinal-and-aromatic-plants/juniperus-communis>

## **Betula spp**

### **Geographic distribution**

The genus *Betula*, commonly known as birch, belongs to the family Betulaceae. There are approximately 50 species of *Betula*, all of which occur in the temperate zone of the Northern Hemisphere (Weaver, 1978). The birches prefer moist sandy loam soils, can tolerate strong winds and high freezing temperatures but not maritime exposure. *Betula* spp. shows a high freezing tolerance (Sakai and Larcher, 1987), which enables them to form a treeline in the Himalayas (Zobel and Singh, 1997; TISC, 2002) as well as in the Scandinavian region (Cairns and Moen, 2004). In the Himalayas, the *Betula utilis* D. Don is considered the dominant birch species which forms the treeline vegetation all along the Nepal Himalayas, and extensive stands of this species can be found on the northern shady slopes and ravines (TISC [Tree Improvement and Silviculture Component], 2002). It is the only broadleaved angiosperm tree species in the Himalayas, which dominates an extensive area at subalpine altitudes (Zobel and Singh, 1997). Although there are other species present which include *Betula alnoides*, *Betula cylindrostachya* and *Betula ashburneri*, *B. cylindrostachya* and *B. alnoides* appear at the lowest altitude, and *B. ashburneri* is found between 3,000 and 3,700 m (Bartlett, 2013). The area under birches in India mixed with *Abies* and *Rhododendron* in different forest types is given in Table 1.

*B. utilis* D. Don is the only birch species which occurs in Jammu and Kashmir and North-West Himalaya. The species has already been declared as critically endangered. in Kashmir by Environmental Information System (ENVIS) Centre on Conservation of Medicinal Plants and Foundation for Revitalization of Local Health Traditions (FRLHT), Bangalore (Anonymous, 2010).

### **Ecological distribution**

Birches are pioneer species that grows in open fields with rotation of 60–100 years. As pioneer species, these are often the first trees to colonise wasteland and abandoned farmland (Rebele, 1992). *Betula pendula* (Silver Birch) is used in forests as one of the major species for fast-growing forest plantations (Zajaczkowski and Zaleski, 2007). Hybridisation and introgression are common in Birches, where the natural distributions of birch species overlap, for example, among the European birch species are *B. pendula*, *Betula pubescens* and *Betula nana* (Palme et al., 2004). Birches are very cold and hardy. White birch (*Betula platyphylla*) is a cold-tolerant tree species and can even survive under conditions as low as -53 °C during winter (Zhou, 1986). During spring, white birch can avoid low-temperature stress by developing two types of leaves, namely early leaves and late leaves. Producing late leaves is observed after the early leaves are completely expanded (Koike, 1995). Their bark is smooth, shining, reddish white or white, with white horizontal lenticels. The outer bark consists of numerous thin papery layers, exfoliating in broad horizontal rolls. The inner cortex is red and moist. White barked species are weak-woody and their twiggy crowns collect and hold ice and snow. Care should be taken to prevent the outer bark of the white-barked species from being stripped or marred, since the injured area will always remain green (Hylander, 1957).

### **Phenology of betula species**

The birches are deciduous trees, leafing begins in late spring (April–May). The leaves are ovate-acuminate to oblong, tapered, elliptic and irregularly serrate glossy dark green, which turn yellow in autumn. Lepisto (1973) reported birches tend to flower at the relatively young age of 10 to 15 years. Mature birch trees carry large amounts of female and male catkins and the flowers are monoecious blooming in May–June and fruiting from June to July (Koski and Tallqvist, 1978; Mehra, 1976). Staminate catkins are formed in late summer or autumn, remain naked during winter, and open after considerable elongation in the spring. The pistillate catkins, which are cone-like with closely overlapping scales are born terminally on short, spur-like lateral branches and appear with the leaves. When the female catkins (strobilus) ripen in late summer or autumn, they become brown and woody. The seeds turn from greenish tan to light brown or tan when mature (Brinkman, 1974). Seeds disperse from late fall until the following spring (Houle and Payette, 1990; Matlack, 1989) and are thin and winged. Although seeds can begin to disperse in late summer, these early-shed seeds may be of poor quality. Wind play important role and blow seeds along the surface of the snow up to 80 m from the mother tree. Ford et al. (1983) trapped about 5% of the total seed-fall

from round-leaf birch at nearly 100 m from the parent tree. An abundance of seeds can be found in the forest soil, but these seeds are found to be short-lived. Most seeds are non-viable after the second or third year.

### **Seed Technology**

Birch seeds are winged nuts, easily disseminated by wind over large distances. Before seed collection, their quality is usually assessed, as some seed lots are completely useless. Seed quality, to a large extent, depends on the abundance of flowers and the pattern of weather conditions. The birch seeds are shallow orthodox and exhibit intermediate dormancy (Gosling, 2007). Moist chilling (0–5 °C) for 4–8 weeks in fully imbibed state usually releases dormancy in birch seeds (Suszka et al., 1996), but premature germination is likely to occur, probably mainly because of individual seed variation in dormancy intensity (Bewley, 1997). *Betula* spp. is known to have physiological dormancy, and the level of physiological dormancy in these genera is nondeep (Baskin and Baskin, 1998). The presence of nondeep physiological dormancy in *Betula* seeds means they become nondormant during either cold (moist) or warm (moist) stratification. Dormancy break by cold stratification during late autumn to early spring allows seeds to germinate at the beginning of the growing season in *Betula* spp. (Wang et al., 2010). Seeds of birch are also sensitive to photoperiod, but the light response diminishes during moist chilling (Vanhatalo et al., 1996; Ahola and Leinonen, 1999). Wang et al. (2010) recorded that germination of 90% after 12 weeks and 94% after 24 weeks of cold stratification in the seeds of *B. utilis* collected from high altitude (3000 m).

In large commercial bare-root nurseries, sowing operations are often delayed. Consequently, there is a risk that the seeds will germinate before sowing, or they get damaged during sowing operations (Tanaka, 1984; Jensen, 1997). However, chilling at a lower seed moisture content (MC) level than the fully imbibed state may be preferable because it greatly reduces the risk of premature germination, and in some cases increases germination after pretreatment (Gosling et al., 2003). Seed quality, to a large extent, depends on the abundance of flowers and the pattern of weather conditions. Good seed crops are recorded every 2–3 years, and then their germination capacity is higher (Antosiewicz, 1975; Bodykl, 2006). Such high-quality seed lots can be stored as reserves to be used in years of crop failure. However, according to Anisko et al. (2006), they must be first dried to an MC of about 3.5%. After shedding, the seeds can remain ungerminated on the ground till spring. In the soil, as a rule, birch seeds are viable for up to 1–3 years.

### **Traditional Use**

The bark of Himalayan birch (*B. utilis*) was used centuries ago in India as paper for writing lengthy scriptures and texts in Sanskrit and other scripts. The bark is widely used for packaging material, roof construction and others. The leaves of the plant show efficacy in treatment of urinary tract infections and in kidney and bladder stones. The wood is used for construction, and the foliage for fodder. The most widespread use is for firewood, which has caused large areas of habitat to be eliminated or reduced. Parts of the plant, including the fungal growth (*bhurja-granthi*) have also long been used in local traditional medicine (Singh et al., 2012).

### **Medicinal Use**

Birches contain various chemical compounds which have valuable medicinal uses; those compounds are betulin, lupeol, oleanolic acid, acetyloleanolic acid, betulic acid, lupenone, sitosterol, methyl betulonate, and methyl betulate which are extracted from bark. A new triterpenoid, called karachic rustics, which is aromatic and has antiseptic properties (Barnes et al., 1974; Bevington and Hoyle, 1981), have also been extracted from birch. The compound, betulin, shows anticancer activity by suppressing growth of malignant melanoma and cancer of liver and lungs (Kikuzaki and Nakatani, 1993).

Traditionally birch bark has been used to cure rheumatism, gout, malaria (Hager et al., 1967–1980) by human being.

Betulin and its derivatives possess biological effects, for example anti-inflammatory, antiviral, anti-HIV, hepatoprotective (Dzubak et al., 2006).

### **Terminalia**

*Terminalia alata* Heyne ex roth. Syn. *T. tomentosa* W.& A.



Family: Combretaceae Local names: Pakasaj, Asan

### **Description**

A large deciduous tree, bark rough black, deeply cracked. Leaves leathery, hard, elliptic or ovate, 3-8 in long, opposite, margin entire or toothed, with two wartlike glands at the junction of the petiole. Flowers dull yellow. Fruit 1-2 in long with five broad wings.

### **Distribution**

Found in Sal forests in the Terai, but principally on the ridges of lower hill forests (upto 3000 feet) of north Bengal. Also found in south West Bengal, though infrequent. Planted both in northern and southern part of the state.

### **Seed**

Fruits ripen in February-March. The best time for collection is April-May from cleared ground or from trees by lopping branches. Fruits are collected late, as early seeds are immature and likely to be insect attacked. Fruits are dried in the sun for 3-4 days and stored in gunny bags. Fruits can be stored for one year. Seed (fruit) weight varies from 530-550 /kg; germination capacity is 36 to 70 %.

### **Propagation**

While natural regeneration has been reported to be fair to good in many regions of the country, the species is normally propagated by artificial regeneration.

**Artificial regeneration:** It can be regenerated by direct sowing or transplanting of nursery raised seedlings.

**Direct sowing:** It is done in worked up soil, where the rains have set in. Seeds are sown in in lines 1.8 m apart; seeds are dibbled 15 cm apart in doublerows.

**Transplanting of nursery raised seedlings:** Fruits are soaked in cold water for 2 days and dibbled in polythene pots in April-May. Germination takes place in 2 to 5 weeks. Shades should be provided immediately after germination. If the polythene pots are regularly weeded and watered, the potted seedlings become ready for planting out in July when the plants are 3-4 months old.

### **Tending**

Pakasaj/Asan needs intense weeding both in nursery and field. If propagation is made by dense line sowing, the resulting crop would require thinning in the 3rd or 4th year.

### **Injury /damage**

Pakasaj is liable to crown damage by wind storm. It is browsed by deer. A number of defoliators attack the plant, though damage is not found to be serious. Attack by some fungi has also been mentioned in some literature.

### **General**

Pakasaj is planted as a Sal associate in Sal Conversion working Circle in north Bengal. It is also planted in mixture with other species in miscellaneous plantations both in north and south West Bengal.

Wood is dark brown, hard, fairly durable and very handsome when polished. It is refractory to season, has to be dried slowly to avoid cracking. Timber is widely used for buildings, beams, rafters, door and window frames and boarding; also used in carts, ploughs and boat building, posts, furniture etc. Treated timber is suitable for electric transmission poles, railway sleepers and wagon floor boards. Also used for agricultural implements and decorative plywood.

The bark contains 15-18% of tannin and is used as a cheap tanning material and as cheap dye. Leaves are lopped for fodder, are also used for feeding tassar silk worm.

*Terminalia arjuna* (Roxb.) Wight. Am. Family: Combretaceae

Local name: Arjun

### **Description**

A large deciduous tree, trunk thick and often buttressed. Bark silvery grey, flaky. Leaves oblong or elliptic, hard, glabrous leathery, 3-6 in long. Flowers without stalk, yellowish. Fruit dark brown with 5 thick, narrow, striated wings, 1 in or more long.

### **Distribution**

It occurs in the wild along the banks of rivers and streams. Planted throughout south-west and central part of West Bengal, and also in plains (preferably in low-lying areas) of north Bengal forests.

### **Seed**

Flowering begins in April and extends to May with the fruit ripening the following February- May, nearly a year after the appearance of the flowers. Generally, every third year is a good seed year. The pattern of flowering and fruiting is not markedly different in different regions.

Ripe fruits are collected during April-May from the trees or from the ground swept clean beforehand. Seeds can be stored for a year. About 175-450 seeds weigh 1 kg. Germination capacity of untreated seed is 50-60%, and that of pre-treated seed is about 90%.

For treatment, seeds are soaked in water for 48 hours and then spread out in shallow pits or trenches.

### **Propagation**

**Natural Regeneration:** Arjun shows satisfactory natural regeneration by seed as well as coppice. Seeds are dispersed by water. Natural regeneration occurs in loose alluvial soil, along water courses. However, in forests, the species is propagated by artificial regeneration.

**Artificial Regeneration:** Arjun can be regenerated by direct sowing and transplanting of nursery raised seedlings.

**Direct Sowing:** Fruits are sown in dug up lines, 2.3 m to 4.0 m apart, in June-July with the onset of monsoon rains. The pits or trenches used for treatment of seeds can be located in the plantation itself when direct sowing in the field is planned. Germination commences in 4 to 7 days.

**Transplanting of seedlings:** Pre-treated seeds are dibbled in polythene pots in April-May. The pots are watered regularly and weeded as frequently as necessary. Two to three months old seedlings whose shoot and root lengths, on an average, become 12.5 cm and 30 cm respectively are planted out in July-August. Spacing of transplanted seedlings may be 2 m x 2m or 2.5 m x 2.5 m. Plantations raised for tasar sericulture, have a closer spacing, say, 1 x 2 m, and are managed by repeated pollarding.

### **Tending**

Arjun, an initial slow-grower, later grows very fast to attain 2-3 m height in 3 years. Weeding and protection from fire and frost is needed for the first two years. Thinning is required to remove the weaker shoots when forking takes place due to frostdamage.

### **Injury/Damage**

Young seedlings are sensitive to frost and drought. Literature cites attack by wood borer and defoliator, as also fungal attack.

### **General**

It is one of the finest avenue and shade trees. Wood is hard, strong, moderately heavy; ornamental, difficult to season; is used for agricultural implements, boat building, cart wheels, mine props, plywood, buildings etc. It makes excellent firewood and good quality charcoal. Leaves are fed to tasar silk worms.

The most useful part of the tree is its bark which contains 20-24 % of tannin. It is extensively used for tanning and dyeing. The bark has medicinal value. It is used as styptic, antidysenteric, cardiogenic, febrifuge; used in haematemesis, leucorrhoea, and many other ailments.

Fruits and leaves have also medicinal value.

### **Reference**

[http://www.worldagroforestry.org/treedb/AFTPDFS/Terminalia\\_arjuna.PDF](http://www.worldagroforestry.org/treedb/AFTPDFS/Terminalia_arjuna.PDF)).

### ***Alnus nepalensis* D.Don**

Family: Betulaceae

Local name: Utis

#### **Description**

*A. nepalensis* is a deciduous large tree that reaches up to 30 m in height and 60 cm in diameter. The leaves are shallowly toothed, 7-16 cm long and 5-10 cm broad. Male flowers are in drooping catkins; females in axillary clusters. Fruits are cone-like, black, about 1.5 cm long. In the forest the bark has a dark green colour, and the tree is easily recognized. In open places it is generally silver-grey, resembling that of the birch. The stem is very cylindrical, tall, and grows very rapidly. The tree grows quickly and is sometimes planted as erosion control on hillsides and for land recovery in shifting cultivation. It tolerates a wide variety of soil types and grows well in very wet a 2.2 Distribution

It occurs in the middle hill forests (3-6000 feet) of north Bengal hills. It is common in Darjeeling. It is often found in second growth forests on landslides and in old cultivation, especially near streams.

## Seed

Seeds ripen in December-January. One kg of fruit gives 100 gms of cleaned seeds. Seeds are light, and 5, 64,000 seeds make 1 kg. Fruits are collected by lopping the branches, dried in the sun, and then seeds are separated by beating with sticks. Viability of the seeds is short and seeds can be stored for 3 or 4 months.

## Propagation Artificial Regeneration

- Nursery work – Seeds are broadcast in shaded nursery beds in March; about 225 gms of seeds are required for each bed. Time taken for germination depends on altitude. In general, seeds take 4 to 6 weeks to germinate. Seedlings are pricked out and placed in polythene pots in July-August and planted out in the following rains. At altitudes below 1500 m, the germination is quicker, and seedlings can be pricked out under shade in May, and planted out the same year during the monsoon. Shades may be advantageously removed from the poly-pot beds after the plants have been under the shade for a short time. *Alnus nepalensis* fixes Nitrogen in root nodules with actinomycete *Frankia*. Nursery bed/potting mixture should incorporate soil from mature plantation of *Alnus* to provide necessary *Frankia* inoculants.
- Transplanting – Transplanting in the field is done during the first or second rains in standard pits at a spacing of 2m x 2m or 2.5 m x 2.5m. Natural seedlings, 15 cm to 23cm in height have been transplanted into plantation entire without the balls of earth in July and have been reported to give 75% success. The species should be planted in mixture in alternate lines with slower growing shade bearers.
- Tending – The plantation may be subjected to normal tending operations during the first three years. Being a fast growing species, no tending is required after the third year.

## Injury/Damage

This tree is damaged by snow-breaks, frost and grazing. It is attacked by a Lepidopterous larvae which girdles the young tree. It is also susceptible to attack by stem borers *Batocera horsfieldii* and *B. numitor*. The species is also reported to have been attacked by defoliators.

## General

*Utis* plantation is sometimes found pure on land slips. It has been observed that sometimes the whole *utis* crop has died out for reasons not known. Growth of pure *Utis* plantation has also been found to be non-uniform. After registering rapid growth in the initial stage the plantation's growth has been noticed to slow down and many pure plantations have been seen to die off. In natural forests *Utis* of any size is found, in scattered population, only in ravines and damp hollows near springs and streams. The preferred site for *Utis* plantation should be shady ravines and hollows and it should be planted in association with shade bearer species. *Utis* wood is moderately soft. It is occasionally used for making boxes and in light construction, and as firewood.

## Reference Materials:

1. Cowan and Cowan 1979 The trees of Northern Bengal, International Book Distributors Dehra Dun
2. J. F. Dastur. Useful Plants of India and Pakistan
3. Ram Parkas 2007 Plantation and Nursery Technique of Forest trees
4. Forestry Nursery Manual of West Bengal 1994, Research and Working Plan Circle, WB Forest Directorate
5. Lesson 14 of Forest Botany
6. <http://www.forestrynepal.org/>
7. [http://en.wikipedia.org/wiki/Alnus\\_nepalensis](http://en.wikipedia.org/wiki/Alnus_nepalensis)
8. Websites cited in the lessons

## Tropical pines

India

*P. radiata*, *P. pinaster*, and *P. maritima* have been planted in small plantations in the Nilgiri Hills. Although they are promising in the earlier stages, they do not thrive well. *P. pinaster* is moderately successful at about 7,000 feet (2,100 meters) in the Himalayas. *P. sylvestris* (Scots pine), was tried at 8,000 to 9,000 feet (2,400-

2,700 meters) in the Himalayas, but was not successful. Successful small-scale introductions are reported of *P. canariensis*, *P. halepensis* in Kashmir; *P. hondurensis*, *P. radiata* in Assam; *P. patula*, *P. pinaster*, *P. taeda* and *P. laricio* in the Punjab.

## Quercus spp

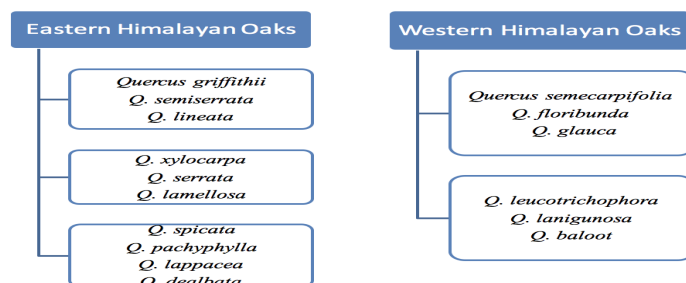
### Oaks Of India: Regeneration & Management

Forests constitute a very important resource base in the Himalayas, the world's youngest mountain range, which covers over one fifth (18%) of India's geographical area. These forests despite being very rich in their floral composition are, by and large dominated by a few widely distributed plant genera, essentially and importantly including the species of *Quercus* commonly known as oak. Oaks (*Quercus* spp.) are the dominant, climax tree species of the moist temperate forests in the Indian Himalayan region. About 35 species of *Quercus* are distributed between 1000-3500 m elevations either in abundance or somewhat narrowly from the north eastern to the westernmost part of the Himalayas.

Oaks in the genus *Quercus* of Fagaceae family (beech family) constitute an important group of forest trees and occupy a sizeable area in the Himalayas. There are 16 species of oaks growing in India, ten in eastern Himalayas and six in the western Himalayas.

The Eastern Himalayan broadleaf forests are diverse and species-rich, with a great diversity (of oaks and rhododendrons in particular). The ecoregion has two broad forest types: evergreen and deciduous. Evergreen forests are characterized by oaks (*Quercus* spp.), chiefly *Quercus lamellosa* together with *Rhododendron arboreum*, *Rhododendron falconeri*, etc. Whereas, Western Himalayas are endowed with diverse vegetation types, ranging from tropical moist deciduous to temperate and sub-alpine forests, grasslands, alpine scrub and meadows. The Western Himalayan broadleaf forests divided into two types: evergreen and deciduous broadleaved forests. The evergreen broadleaf forest is dominated by oaks.

Himalayan Oaks are listed below : flowchart



Oak forests are source of fuelwood, fodder and can be correlated with natural springs and wildlife and plays a vital role in conservation of soil, water, native flora and fauna thereby, providing numerous ecosystem services to mankind. Oaks are the best coppicers, re- sprouters because it forms many dormant buds on the root collar, about an inch below the forest floor where they are often protected from high temperature associated with fire.

Regeneration, one of the major problems of forests of western Himalaya, is influenced by the interaction of biotic and abiotic factors of the environment. As per growth and regeneration under natural conditions are not successful. The reason being the biotic pressure on them namely, uncontrolled lopping and felling of trees for fuel wood, fodder and grazing.

#### **Regeneration of oak:**

Successful regeneration of tree species might be considered to a function of three major components:

(i) ability to initiate new seedlings (ii) ability of seedlings and saplings to survive (iii) ability of seedlings and saplings to grow.

The existence of a species in a forest community depends on its ability to regenerate under varied environmental conditions.

The causes of failure in regeneration include lack of viable seeds due to insect and animal predation, unfavourable micro-sites and overgrazing by domestic livestock. Other reasons for dwindling of oak forests are erratic seed production, poor seed viability, defoliation, acorn predation and increased incidences of fire.

It is also observed that oaks in the accessible Government forests have been mutilated by continuous lopping such that they are rapidly dying out. Few patches of intact oak forests are present in the region today and the remaining intact patches are also changing rapidly due to invasion by alien invasive species, such as *Eupatorium adenophorum*, *Lantana camara* and more aggressive species such as chir pine (*Pinus roxburghii*). The replacement of oak by pine has become a common and ever increasing phenomenon.

#### **Management:**

The competitive oak regeneration sources can result from natural stand processes including natural disturbances, or we can implement silvicultural treatments to develop competitive regeneration sources. These silvicultural treatments can :

(1) make oaks more competitive. (2) reduce competition from other species. (3) make the area protected for practices like grazing, burning, logging and lopping.

Conservation of these valuable species would not be possible without the active participation of the local communities. By improving their living standards and giving benefits of conservation to them, long-term conservation goals can be achieved. To improve the understanding of ecosystem functions and processes, to develop a holistic description of the landscape, both intensive studies on small areas and assessment of much larger areas are required.

#### **Reference**

[http://ifsa.net/oaks-of-India-regeneration - management](http://ifsa.net/oaks-of-India-regeneration-management)

#### **Abies pindrow (Silver fir)**

1) Habit – Very tall, evergreen, dense, crown conical when young and cylindrical later, dark foliage. Branches horizontal in upper part and drooping lower. Branchlets stiff and horizontal. Leaves narrow linear with two silvery streaks on lower surface. Spirally arranged. Bark light grey with deep vertical fissures. Long and narrow scales.

2) Uses – White smooth wood, mostly used for packing cases. Also for railway sleepers if treated. Can be used for matchwood and paper pulp. Large dimensions recorded Mundali 1) 206 ft. ht. 18' – 9" girth 2) 202 ft. ht. 26' girth Under normal conditions 180' height is very common.

3) **Distribution and habitat** – Afghanistan to Nepal from 7500' to 11000' mostly mixed with spruce, kail and even deodar. Pure patches in cool and moist locations common where *Q. semecarpifolia*, *Q. dilata*, *Acer sp.*, *Aesculus indica*, *Juglans regia*, *Ulmus wallichiana*, *Prunus padas*, *Corylus sp.*, etc are found mixed. Does not come upon dry and shallow soils. Undergrowth practically nil when full density. Otherwise *Rubus*, *Rosa*, *Viburnum*, *Salix*, *Strebilauthes*, *Senecie*, *Dipsacus*, *Brackan*, *Poligonum*, *Arundinasia*, etc. from dense undergrowth. A species associated with heavy snow fall and accumulation. Rain including snow 45 to 100 inches but does not extend in dry inner valleys.

4) **Phenology** – a) Needles persist 3 – 6 years, rarely more and fall in May – June. New appear April – May typically yellow.

b) Male flowers – On previous years shoot in leaf axil. 3” – 5” x 2” – 3”. Length increasing to 0.5” – 0.8” after pollen shedding. Pollen shed and April and beginning of May.

c) Female flowers – Appear on upper part of tree on horizontal branches. Erect stock appears bearing cone 1.5” – 2.0” x 4.0” – 5.0”. Cylindrical, dark purple. After pollination scales close and rapid growth commences. 4” – 5” x 1.75” by June in warm locations. Mature 4” – 7” x 2 – 2.5”. Seed 1 – 1.3” with wing and 0.5” – 0.6” without wing 0.5” – 0.8” wide. Ripen October or early November when scales fall off leaving central axis.

d) Seeding – 3’ – 7’ girth trees best as bigger ones have dry and inactive top. Collection of cones and September or so. Good seed year once in 3 – 4 years. 470 seeds to an ounce. Fertility about 70%.

**5) Germination and the seedling** – Epigeous 5 – 7 cotyledones develop in May with melting of snow. Hypocotyle 1.0 – 2.2”, root 1.5” – 3.0” lateral roots appear. Third year shoot 0.8 to 1.5”, roots continue to grow more laterally. Thus total height about 3” – 5” only. Slow growth – about 3” height in 10 years. Most fresh soil needed for best development. Shade tolerated, sensitive to drought and frost. Best growth in open over head light and side shade. Browsed by goats easily.

#### 6) Silvicultural characters

a) Light – Shade bearer but very poor growth in shade, for which complete overhead light best. Side shade useful to clean the bole branches persist to ground level in open poles

b) Wind – Root system superficial, spreading and not massive. Grows in sheltered situations; but in exposed places blown over

c) Frost – Seedlings are sometimes affected

d) Snow – Practically no snow breaks because of short branches. On very steep slopes a little snow bend is caused

e) Browsing – Young plants have tender new shoots which are browsed. Trampling damage considerable. Grazing is helpful the heavy seeds and deep humus

f) Fire – Extremely tender, no natural fire usually

g) Fungi – Heartwood liable to decay in old trees

#### 7) Natural reproduction

Seed capable of germination in fairly heavy shade, most of the crops are over mature. Seed limitation – seed bed very poor humus debris weeds. In freshly exposed soil cattle paths, new roads, slips, grazed area, etc. new seedlings appear profusely. Given a little light, establish in course of time. Under spruce where humus not so deep regeneration of fir very common succession so under broad leaved species. Natural regeneration is very difficult task, impossible over most area because of heavy fellings and neglect of regeneration which has produced weeds.

#### 8) Artificial regeneration

Experiments have shown that scraping of humus followed by a little soil working and sowing of seed produces a thick of seedlings. In moderate openings weeds and shrubs are lesser than in big openings. Shrub cutting and weeding helps establishment. Natural spruce and kail also invade and give a mixed crop – the most desirable conditions. Seedling grows much too slowly. Weeds a problem. Planting more successful and economical on the whole. Nursery sown in October, November, 6’ x 4’ bed needs 2 oz. Seeds. Germination and growth better on warm soil. Side shade important, 1st rains planting out 3” x 4”, 2nd rains 4” x 6”, 3rd rains 6” x 9” and in 4th rain planted out when seedlings are about 9” high. Nursery should be planned in the planting area itself.

Planting – 6’ x 6’ would be ideal. Cannot be closure because of cost. Planting spade for which notch planting to reduce cost. Seedlings grow during summer. Autumn planting worth trying. It may give better results. Failures should be beaten up next year with bigger plants.

**Tending** – weeding during rains done. Also shrub cutting. Hot weather weeding may prove useful. Weeding, etc. essential for 5 – 6 years after planting.

9) Removal of overhead shade – Due to weed has to be very cautious. Encourage broad leaved species – Populus, Corylus, Aesculus, Prunus padus, etc. Cost of planting should not be high as the species fetch very low price. Initial removal of inimical conditions move a capital investment for a few rotations than the cost of regeneration in the 1st instance.

#### 10) Silvicultural treatment

Earlier managed under selection system. Not suitable mostly because concentrated regeneration operations essential. Punjab shelterwood and selection systems followed in Punjab and Himachal. Aim is mixed crop.

Exact number of seed bearers (misnomer) not known. Roughly 25 trees per acre should be alright. Even very small groups of advanced growth should be retained. Debris burning has to be careful. A difficult operation because of moisture.

Artificial regeneration – Shelter essential to keep down weeds. Weeding and shrub cutting explained above. Thinnings not studied yet.

11) Statistical

Rotation 150 years for 24" d.b.h. and 180 years 26" d.b.h. If progress of regeneration satisfactory, 150 years more suitable. 160 cft in round volume at 180 years rotation per tree. Site qualities not worked out, quality will be at 170 feet or so.

### ***Cedrus deodara* (Deodar)**

Family : Coniferae

English name : Himalayan Cedar, Deodar

Vernacular name : Diar, Deodar, Dedwar, Kelu, Kilar (W. Him.)

#### **General Description**

A very large evergreen tree with dark green or in some cases, silvery foliage. Branches horizontal or slightly ascending or descending, not whorled but arising irregularly from the stem. Extremities of leading shoots and branches drooping in normal young to middle age trees, stiffer on stunted, slow growing specimens. Has a conical crown upto middle = age; later the crown becomes rounded or broad and flat with spreading horizontal branches. The flat topped formation sometimes hastened by injury to the leading shoot or by the action of the wind in exposed situations. Leaves acidular, still, 1.0 – 1.5" long, arranged spirally on the normal long shoots and in pseudo-whorls in the short shoots. The successive years of growth are marked on the branchlets by rings of recurved bud scales marking the joints of junction between the successive years on the arrested shoots also a fresh ring of small brown recurved scale marks each years growth. Bark grayish brown with vertical and diagonal cracks dividing it into irregular oblong scales. Maximum height – 240' (Sutlet valley – Schlich). Maximum girth – about 50" (Manali – Troup).

Uses

Wood moderately hard; sap wood white, heartwood light yellowish brown. Oily and strongly scented, very durable, most important timber of the Western Himalayas, extensively used for building, railway sleepers and other purposes requiring durability, also used for furniture, general carpentry, etc.

Distribution and Habitat

General distribution – Throughout the Western Himalaya from Afghanistan to Garhwal upto the valley of the Dhauri river below the Njti pass, long 79o48', at elevation from 4000' to over 10000'. Most common from 6000 – 8500'. Altitudinal range is higher on southerly than northerly aspects. Jaunsar, Kulu, Kashmir, Chitral and Dir, Chamba, Bashahr, Tehri, Garhwal and other minor hill states carry deodar forests.

Topography, geology and soil – Occurs naturally in mountainous country with slopes varying from moderate to precipitous. Also grows on level ground in river valleys at suitable elevations. Found in all aspects. Reaches its best dimensions in northerly aspects and regeneration can be established only with the aid of a shelter.

Climate – Rainfall – 40" to 70" mostly from the S.W. monsoon. Considerable fall of snow during winter.

Temperature – Date scanty - Max. 80o to 100oF Min. 10o to 25oF

Associates – A typically gregarious species. Is usually associated with coniferous and broad-leaved species, but even so tends to retain its gregarious habit.

The following are associations with Himalayan conifers:

1. Deodar – kail: Characteristics of the drier types and is the commonest. Sometimes found in the form of deodar under wood making its way through an open over wood of kail.
2. Deodar – spruce: Characteristics of moist rich soil. Deodar attains its best bright growth with a tall, clean bole, e.g., forests of Chamba, Jaunsar, Bashahr, etc.
3. Deodar – silver fir: Found sometimes at the higher elevation. The conditions sometimes is that makes its appearance under an over wood of deodar
4. Deodar, kail, spruce and silver fir: Found in parts of Hazara, the deodar seeking here the more rocky spurs

5. Deodar – chir: At lower elevations, chir occupies the drier ridges and spurs and deodar the moisture and cooler depression. The appearance of deodar may sometimes be due to fire protection

6. Deodar – cypress: In area carrying *Cupressus toulosa*

7. Deodar – pinus: In the dry inner Himalaya

8. Deodar – yew: In moist shady situations, the yew (*Taxus baccata*) being an under wood

Many broad leaved species are associated with Deodar, *Quercus incana* and *Q. dilatata* are frequent companions, the former at lower elevations. *Q. dilitata* often occurs in the spruce, deodar associations in moist situations. Deodar extends into the Kharsu oak region but is not typical of it. Apart from the Oaks, *Pieris ovalifolia* and *Pyrus pashia* at lower elevations, *Rhododendron arboreum*, *Prunus padus*, *P. puddum*, *Aesculus indica*, *Cedrela serrata*, *Populus ciliata*, *Corus macrophylla*, *C. capitata*, *Juglans regia*, *Tilmus wallichiana*, *Retula almonds*, *Corylus colarome*, *Ilex dipyrena* (in moist situations) and various maples are other road wood associates.

Phenology – Leaf sheeding and renewal – old leaves are shed mostly in the hot season, chiefly in May and sometimes in autumn. Persistence of leaves varies from one year in vigorous sapling to six years in older ones. New shoots appear in March to early April.

Flowering and fruiting – Male flowers (Catins) first appears in June, Ripen and shed pollen from the middle of September to middle of October. Majority fall down after ripening being dislodged by showers of rain. Female flowers appear in August. Pollinated from the middle of September to middle of October. The flowers are inconspicuous at the time of pollination. By early May they become sufficiently big to be visible. By the end of June or during July they become full sized and are bluish green. Turn chocolate brown in August and ripen from the end of September to middle on end of November. From the time of its appearance the female cone takes 12½ to 13½ months to ripen. On ripening the cone breaks up on the tree, the scales and seeds fall to the ground and only the persistent axis remains on the trees. Opening of cone is favoured by dry, sunny weather. The species is generally moncecious and sometimes also dioecious.

Seed and seedlings – Seeds only and soon lose their fertility which is quite high in good fresh seeds. Size of tree does not seem to affect fertility. Old trees produce quite fertile seeds. Cones with fertile seed may be provided at an early age as low as 28 years. Seed bearing is increased by isolation. Trees in the open bear more than those in the dense crop.

#### Silvicultural characters

Light – A light demander, capable of standing much lateral shade. Finest deodar with clean bole grown in mixture with spruce affords dense lateral shade. Young plants are capable of standing moderate shade, but cannot grow satisfactorily unless afforded complete overhead light. On hot aspects protection against desiccation is necessary for the first two or three years.

Drought – Affected chiefly in the seedling stage. If it survives this it has nothing to fear later.

Wind – Has a massive root system and is seldom affected ordinarily

Frost – Seldom affected

Snow – A cause of serious injury, poles bent, broken or uprooted, unthinned crops suffer most. Start thinnings early and do them lightly and at a regular intervals. Snow has some beneficial effects. Protects seeds during winter from birds and animals. Provides moisture in the dry season immediately preceding the monsoon. Is the only source of moisture in the inner areas where monsoon rainfall is not received.

Fire – Fire tender, fire seldom a factor in the moisture types. Extensive damage done in drier parts.

Browsing – Goat browsing causes much injury to younger deodar when other edible plants aren't available. In certain areas it is browsed down to bush like form and kept in this condition.

Lopping – Lopped commonly for litter production and manure. Cone production prevented and natural regeneration hindered. Lopped trees die off by degrees and wooded areas become grasslands.

Wild animals – Bears, percupines and monkeys are the most injurious. Bears remove the bark of deodar poles and saplings with their teeth and claws and this has often a girdling effect. Procupine do similar damage at the base. Langur monkeys do much damage by grawing the bark round the base of the poles and saplings. They and the brown monkeys pull out seedlings. Birds like Jays and nut crackers attack unripe cones from early September tear off scales and eat the seeds. Pheasants devour seeds which lie on the ground.



Insects – The larvae of a small brown moth, *Euzoppera cedrella* destroys the seeds. Attack noticeable in July when cones are half grown. Young plants suffer much from the attacks of insects particularly cook-chafer grubs which destroy the roots, and cut worms (*Agrotis psilon*) which bite through roots and stem.

Climbers – *Rosa moschata* the worst as it isscrambles into the crown of young trees and suppresses them.

Fungi – (i) *Fomes annosus* – Constitutes a serious meance to deodar in some pares of Himalayas. Has spread into plantations in Kulu. Young trees appear to be more prone to the attack. Spreads centrifugally attacking the roots which become rotten; the bark cracks, and while bands and sheets of mycelium are found beneath the scales. The mycelium ascends from the roots along the cambium into the lower part of the roots along the cambium into the lower part of the stem, which shows on exudation of resin and the needs turn yellow and fall when the mycelium has encircled the stem the tree dies. The wood is also attacked by fire hyppae which disintegrate the tissues and reduce the value of the timber.

ii) *Paridermum cedri* – Attacks young needles of the current years shoots. Eventually foliage becomes thin and the twigs and afterwards the branches die. A characteristics result in the appearance of ‘Vitches broom’.

Natural reproduction – Factors influencing natural reproduction (1) seedling conditions, (2) germination, (3) weather conditions, (4) conditions of soil and soil covering, (5) light and (6) miscellaneous factors. In the management of the deodar forests, canopy manipulation is primarily depended upon for inducing and establishing natural reproduction. Such manipulation has most important results on the composition of soil, the light reaching the ground, the temperature and the moisture content of the soil. Regeneration fellings leaving the trees 50’ apart, i.e., leaving 20 trees per acre, have given excellent results.

**Artificial reproduction** – Natural regeneration cannot be wholly relief upon for complete and rapid regeneration for a coniferous crop. Has to be supplemented by sowing and planting either to fill up failed areas or to restock blanks. Artificial reproduction is indispensable to restock burnt areas, clearfelled areas abandoned cultivation and landslips, to introduce deodar in pure kail and spruce forests, to increase proportion of deodar in mixed forests, to convert oak and other inferior forests into mixed deodar crops and lastly to create new plantations of deodar.

Deodar is both sown and planted. The choice depends on the site to be stocked and the quantity of seed available. On difficult areas such as poor exposed hot and dry ones and those overgrown with thick grass, heavy weeds, etc. and steep slopes landslips, etc. planting is more certain and on the whole less expensive and should be preferred to sowing. Where failuresplanting is the more probable to succeed. Direct sowing on a large scale is impossible except in good seed years. Where damage from birds, monkeys and hail is prevalent, sowing may not be desirable. If sowing are followed by snowfall and monsoon rains are timely and copious, good results are obtained.

Direct sowing – Follow nature by sowing in November or December in advance of the snowfall. Sowing is done broadcast or in contour lines broken or continuous or in patches of various size. Broadcast sowing is useful for sowing up abandoned cultivation, gaps and where falling refuse has been collected and burnt. In the restocking of burnt areas, the bushes and dead trees and cut, soon after fire damage and set on fire when dry and deodar seed is broadcast if sufficient seed is available (20 to 25 lbs per acre), if not, transplant from nurseries are put in. If too much weeding is to be anticipated or if sowing has to be done in areas carrying dense shrub growth line sowing is indicated lines being 10’ apart along contours, 1’ wide and terraced (20 lbs of seed per acre). Patch sowings patches varying from square are indicated in areas where there is not much of weed growth. In the Punjab, patches 5’ x 2’ and 6’ apart from end to end are used but in areas with heavy weed growth, the patches are 5’ x 5’. The shrubs and herbaceous weeds are uprooted and the soil dug 9’ x 12’ deep. The slopes of the surface of the patches must conform to that of the hill side. The patches are used as temporary nurseries for the next year, surplus seedlings being planted out. When this is intended, the patches are made 12’ apart from edge to edge in the line.

Planting – Nursery plantation put out in July after rains have just set in. In Punjab the nursery beds are of a standard size of 6’ x 3’. These beds are sown after broadcast or in drills accordingly as the young plants have to be pricked out in the nursery lines or not. In broadcast sowing the seeds are scattered as evenly as possible over the entire surface of the bed, sown rather thick and lightly covered with fine earth. In drill sowing when seedlings are to remain for less than 1½ years, drills must be 2” apart and seeds sown in the drills ½” deep and spaced ½” to 1” apart, when seedlings have to remain longer the drill must be 9 apart and the seeds should be spaced 3” in the lines. After sowing the soil of the bed, must be properly consolidatedwith a light wooden roller

3' wide or with felt. Sowing is done in November – December. Germination takes place in March or April. Transplanting in nursery lines is expensive and should be resorted to only when the locality to be restocked is poor and conditions of growth weedy and very unfavourable for unpricked seedlings. Seedlings are pricked out when 6 months old and planted in parawise nursery lines 3" x 6" each seedling being placed in a hold with its collar level with the surface and the earth processed round it. The weakest and worst shaped plants are discarded. A second transplanting should be done, if needed, when the deodar is 1½ years old. The planting spacement is 6' x 6' or 8' x 8' for pure planting and 10' x 10' or 12' x 12' when in mixture. For line sowing 10' x 6' spacement is usual in the Punjab.

Silvicultural treatment – May be considered under these heads: (1)

Regeneration measures, (2) Tending operations and (3) Silvicultural systems.

### ***Pinus wallichiana* (Kail)**

Habit – A large evergreen tree with bluish feathery foliage. Branches whorled, spreading, usually ascending in young trees and horizontal or drooping in cold trees, with unturned ends. Two whorls often produced in one season, the second or summer whorls being only a few inches above the first or spring whorl below which is the long spring internode of the current year. Adult needles in fascicles of 5, abnormal fascicles containing 4, 6 or 7 needles may be found occasionally.

Uses – Wood moderately hard, with a pink heartwood of good quality, less durable than Deodar, but easily worked and much used for building especially interior work, furniture and general carpentry. Resin yielded by this pine is superior to that of *P. longifolia* but not tapped as yield during the season is small owing to occurrence of this tree in cooler regions. One of the most beautiful pines in the world when growing vigorously, tends to become regged in old age.

Large dimensions recorded Kishen ganga valley, Kashmir

i) Height 165 ft; girth 9 ft

ii) Height 110 ft' girth 16 ft

Normally under favourable conditions a height of 120 ft with a girth of 8-10 feet not uncommon.

Distribution and habitat –

It occurs in the Himalayan moist temperate and dry temperate forests. It is considered to be a seral species by champion. Occurs chiefly at 6000 – 10000 ft but sometimes as ascending to 4000, extending westward to Afghanistan and Kafiristan and eastward to Bhutan, though absent from Sikkim and a considerable portion of Kumon, altitudinal range greater than any other Himalayan conifer. At lower elevations descends into region of *P. longifolia* with which it is frequently mixed towards upper limit of latter. At higher elevations extends into region of birch and juniper but growth here stunted and often prostrate. Most abundant in W. Himalaya between 6000 ft to 8500 ft and occurs gregariously as a rule on warmer slopes and spurs except in lower zone where it occupies colder aspects and depressions. Blue pine frequently occurs mixed with other species, of which the commonest are among conifers Deodar, spruce and silver fir and among broad-leaved species oaks (*Q. incana*, *A. dilatata* and at higher elevations *Q. semecarpifolia*), Rhododendron, Pieris, Populus, Cornus macrophylla, Prunus, Cedrela, Aesculus, Acer, Ulmus and others.

Among conifers most important companion is deodar and mixed crops of the two are frequently met with. Mixture of blue pine with *Q. incana* and *Q. dilatata* also common, pine usually flourishing well with oak. In mixture with spruce which is common, blue pine usually reaches large dimensions. As already mentioned blue pine is considered to be seral species. It readily colonizes fire burnt areas, abandoned cultivation, landslips, avalanche paths, etc. and also comes in when oak forest is lopped. Mixture of other species is often the result of succession. Under growth in blue pine forests sometimes absent owing to density of crop. Maiden hair fern, wild straw berry and bracken fern (*Pteris aquiline*) usually present. Where light sufficient a plentiful growth of grass, other herbaceous plants and shrubs appear.

Geology and soil –

Found on a variety of geological formations. Thrives on moderately dry soils but, provided drainage is good, it grows best on moist, fresh, deep soil. Avoids very wet and badly drained ground. Sometimes suplings upon boulder and gravel deposits in beds of streams, showing its partiality for a prows soil with a fair amount of sub-soil moisture. Micaschist, which decomposes into a moist fresh soil often of considerable depth, is very

suitable. On shade, growth varies according to hardness of rocky and depth of soil. Limestone suitable only if soil sufficiently deep. Effect of geological formation in determining local distribution well illustrated below Bental in Tirthan valley, Kulu, normally blue pine occurs above chir, but there is a belt of pure blue pine on moist micaschist, above this a belt of pure chir on quartzite on account of dryness of the soil, higher up blue pine again makes its appearance on micaschists.

Climate –

Most of important blue-pine forests suitable in regions with 40-75 inches rainfall. In Bhutan, however, rainfall probably well over 100 inches while in Suliman range pine occurs where rainfall possibly little more than 10", but there its existence believed to be due to pockets of moisture in limestone formation. Does not extend so far as the Deodar into inner dry valleys of Western Himalaya. Absolute minimum and maximum temperatures vary from near zero to about 100°F. Throughout its habitat there is snowfall during winter.

Leaf shedding, flowering and fruiting –

New shoots and needles appear in March or early April according to locality. By August or September needles attain full size and their based sheaths have fallen. Needles persist for 14 to 15 months and in part for a second year. Needles shed chiefly during May, June and July. In June – July trees often have a somewhat bare appearance when many of old needles have fallen while new ones have not yet expanded fully. Needles usually shed earlier in case of less vigorous trees, at high elevations and on exposed ridges, that in case of vigorous poles in favourable situations. Sometimes partial shedding of needles from October to December. Male flowers (or male catkins) – Arranged in rather indistinct spirals in a cluster 0.5 to 2 inches long at best of current year's young shoot. Catkins 0.3 to 0.4 in long before ripening. Pollen shed from end of April to beginning of June according to elevation. Catkins fall soon after ripening.

Female flowers and development of cones – Young female flowers become visible in April, are pollinated from end of April to beginning of June according to elevation, locality and season. Young cones erect and terminal on 1" to 1.5" long scale covered peduncles, solitary or usually 2 or 3 together sometimes more, at end of new shoots forming a short round terminal bud. Cones dark reddish purple with scale open. After pollination scales close and cones increase somewhat in size becoming glaucous green or bluish in colour and remain in this condition for remainder of first season. Fertilization not completed until beginning of year after pollination. After this cones start growing rapidly in March – April and reach full size from latter half of June to early August and become pendulous. They ripen and shed seed from end of September to early part of November, 18 months after pollination. Ripe cones 6 to 13 inches long. Old cones remain on trees for varying times occasionally upto 5 years or even more.

Seed and seedlings –

Seeds winged, lie in pairs at base of each cone scale. Weight about 450 per ounce. Tree starts seeding at an early age of 15 to 20 years, sometimes trees fairly fertile. As long as tree remains vigorous, number of cones produced increases with size of tree. Consequently where possible, select seed bearers from among larger vigorous trees with well-developed crowns. Tests at Dehradun have shown that seed retains its fertility to some extent for at least 14 – 18 (Troupe monghs). On the average every other year is a good year. A certain amount of seed produced almost every year, complete failure is rare. Probably good seed years can be foretold about 18 months in advance of seedling. Crop of cones may, however, be largely or completely destroyed in immature state by animals and birds. Chief such animals being monkeys and flying squirrels, particularly latter. Both the common Western Himalayan flying squirrels (the large red and the smaller) are concerned. They are natural in habit and destroy large quantities of green cones of 2nd year from May onwards. Among birds worst offenders jay and nut crackers which attack green cones from June onwards. After seeds fall pheasants feed on them throughout winter. In spite of all this damage to seed the tree reproduces itself freely in nature.

Germination – Epigeous, Cotyledons 9 to 12 number from first green leaves of seedling.

The seedlings – A natural forest seedling grown under average conditions attains a height of 4 to 8 inches in 4 years, though under specially favourable conditions height may be considerably more. There is little or no growth above cotyledons in 1st year and adult needles commence to form in 2nd year. In counting rings on stumps a least 5 years should be added for a seedling to reach stump height. Nursery raised seedlings reach a height of 9 to 15 inches in 5 years with stout stems and well developed masses of adult needles. In first year they usually show a distinct elongation of stem above cotyledons. Seedlings flourish best on well drained soil

with an abundance of light. Tend to damp off with an excess of moisture and to die of drought in shallow dry soil, frost hardy. Persist for sometimes under slight shade but die off under heavy shade. Rats often do considerable damage growing through seedling roots.

#### Silvicultural characters

Light – Strong light demander from young onwards. Persists under moderate shade for many years but makes little progress, and eventually loses power to recover. Vigorous growth attained only with complete overhead light. Even in fair sized gaps growth is poor compared with the open. Young blue pine plants have a remarkable altitude for pushing their way through shrub by growth if this is not too heavy.

Wind – Root system massive but some extent superficial. The tree is wind-firm.

Snow – Suffers more from than any other Himalayan conifer. Damage consists in breakage of crowns and stems and curvature at base of stem. The latter is due to snow sliding and many feet length of lower part of bole may be rendered useless for timber. Snow-break particularly common in dense pole crops and is aggravated if these crops are suddenly heavily opened.

Fire – Blue pine is very sensitive to fire

Browsing – Goat browsing causes serious injury. Sheep and cattle avoid pine if other food available, though in case of cattle damage caused by trampling. Bears and porcupines, they do much injury in some localities by girdling poles and saplings.

Man – Branches lopped for little and manure. Torch wood removed from base of trees.

Climbers – The only serious climber is *Rosa moschata*. Other climbers that occur do not do much damage.

Parasitic plants – A minute plant of Loranthaceae is called *Arceuthobium minutissimum* does considerable injury in many localities particularly where the blue pine does not grow vigorously. Particularly in the dry inner Himalayas it causes a large number of casualties among trees annually and it is now considered that the damage is so serious that the extinction of blue pine from those regions is only a matter of time.

Fungi – It causes root and disintegration of heart wood of blue pine and renders the wood useless for any purpose. At a later stage several years after infection sporophores of fungus appear on stem or on exposed roots. Infection as a rule takes place through wounds in stem and disease spreads mostly on account of practice of lopping. The disease can be controlled to a large extent by stopping lopping of trees and felling the infected trees. In some localities where lopping has been prevalent almost every tree may be infected. It is no use allowing such crops to grow to maturity as timber from them will be useless. Such crops should be replaced by new ones at the earliest. Diseased trees can be used as seed bearers as infection is not transmitted through seed.

One of the chief objections to starting resin tapping operations systematically in blue pine forests is that this is likely to spread the *Trametes pini* disease. Possibly tapping to death a few years prior to felling may have no adverse results.

#### Natural reproduction

Wherever conditions favourable natural regeneration profuse. Factors influencing natural reproduction may be considered separately under (1) seedling conditions, (2) germination, (3) climatic conditions, (4) soil and soil covering, (5) light, (6) fire and (7) grazing.

#### Artificial reproduction

Planting – Planting of three years old seedlings which have been pricked out twice in nursery at age of one year and two years respectively is successful provided planting is carried out with balls of earth and much care taken to avoid injury to roots. In practice planting is not done.

Sowing – Direct sowing usually more successful than planting. For sowing up abandoned fields, clear felled areas or burnt areas broadcast sowing is best. About five seeds required per acre. In acre as with excessive weeds or bushes sowing in contour lines in which soil has been worked in a width of one foot or 1½ feet or in patches is very successful. Soil should not be worked to a fine tilth. Sowing should be carried out before break of monsoon. If done earlier much of the seed is likely to be eaten up by birds. Sowing on hot bare hill sides with shallow soil do not usually succeed.

#### Silvicultural treatment

May be considered under following heads:

Regeneration – Good regeneration can be obtained with seed bearers varying in number from 5 to 20 per acre. Normally space out seed bearers 60 to 70 feet apart, i.e. 10-12 per acre. On hot aspect upto 20 per acre should be retained but further opening up of canopy desirable as soon as regeneration is 3 or 4 years old. Where there is

heavy growth of undesirable weeds of a mass of felling refuse on the ground it is necessary to cut and burn weed and to collect and burnt felling refuse. Badly suppressed advance growth should not be retained. Where pure blue pine is concerned a regeneration period of 20 years will usually suffice. Normally it is mixed with Deodar a regeneration period of 25 to 30 years required.

Tending –

Weedings not always necessary but required where there are trouble some seeds like *Viburnum foctens*, *Parrotia* and others.

Thinnings – In order to prevent development of side branches and minimize damage from snow thinnings should be light and repeated frequently that is on a cycle of 10 years in the early stage. Where much risk of fire remove suppressed stems to prevent crown fires. Heavy thinnings should be done when the crop nears maturity to produce increment and to induce crown development for production of seed. In carrying out thinnings in mixed crops of Kail and Deodar cutting out of large well grown Kail in order to favour small Deodar is not desirable.

Statistical – According to yield tables publishes for this species three quality classes have been recognized:

Class	Age	Average ht. in feet
I	90	120-140
II	90	100-120
III	90	80-100

As a rotation age of 120 years the average diameter reached for I, II, III qualities is 23.8", 20.4" and 17.6" respectively and the mean annual increment for stem timber at that age is 173, 139 and 104 cft respectively. In many places a rotation of 150 years has been adopted for mixed crops of blue pine and deodar.

### ***Pinus roxburghii* (Chir)**

Habit – A large evergreen tree, sometimes nearly deciduous in dry localities and seasons. Branches upto middle and whorl but whorls not so well defined as those of blue pine upto middle age elongated and more or less pyramidal, afterwards becoming spreading, rounded or umbrella shaped, with a massive branch system. Adult needles in fascicles of 3. Basal sheath persistent, of 10-15 imbricate scales. Needles long on vigorous tree, short in poor localities, at high elevations and on over-mature trees. Bark thickness varies from about 4" in young sapling to about 2" in mature trees sometimes reaching 3" on lower part of stem.

Uses – Sapwood white, heartwood light reddish brown. Much used for building, common furniture, boxes and general carpentry. Also principal resin producing pine of India and resin tapping industry for this species now flourishing in U.P., Punjab, Himachal Pradesh and Jammu.

Large sizes recorded

i) Ht. 180 ft, girth 10 ft

ii) Ht 178 ft, girth 10 ft 3 inch

Perhaps the largest trees to be found anywhere are those in the Tons valley of Janssar and Tehri Garhwal. On shallow soil, exposed ridges and other unfavourable situations maximum height may be only 29 to 30 ft with tapering and often twisted and gnarled boles.

Distribution of habitat –

Chir pine occurs in the Himalayan sub-tropical pine forests which is a sub-type of sub-tropical pine forests according to Champion's classification. Normally occurs from 450 – 2300 m descending at places in the northwest to 1500 ft and ascending at other places to 7500 ft, occasionally higher. Extends from Bhutan in east to Afghanistan in West, occurring extensively in NWFP, Jammu, Punjab, U.P and Nepal. Does not occur on Southern face of outer range of Himalayan which is primarily due to excessive summer heat and excessive monsoon moisture which are perhaps unfavourable to regeneration. A typical gregarious tree forming pure forests of considerable extent though it often occurs mixed with other species particularly at its upper and lower limits. Towards upper limit common companions are deodar, blue pine, *Quercus incana*, *Rhododendron arboreum*, *Piaris ovalifolia*, *Myrica nagi* and other species. At higher elevations it seeks hotter slopes and drier spurs whereas the moisture depressions and cooler slopes are occupied by its associates.

Towards lower limit associated with low level species as *Shorea robusta*, *Anogeissus latifolia*, *Ougenia delbergiodies*, *Buchania latifolia*, *Bauhinia retusa*, *B. variegata* and others. True chir pine belt occurs between

upper and lower mixed belts. Apart from gregariousness, this pine has a marked tendency to form even-aged crops of varying extent from small patches to extensive stretches, this is partly due to ease with which it regenerates and partly to its light demanding character.

Climate –

Absolute maximum shade temperature at lowest elevations probably about 46°C in pure chir pine zone it varies earlier usually below freezing point. Rainfall varies from about but most 900 to 3000 mm. Most of rain falls during monsoon. Snow fall usual towards upper limit but rarely lies for more than a few days.

Geology and soil – Occurs on a variety of geological formations. In outer

Himalayas and Siwaliks on tertiary sandstone with occasional bands of clay or beds of

conglomerate. In Himalayan valleys chir common quartzite and often attains large

dimension. Also commonly occurs on micaschist, gneiss and shales. In certain localities

found on limestone, does well on loose porous soil. Consistency and depth of soil and

sub-soil appear to have more effect on growth of chir and natural reproduction than

underlying rock. Often grows on bare rock but trees in such localities stunted and gnarled. On

quartzite chir forests usually remarkably pure, other species mainly occurring in moisture depressions. In

Tirthan valley Kulu a somewhat dry quartzite formation is found above micaschist with oak and other species

while chir pine covers quartzite area at higher elevation than blue pine, thus reversing the usual order. On

micaschist with a deep soil Chir is often found mixed with oak and other broad leaved species and attains large

dimensions under favourable conditions. Where underlying rock is hard and depth of soil shallow, chir is as rule

stunted. In Nainital chir generally absent on dolomite and where it occurs it does not grow well. Chir sowing

have done well on sandy loam derived from laterite with several feet of sub soil on Supkar plateau in Madhya

Pradesh

and also on arable land at Dehradun.

Leaf shedding, flowering and fruiting

i) Growth and persistence of needles – Needles usually persist for about one year and 5 months from the time of sprouting of buds in January to shedding of needles in May or June of following year. In many cases, particularly in vigorous saplings and poles they persist in whole or in part for a second year and in exceptional case also for a third year. In dry hot localities and in exceptionally dry seasons trees nearly deciduous. Resting period short, winter buds form in October or November and growth ceases till December or early January when new shoots begin to appear. Needles mostly fall during April, May and June though some may begin to fall during March and some may continue to fall earlier. While old needles are falling new ones lengthen rapidly and by the time the former have fallen the latter are 3” to 6” long and still erect. In June trees have a characteristic bare appearance. By September needles reach fully length. In October – November terminal winter buds formed and growth ceases till December or early January.

ii) Male flowers – Male flowers 0.5” to 0.7” long when ripening grouped on axis of new shoots in spirals of 5. Whole inflorescence 1” to 4” long by 1.5” to 2” in diameter. At low elevations inflorescence visible by beginning of January. Flowers ripen and shed pollen from February to April according to altitude and season. After pollen escapes flowers elongate to about 1”, remain on shoot for a short time and are then shed one by one, leaving the axis destitute of any covering except persistent recurved triangular bases of scales.

iii) Female flowers and development of cones – Female flowers erect, occur on or near spines of new shoots either solitary or in pairs or in 1 or 2 whorls of 3 each. Appear from early February onwards. Pollination from February to April according to altitude and weather. Within a month of pollination increase to about 0.6” to 0.8” in length. Remain green during greater part of first season increasing somewhat in thickness but not much in length. About end of October turn grayish brown outside remaining green inside and become horizontal. At this time new needles have become full sized and young cones are hidden by them. Remain in this condition throughout winter.

Fertilization probably occurs during second year. At beginning of second season again turn green and start growing rapidly. By middle of April 3-4 inches long and by June or July reach full size but still green. Towards beginning of winter gradually turn brown and hard, and in this stage pass winter. At higher elevations cones may be up to 6 weeks late in development. In spring of 3rd season 24 months after appearance they are light brown, 4, 5 to 8 in long by 2.5” to 3.5” in diameter and pendulous or horizontal. Cones begin to appear as a rule in April or May but sometimes as early as March, open only in dry weather, closing up again with rain. In cool

localities and in case of rains seed may remain unshed till June. Thus from first appearance of cones till the seed is shed it takes 26 to 27 months. Cones are gradually blown down from trees in about a year's time mostly during storms in May – June and in autumn. Some might remain on trees even a year after opening.

Succession of cones and flowers - Male inflorescence may follow each other in successive years on same branch. Female cones may succeed female cones at intervals of one or more years. Male flowers may succeed female flowers same shoot at intervals of one or more years. Male and female flowers of same year do not occur on same shoot.

Seed and seedlings – Seeds winged, lie in pair at base of each cone scale seed weight varies from 8800 to 12300 per leg. Light as well as heavy seed is equally fertile, number of seeds per cone varies from about 30 to 100; on the average it is 40 to 50. Chir crops start producing seed at about 30 years age or little earlier but some trees 40 years or older may not produce seed. Vigorous trees in open field seed earlier. Male flowers produced at an earlier age than female flowers. Trees with wounded or umbrella shaped crowns bear a much larger number of cones than these with conical crowns. In good seed years nearly every tree of former type is heavily laden with cones. Such trees should therefore be selected as seed bearers.

Trees of fairly small dimensions, any about 2' in girth are capable of producing seed of good fertility and fertility remains high until trees become over mature, when it diminishes. At the same time only trees approaching maturity with well developed crowns produce seed in sufficient quantity to effect complete regeneration. If stored properly seed remaining viable for several years, particularly when kept in sealed tins. A fair to good seed year occurs on an average once every two to three years. A good seed year can be forecast 2 years in advance by looking at top of trees in March – April with a pair of binoculars when they are visible for 3 to 4 weeks. While on trees seed subject to damage by birds, flying squirrels and monkeys.

Germination – Epigous, cotyledons 9-13 in number from first green leaves. Seedlings – 1st year – Natural seedlings in dry localities have tap roots 15" or more in length. Hypocotyle 0.75" to 0.8" stem above cotyledons 0.5" to 3.0" or more long. Leaves primordial. 2nd year – Roots on rich soil much thickened but not conspicuously elongated, on poor soil root may elongate to 2' or more. Some 5" to about 1.2". Adult needles formed towards the end of grow in season in vigorous seedlings. 3rd year – Height of average natural seedlings 1' by end of season, well grown seedlings 2'. Needles usually prescribed early in season and mature later on. 4th year – Height of average natural seedlings. 1.8" by end of season and 3.4" in well grown seedlings. 5th year – Ht. of average natural seedlings 2"10" and of well grown seedlings 6'. Chir seedlings are very light demanding. Growth greatly retarded under shade. Frost hardy, drought resistant but in still soils in which root development is unsatisfactory may die off in quantity due to heat of sun. Young plants cannot endure bed drainage and where there is excessive moisture in soil or under growth they damp off. Seedlings more fire resistant than those of other conifers but suffer badly from severe fires which occurs in chir pine region. Not readily browsed, but in many localities heavy grazing accounts for absence of regeneration. Among animals porcupines eat the roots of seedlings and saplings, rats gnaw through the roots of seedlings and birds bite of cotyledons during and shortly after germination. Among insects grasshoppers bite through stems of seedlings.

Silviculture characters

Light – A strong demander, grows best under complete overhead light. On hot, southerly aspects side protection from sun may be necessary especially on stiff clayed soil.

Soil – Least exacting of Himalayan trees growing often on base rock but intolerant of badly drained soil.

Wind – Root system massive spreading both downwards and laterally. Trees ordinarily wind firm.

Frost – Very frost hardy Chir pine more fire hardy than any other Himalayan conifers owing to presence of thick bark in saplings as well as trees. In spite of this heavy casualties occur on account of the following reasons:

- i) Chir needles are shed during the hot season and these are very inflammable
- ii) Chir occurs on hot inflammable slopes
- iii) When trees are tapped for resin the blazes catch fire and trees suffers badly unless all inflammable matter is kept cleared from their base
- iv) Where there is heavy growth of grass or bushes, particularly on steep slopes chir needles get lodged in them and a fierce conflagration results when they catch fire
- v) Crown fires are likely to take place in chir crops particularly in unevenaged crops On account of the above reasons controlled during early in the season is carried out in many of the chir forest to reduce the inflammable

material on the floor of forest. As a result of fire protection less fire hardy species such as Deodar, blue pine and oak often invade chir areas towards the upper limit of distribution of later.

Climbers – In true chir pine some the only destructive climber of serious importance is *Rosa moschata*.

Fungi – i) *Cronartiu himalayense* – A rust disease occurring on chir saplings and often kills them. Sweet species are alternate hosts for these rust.

ii) *Caleosporium campanulas* – Needles rust of chir. Occurs on chir pine needles. Not very harmful except that carbon assimilation by needles is retarded. *Campanule colorate* is an alternative host for this rust.

Twisted fibre – Twist may be left handed or right handed. Twisted trees useless for timber. The defect appears to be inherited. It also appears the twist is caused by maltreatment on damage to chir in the young condition by grazing, browsing, fire, lopping, etc. This is especially so in unfavourable localities such as hot aspect or shallow soils. It appears to be specially common on micaschist formations.

Natural reproduction – In natural seed falls during April to June and sometimes in higher altitudes upto July. It germinates within a few days of start of monsoon. Various factors affecting natural regeneration are dealt with below:

Seed bearers – It is important that only large trees with rounded or umbrella shaped trees should be retained as seed bearers. Younger trees do not produce seed in adequate regeneration.

Light – A strong light demander, ordinarily 5 to 8 seed bearer retained per acre. Number increased on poor localities as trees have smaller crowns and also on hot aspects particularly on stiff clayed soil.

Drought – On hot slopes regeneration may fail on account of drought particularly where soil is stiff and grass and under growth is scarce. In such localities heavy opening up of canopy should be avoided, grass and under growth should be retained and soil should be hoed up.

Aspect – In general, regeneration is better on northern slopes than on southern slopes except near the upper limits of chir.

Topography and soil – Reproduction good as a rule on well drained porous soils, such as those containing a fair proportion of senior fine mica, particularly on moderate and gentle slopes and rounded spurs. On flat places with bed drainage, on stiff clayey soil and shallow soil regeneration is poor. Regeneration good on abandoned cultivation provided soil is loose and drainage good.

Soil covering and undergrowth – The presence of a thick layer of undecomposed needles, characteristics of chir forests, which have been protected from fire and grazing for some years, is inimical to reproduction. Accumulation of debris from fellings also acts as a serious hindrance. Presence of a fairly heavy growth of grass on moderate to steep slopes is by means inimical to reproduction and in fact on bare hot slopes presence of grass is very helpful. A heavy growth of grass on flat soil often denotes bad drainage, in such places reproduction fails. Shrubby growth is beneficial only on hot unstable slopes. In general it is adverse to chir regeneration.

Fire – Natural regeneration normally not possible without fire protection. Young crops are likely to be wiped off by fire, but regeneration may reappear on loose porous soil in areas subjected to grazing as even when a fire occurs there is not much inflammable material on ground on account of grazing. Regeneration in such cases only

appear if there are large gaps otherwise needle fall will add to severity of fires. A long period of fire protection is inimical to reproduction. Young regeneration areas should be control burnt in winter as soon as regeneration is about 4 to 6' high. For this purpose it is better to prune the lower branches and remove grazing to reduce the intensity of grass.

Grazing and grass cutting – In many localities excellent regeneration established inspite of cattle grazing as distinct from goat browsing provided grazing not heavy and other condition usually not possible without closure to grazing. Browsing by goats is particularly harmful. At the same time even in Kangra forests which are subjected to heavy grazing are easily regenerated when closed for regeneration but in areas which are excluded from grazing for long periods dense under growth develops and regeneration of such areas is very difficult as in case of the reserved forests in Kangra. Grass cutting is very harmful when the chir seedlings are young as these get cut along with the grass. Often this cutting of chir seedlings is intentional by villagers as they are usually interested in keeping the area un-regenerated because grass growth gets much reduced under cover of chir crop. Artificial reproduction: Cones collected from December to March usually from felled trees, then dried in sun. Cones open and seed is shaken out.



**Planting:** Planting successful if done carefully without injury to roots and with balls of earth. In practice planting not done.

**Direct sowing:** Direct sowing is done in patches or in contour lines at the break of monsoons. Proper drainage should be provided by keeping patches a little sloping. Clods of earth should not be finally broken. In dry localities grass should not be removed.

**Silvicultural systems:** Chir pine is mostly managed under the uniform system. Selection system is not very suitable as chir is a light demanding species and it has a tendency where possible to regenerate in even-aged masses. Even the group selection system is not very suitable as the diffusion of work renders subsequent tending of groups difficult and the suppression of much of the young stock is almost inevitable. Damage by fire is intensified in the unevenaged crops produced by such a system, while the concentrations of fire, protection in areas under regeneration, with controlled burning for protective reasons in other areas is impossible. Again, resin tapping operation can be conducted more efficiently and economically when concentrated on definite areas than when spattered widely as they would be under any form of the selection system.

The rotation adopted for chir pine in most places varies from 120 to 150 years. In Kangra fixed periodic blocks with period of 30 years and rotation of 120 years are adopted. In Chaimata and Kumaon chir is being converted to the uniform system by the floating periodic block method with no fixed period and the conversion period has been fixed at 100 years.

**Tending:** Cleanings in chir regeneration should start early as soon as the young regeneration is about 3 to 4 ft. high, in order to space out the saplings. In Punjab pruning of lower branches is also carried out as a fire-protection measure. Controlled burning in young regeneration areas should be carried out as soon as practicable. Regular thinnings after the crop is about 15 years old are necessary as chir is a strong light demander and suffers badly by congestion.

**Statistical:** The existing yield tables for chir were prepared by Howard in 1926.

Three quality classes have been distinguished and their heights at 100 years age and at maturity (150 years) as under:

At 100 years At maturity

Quality I. 114 – 138 ft Over 128 ft

Quality II. 91 – 114 ft 103 – 128 ft

Quality III. 72 – 91 ft 80 – 130 ft

The diameter attained at 120 years age by crops thinned to C grade in the quality classes I, II and III is 25.9", 23.2" and 20.2" respectively. The mean annual increment for stem timber for all the three quality classes culminates at 110 years age is 131 cft., 86 cft., and 54 cft. Respectively.

### ***Acacia nilotica* (Babul)**

An excellent multipurpose timber used in building carts and carriages wheel work, agricultural implements, boat, building, etc. Excellent fuel. Bark for tanning, pods serve as fodder for cattle, goats and sheep.

**Distribution**

Indigenous to Sind, Rajasthan, Gujarat and the Northern Deccan. Cultivated or self sown throughout most of the drier parts of India, but not in the extreme northwest of the Punjab where the winter cold is too severe – also found in Africa and Arabia. Climate: Temperature Maximum 105oF to 122oF = 41°C – 50°C Minimum 30oF to 60oF = -1oC – 16oC

Rainfall: 750 – 1250 mm

Soil: Alluvial – black cotton soil

Leaf fall: Hardly ever quite leaflets on poor dry areas for a short time in April – May.

Leaf renewal: April to May

Flowering – June to September or October – sometimes as late in December or January. The time for ripening varies correspondingly but is usually from April to June or earlier in South India. In Sind flowers twice a year one in June – July and again in November – December. Fruit from 1st flowering ripen about October but of poor quality, 2nd fruiting about May and gives good crop.

A strong light demander.

Develops a long tap root – also a strong superficial root system is provided.

Root suckers – Not usually produced root suckers in some places (Kistna district).

Coppicing – variable – generally poor coppicer. In some places (e.g., Guntur) worked on coppice.

Pollarding – Pollarding wall – freshly cut for fencing and fodder.

Storms – Fairly wind firm liable to be uprooted on extensive scale on inundated ground which has become soft.

Frost - Tender

Drought - Hardy

Fire - Tender

Animals – Goats and camels are the worst – sheep and buffaloes are also harmful – young plants damaged by deer, antelopes, hares and rats.

Insects – *Coelosterna scabrata* – beetle (a root boring longicorn) grubs tunnel into the roots and kills young trees the imago (completely mature state of insect) strips the bark from the leading shoot and branches of young trees.

*Psilopterus fastuosus* – beetle – attacks trees only in its mature stages, stripping the bark of the stems and branches.

Fungi – Much damage caused in Berar by the fungus *Fomes pappianus* – attacks the heartwood of the stem and branching and spreads into the roots, causing the wood to become brittle and in severe cases, to crumble away; infected trees thus liable to be blown over or to have their stems and branches snapped by wind – does not attack young healthy trees.

Protection

1. Remove all sporopores from infected trees
2. Cut out badly infected trees
3. Thin regularly
4. Cultivate field crop after removing babul crop raise babul again by Taungya

Another fungus which attacks babul is *Gamoderma lucidum* (also attacks sissoo)

Natural reproduction - Germination commences early in the rainy season and continues for sometimes. Natural regeneration favoured by (1) complete sunlight, (2) abundant moisture, (3) loose soil, (4) absence of grass and weeds.

Artificial regeneration

220 seeds to the ounce. Collect pods from tree or ground. Soak for 40 hours before sowing when plant per cent is 30 seeds from sheep or goat pens give best results – germination commences after 2 or 3 weeks and almost complete in a month. Should be sown not transplanted. Does not stand root or shoot pruning. Best method is direct sowing early in June or cover seeds about 1/4" weed in 1st and 2nd rains and if necessary 3rd rains also. Plantations raised in dry localities combined with or without cultivation.

Treatment Hilly clear felling with artificial regeneration. Except hills of Madras and Mysore by private owners.

### ***Acacia catechu* (Khair)**

Family - Leguminosae – Mimoseae

Moderate sized deciduous tree; heart wood very hard used for house posts, agricultural implements, wheels, tool handles, etc. gives excellent fire wood and charcoal. Cutch and katha obtained by boiling down chips.

Varieties

- 1) *A. catechu* – Punjab, Garhwal, Kumaon, Bihar, Ganjam and in the Irrawady valley. Also in North Kanara and Konkan.
- 2) *A. catechu* – Chiefly in Sikkim, Tarai and Assam, also in Upper Burma, Mysore and the Nilgiris.
- 3) *A. chundra* - Chiefly in the lower Peninsula and Upper Burma.

Habitat – Distributed throughout India except in the most humid regions. Typical in (1) the shingly and sandy alluvial beds or rivers and streams which may or may not be dry for a considerable portion of the year – here markedly gregarious and (2) in dry types of forest on high land away from water courses where it is frequently more or less gregarious, though often mixed with Xerophytes. Geo. Rock and Soil – Occurs in a variety of geological formations. Thrives best on porous alluvium comprising sand and shingle and on well drained sandstone. *A. chundra* comes up on a variety of soils including clay and shallow soil with sheet rock below.

Climate – Rainfall – In Eastern Sub-Himalayan tract, stands high a rainfall as 150". Away from rivers in tracts occurs when rainfall is 20" to 85". Max. temperature - 105o to 120oF Min. temperature - 30o to 55oF

Leaf fall – Leaflets for a time in the hot weather. In Northern India leaves shed about February.

Leaf renewal – about end of April or during May. By June complete.

Flowering – Appear with the new leaves, i.e., by June – continue in flower till July or August or even later.

Fruiting – Develop rapidly, full size by September to October. Turn from green to reddish green and then to brown, ripen by the end of November and continue ripening during December and early January. Pods dehisce not long after ripening and commence falling in January and proceeds in succeeding months. Seeds adhere to the pod valves and, the later being light, are blown by wind over considerable distance.

Silv. Characters – A strong light demander. Decidedly frost hardly in the habitat, young seedlings frost tender. Coppice-well up to a moderate size. Produces root suckers when roots are exposed. Fairly fire hardly, but benefits from fire protection.

Is Xerophious, but suffers from abnormal drought. Subject to damage by browsing and responds well to closure. Porcupines are particularly destructive, gnawing the bark off from the bases of trees and killing them as a result. Elephants very fond of this species and so should not be grown in elephant ridden areas.

Natural regeneration – Seed disseminated by wind and water germination takes place early in the rainy season profusely under shade and in the open. The former die from shade and sampling off, a fair proportion survive in the open if saved from grazing natural regeneration occurs remarkably freely in alluvial tracts.

Artificial regeneration – Weight of seed 1100 to the oz. Best to collect from the tree and then spread them for a few days in the sun to dry. Ripe pods dark chocolate brown in colour. Requires no pretreatment but it is better to soak for 24 hours, before sowing. Germinates over a long period, commencing after a few months. Germination per cent upto 75 in the nursery and 30 to 50 in the field. Should be sown and not planted Does not stand root and shoot pruning at all. Nursery seedling partially successful when planted at the break of rains. Not recommend. Direct sowing in lines done just before the break of monsoon, lightly covered with earth and weeded. Success of direct sowings depends on (1) extent to which soil is kept loose in the first two years after sowing, (2) thorough weeding and (3) abundance of light. In Dehradun experiments, the greatest success was attained by line sowings, particularly in combination with field crops. Strips x 32 to 3' wide and 8' to 10' apart indicated [field crops mendus (*Eleusine coracana*) sown in May or June and reaped in October khair seed sown at the same time as millet. Plants attains a height of about 2' at end of the first season and 4' at the end of the second. Two years weeding sufficient. A fast grower in early youth. In favourable localities two year old plants are on an average 7'. In Dehradun plants ripped by frost for a year or two. In Bengal 14' high in 3 years.

Tending – Needs regular weeding and climber cutting or pulling till it gets established.

Diseases and pests – Liable to attack cattle, deer, porcupine, rhinoceros and elephants. Climber damages from *Dregea volubilis*, *Cryptolepis* and *Valleris*.

System of management – Generally coppice or coppice with standards and selection fellings.

Statistical – Standard, commercial and heartwood volume tables (Factory working) for *Acacia catechu* by H.G. Champion and I.D. Mehendru – I.F.R. (silvicultural series – Vol. XV – Part III).

## ***Shorea robusta* (Sal)**

Family : Dipterocarpaceae

Local name : Sal, Sakhu (Hindi), Sakwa (Nepali), Shal (Bengali), Sariatigal (M.P.), Gugal (Telugu)

A large deciduous tree, seldom leaf-less with shining foliage, mature leaves somewhat coriaceous, ovate-oblong, usually about four to eight inches long. Crown conical or elongated in young – afterwards rounded with strong root system. Bole clean and straight in forest grown trees. Bark of saplings grayish brown and smooth. In older trees 1” to 2” thick rough with deep longitudinal furrows. Sapwood small, pale coloured heart wood brown, hard, cross grained very strong and durable seasons slowly. One of the most important timber trees of India. Wood used for buildings, railway sleepers, wagons and a large number of other purposes. When tapped the tree yields a whitish resin which is burnt as incense and used for chaulking boats. In favourable localities reaches height of 125 ft and girth of 12 ft or more. In Nepal, many attain a height of 150 ft with a clear bole of 60 to 80 ft and a girth of 20 to 25 ft.

General distribution – It occurs two main regions separated by Gangetic plain – namely the ‘northern’ and ‘central’ Indian regions. Ascends to 4000’ and occasionally to 5000 ft.

Climate – Sal regions vary widely as regards temperature and rainfall. Maximum temperature is 95°F to 117°F, minimum from 30°F to 45°F. Rainfall varies from 40” to 140” per annum.

Topography, Geology, Rock and Soil – Occurs both in hilly country and flat ground – grows best on lower slopes and valleys with deep, moist and fertile soil. Found on a variety of geological formations. Avoids swampy tracts with poor drainage.

Most favourable soil is well drained moist deep sandy loam with good subsoil drainage. Under lying rock – Occurs on the older Himalayan rocks of outer ranges consisting chiefly of shale or mica, schist with occasional lime stone; on the tertiary sand stone and conglomerates of Siwalik range, deep boulder deposits at the foot of hills. Avoids pure limestone but thrives on soil consisting partly of lime stone debris. In Doon avoids dry shallow soil over lying hard calcareous pan. In Assam occurs on schist, granite, sand stone conglomerate of lower hills and deep boulder belts flanking the outer ranges.

Types of forests and local occurrence – It is one of the most gregarious of the Indian trees. Tends to regenerate to profusely under favourable conditions and grows in more or less even-aged crops. Also occurs frequently in uneven-aged crop and may be found more or less scattered by single tree or in small patches mixed with various other Sal forest is generally separated in two extreme types (i) the dry type, (ii) the moist type, between these various gradations occur.

Leaf shedding, flowering and fruiting – Leaves commence turning yellow and falling from January to March. In dry seasons and in dry localities leaf shedding takes place earlier and is more complete than in wet season and moist localities. New leaves and shoots appear February to May. Young leaves are tender reddish and shining, soon turning to a fresh delicate green. Where old foliage is defoliated by insects early in the year – new shoots appear earlier than usual. Sometimes two separate flushes of raw leaves appear in one season.

Flower buds, as a rule, just become visible in February, but in early season this may in layer parts of January. They are full out from end of February to April. At this time the trees are partially leafless. Fruits are 0.6” long by 0.5” in diameter. 350 to 420 fruits per lb. Ripen in June and fall as soon as ripe. Under favourable moisture conditions seeds germinate soon after falling or even on the tree. Sound fresh seed has a high percentage of fertility but it rapidly loses its viability and under ordinary conditions will not keep fertile for many days. Drought is the chief cause of mortality and it care is taken to keep the seeds cool and prevent their dying they may retain their viability for a few weeks. In most localities good seed years are of fairly frequent occurrence, while occasionally the seedling is remarkably gregarious and profuse. Storms hail or strong dry winds occur from March to June. The flowers and mature fruits may be blown or knocked down destroying the seed crop. At times insects destroy good deal of seeds. Germination hypogeous.

Stem development – Stems of sal seedling are at first thin and whippy, eventually becoming thickened with ausmoth cortex. After this the growth is more rapid and the seedlings is considered established. Before long the smooth cortex begins to crack, forming rough bark – this is sapling stage.

Dying back – Dying back or complete dying of Sal seedling in the forest is the phenomenon peculiar to this species. Subsequent recovery takes place with vigorous development of the tap root so as to with stand the adverse influences.

#### Silvicultural Characters

Light requirement – Although sal is able to persist under moderate shade – it is strictly speaking a light demander, young plants require protection from frost and drought.

Root system – Produces a long stout taproot of great length which reaches down to a strate most enough to supply the water requirements of the tree. Stout lateral roots are produced at no great depth below the surface, while deeper down are found numerous fibrous lateral nutrition root-lets a in all directions where there is sufficient moisture.

Coppicing power – As rule coppices well upto a moderate size. Shoots are usually produced from the sides of the stool near ground level.

Drought – It causes great damage.

Frost – Stands frost better than many of its associates, but since it often occurs in grassy tracts and other localities subject to severe frost it is particularly susceptible to injury by frost.

Fire – One of the most fire resistant species of its region.

Storms – Is not ordinarily liable to be thrown by wind, but as badly drained clayey ground the taproot sometimes rot and the trees are readily blown down.

Animal damage – Injury by animals occur in younger stages. Pigs and porcupine uproot young plants. Wild elephants trip the bark of lower parts of poles and small trees. Browsed by deer and cattle particularly in coppice shoots, heavy grazing may result in complete absence or natural regeneration. It has numerous insect enemies.

Parasitic plant – Loranthus causes much damage.

Fungi – i) Polyporus shoreae, ii) Fomes caryophylli and iii) Sylarya polymorpha

Natural reproduction – Natural regeneration of Sal has many puzzling features. In some localities it springs up in great profusion and with great vigour. Whereas in other localities it is completely absent for no apparent reasons. Three factors have bearing on nature reproduction viz., (i) seeding, (ii) germination and (iii) establishment. In germination the most important factor is monsoon. The seed falls at or immediately before rains and if they are delayed many days after the seed fall germination falls. In the open Sal seed falling on a layer of dead leaves either fails to germinate or dies after germination.

Establishment of seedlings – Under this the following factors are important:

- 1) Dying back
- 2) Effect of dead leaves
- 3) Light
- 4) Frost
- 5) Grazing
- 6) Hardened soil and bad drainage
- 7) Fires

8) Indicator plants and nurseries

9) Seasonal variations, e.g. untimely monsoon, etc.

Artificial regeneration – Various methods followed but generally natural reproduction is taken advantage of.

Rate of growth

Place	Age in years	Girth in inches
Saharanpur	13	27.0
„	30	54.5
„	35	79.5
„	25	69.0

### ***Dalbergia latifolia* (Rose wood)**

Family: Papilionaceae

*Dalbergia sisso* till lately believed to be variety of the same species is also known as Rosewood. This has however been found to be distinct. For purposes of the present silvicultural study both will be treated as one.

Vernacular name: Setisal (Bengal), Shisham (Mar), Sissu (Gujarat), Beeti (Kann), Jitengi (Telugu), Eeti (Tamil), Thothagathi (Malayalam).

Habit -Tree, shrub or herb – A large deciduous, nearly evergreen tree with a full rounded crown. Erect, climbing, etc. – Apot to the somewhat cooked in the earlier years but straightens itself in the long run.

Gregarious, sporadic, etc. – Although found distribute in large numbers in typical localities, the species cannot be called gregarious. It grows more or less scattered in mixed deciduous forests.

Maximum girth – Trees of 25' girth were found in Ulandi valley of Tunacaduvu range, Coimbatore south division.

Maximum height – Troup cities, Tiraman's recorded measurement of 130' height of a tree of 15' – 5" girth in Coorg. It is likely that trees of greater height have existed.

Flowering period – January to March; local variations are noticed. Fruiting period – November – January, local variations are noticed.

Leaf fall – In most localities, the tree is seldom leafless and in almost evergreen. In dry localities, the leaves are shed in February – March.

Leaf renewal – April – May.

Habitat – General distribution – The sub-Himalayan tract from Oudh (Gonda and Bahraich) to Sikkim. Chota Nagpur, Central, Western and Southern India.

Class of Forests – Mixed deciduous forests, dry and moist, not frequently it is found in semi-evergreen forests as well.

Altitude – It is found in elevations upto 4000' and in the Anamalais upto 4500'.

Soil – It reaches its best development on deep moist soil particularly in the neighbourhood of perennial streams. It grows on a variety of geological formations including gneiss, trap, laterite, boulder deposits and alluvial formations, but requires good drainage. Climate – In its natural habitat max. shade temperature vary from 95o to 118oF, the absolute minimum from 32o to 60o and the rainfall from 30" to 200".

Chief associates – The associates depend on the elevation and type of soil at which it is found. In Bombay it occurs in elevation upto 3000', associated with teak, *Terminalia tomentosa* and other trees and bamboos. It is indigenous in dry savannah forests of Khandesh on trap and ascends to 3700' where it is mixed with teak, *Quercus dalbergioides* and *Z. jujuba* and is usually a small tree owing to unfavourable climate and soil. In Madras, it is found in most districts but grows best on the Western slopes of Nilgiris upto 4000' and on the Anamalais upto 4500', the associates are teak, *Terminalia tomentosa*, *T. paniculata*, *Lagerstromia lanceolata*, *Anogeissus latifolia* and *Xylia xylocarpa*. Attains large sizes in these localities. It occurs in the drier types of forests in Madras in small sizes. In the Madhya Pradesh, its most important companions are teak, *Terminalia tomentosa*, *Lagerstromia parviflora*, *Anogeissus latifolia* and *Quercus dalbergioides*, largest dimensions are attained in Chanda, but trees over 4½' girth are seldom sound. In Bihar and Orissa the tree is somewhat scattered and does not reach large dimensions. The Chota Nagpur it is common in cool aspects along streams. U.P. sparsely scattered in dry deciduous forests of Bundelkhand and adjacent tracts and along the sub-Himalayan tract in Gonda and Baharaich district, chiefly in mixed deciduous forests but sometimes in Sal forest. This is the Northern limit and the tree is similar size.

Economic uses – The wood is very hard, close grained strong, durable and ornamental and is used for a large number of purposes such as for furniture, paneling, ornamental work, ordinance work, agricultural implements, etc. It is exported to Europe under the name of rosewood or Bombay blockwood. Wood is also used for cart wheels, gun carriages, etc.

Silvicultural characters – Light, moderate light demander; capable of standing a fair amount of shade, particularly in youth it benefits greatly by overhead light. If however, it is grown in too open a situation it is apt to become crooked and brancy.

Frost – Frost tender more so in early stages. In Chanda Mangla plantations it is reported to have failed because of frost. Frost a key factor determining its distribution.

Power to coppice – Coppices well, the season of cutting appears to influence production of coppice shoots. Experiments in North Chanda revealed that cutting between April and May produced 100% results. August 80% and September 25%.

Reproduction by root suckers – Very pronounced; has dimorphous roots. A long taproot is formed in the earlier stages; this becomes thickened and other main roots, as well as numerous smaller nutrition roots and fibrous rootlets without buds, are also produced, growing downwards into the ground. In addition to this root system, long superficial propagation roots with buds spread rapidly outwards, running horizontally not far below the surface or at times even along the surface of the ground. From these numerous suckers are sent up, particularly where the roots are exposed or wounded, old trees being often surrounded by quantities of suckers. Root suckers are most numerous in situations exposed to light, e.g., on the edge of roads, fire lines, boundary lines and the like.

Drought – Decidedly resistant, though vulnerable in the seedling stage. Growth in young – Growth is moderate during the 1st year but in the 2nd and subsequent years it is rapid under favourable conditions. It is however far slower grown in the earlier years than *sissoo*. Development is greatly stimulated by weeding particularly when accompanied by periodical soil working. Under natural conditions it is not a fast grower. Compared to teak it grows slower but later catches up with and in favourable situations, overtops.

Fire – Not so hardy as teak. It does withstand annual fires, however, but benefits from protection. Injury by grazing, etc. – Seedlings and saplings are readily browsed by cattle and goats. Light grazing helps to put down weeds and benefit its growth. Browsed by deer and damaged by elephants. Owing to its capacity to coppice well, it manages to withstand mechanical injury considerably.

Germination and early growth – Germination epigeous. Development greatly stimulated by weeding, soil working and watering. In early young seedlings are tender to drought and frost, but become more hardy later. Partial shade is beneficial in young. Develops long taproot early in life. There is cessation of growth between

November and February sometimes upto April. Weight of dry pods, 680 to the oz. seeds need not be removed from the pods. Better germination is noticed when sown with pods. Pods to be well dried before sowing. Care should be taken that only ripe seeds are collected. Experiments on pretreatment of seed have not revealed any method which improves germination per cent. As it is, germination per cent is high being about 65% on size, age and condition of seed bears are inconclusive. Seeds are good up to three months (30% to 50%) falling to about 10% after six months and to zero when kept for over a year. Sowing of seeds when fairly fresh is indicated.

Natural regeneration – The species propagates itself freely by root suckers. It also regenerates itself from seed.

Germination takes place early in the rainy season. Chief cause of mortality is drought in situations exposed to direct sun. Seedlings are found usually in places with loose moist soil with moderate growth of grass, etc. In fire protected areas where grazing also is restricted, natural regeneration is usually good under light shade.

Artificial reproduction – The best method of raising is by planting one year old stumps early in the rainy season. Direct sowing is next best and entire plants the worst. Stumps of 0.2” to 0.6” diameter give the best results in point of survivals and height growth.

In Madras artificial regeneration has been confined so far to growing in mixture with teak and lately this too has been given up owing to slower growth of rosewood in the earlier stages as compared with teak. It was tried in gap regeneration in areas subjected to selection felling but here too its slow growth in the early stage and its susceptibility to browsing have necessitated the abandonment of this method. So far as is known no concentrated regeneration of the species on any systematic and large scale has been attempted.

Seed collection – Seeds from December to May. Best time of collection is February/March.

Method of collection – Collected from trees by lopping branches. Only ripe pods to be collected. Pods turn bark brown on ripening.

Seed treatment – Dry in the sun, not necessary to extract seed, better results by sowing pods.

Storage – Stored in bags until required for sowing in May.

Germination – Starts in a week and is complete in three weeks with 40% success.

Treatment in nursery – Regular weeding and watering. Pricking out not necessary as planting out is done in the same year. For stumps kept in the nursery until the 2nd or 3rd rains.

Tending – At first weeding pluck off all except one shoot in the case of stump planting and put mud over cut shoots. Rate of growth slow at first, so, frequent cleanings required.

Rate of growth – No yield tables, generally slow under natural conditions.

Treatment – Usually worked out selection fellings. Partly also simple coppice, coppice with standards and coppice with reserves systems. For intensive management clear felling with artificial regeneration in combination with other valuable species is indicated.

### ***Dalbergia sissoo* (Sissoo)**

Family: Papilionaceae

Vernacular name – Sissoo (English), Shisham (Hindi), Tali (Punjabi)

Habits – Large deciduous tree; erect; comes up gregariously in the alluvial deposits on the sissoo of rivers and streams in the sub-Himalayas and outer Himalayan valleys. In favourable localities attains a girth of 8’ and a height of nearly 100’. In favourable localities is a small tree.



Roots – Dimorphous, comprising nutrition roots without buds penetrating downwards into the growth and long horizontal roots with buds from which suckers are produced. The seedling produces a long taproot at a early stage; this thickness considerably during the sapling stage becoming such gnarled and twisted by contact with boulders. In the meantime lateral roots are thrown out; the original taproot often dies off in part and forms nothing more than a short thick garled mass in which boulders and pebbles are often embedded. The taproot is sometimes thicker than the bole itself. It may consist of several branches with numerous subsidiary fibrous nutrition roots. Lateral roots may attain considerable length and thickness, e.g. tree 3' – 3" in girth in Siwaliks had lateral roots 30' long. They spread at a depth of a few inches to about 2' below ground level, frequently sending up root suckers where exposed.

Trunk – Boles as a rule somewhat crooked, straight logs of any great length are difficult to get.

Grown – Light, spreading.

Uses – Heartwood brown with darker streaks, very hard, strong and durable; used as furniture wood and for building, carts and carriages, wheel work, gun carriage wheels, carving, etc. Used in tea gardens of Dehra Dun as a shade tree and fertilizer for tea bushes. Makes excellent firewood.

Latitude – Normally upto 3000' sometimes ascending to 5000'.

Slope – Thrives best in alluvial riverbeds with gentle if any slope. Also distributed on hills sides in pronounced slopes.

Leaf fall – Begins in November. Leaves turning brown a little earlier, leaflets fall separately; in colder places leaf fall may be complete by the beginning of December; elsewhere this may be incomplete even at the end of January; very irregular. Leaf renewal – Young leaves appear in the 2nd half of January or in the 1st half of February.

Flowering – Flower buds appear with the new leaves and these open in March or April.

Fruiting – Young pods form rapidly and by the end of April may be as much 2" long. By July, they are full sized, but remain unripe and yellowish brown till November when they commence to turn brown. They ripen towards the end of November and in December and beginning of January. Ripe pods are partly blown off; the trees b wind and carried down the gorges and rivers of the sub-Himalayan tract in winter. Part of the pods remain on the trees till April and May.

Soil – Thrives best on alluvial soil in beds of streams of rivers. It avoids stiff clay in which it does not attain and size; prefers porous soil on sand, pebbles and boulders. In Rawalpindi district it occurs in the form of a straggling bush at an altitude of 5000' clinging to crevices on the sides of sandstone cliffs and spreading by means of root suckers. Detrital boulder fans, torrent beds, etc. along the base of the outer hills are covered with dense sissou crops.

#### Climate

Maximum shade temperature - 103oF to 120oF Minimum shade temperature - 25oF to 42oF Normal rainfall - 30" to 180" Growth stunted when rainfall is below 40"

#### Ecology

In the alluvial sissou forests, characteristics sub-Himalayan and outer Himalayan tracts, sissou grows gregariously on new alluvial depots or low banks formed of deposits of sand. Advent of sissou is preceded by or takes place simultaneously with *Tamarix dioica*. Grasses appear immediately before, along with or a little after sissou. In the Western sub-Himalayan tract *Saccharum munja* colonises large stretches of rather sandy or shingly alluvium. Sissou subsequently invades the area making its way through the *munja* grass. Other grasses associated with the early development of alluvial sissou are *Saccharum spontaneum*, *Aristida cynantha* and *Triraphis madagascariensis*. When sissou gets well established its characteristic density kills out the grasses.

Subsequently, reduction in the density of the crop due to fires, fellings, etc. brings in miscellaneous species such as *Ehretia laevis*, *Hollarrhena antidysenterica*, *Lannea grandis*, *Bombax malabaricum*, *Kydia calycina*, *Premna latifolia* and the composition of the forest is changed. Changes in river and stream – courses frequently account for the washing away of immature sissou stands. In the moist climate of Duars the alluvial sissou forests are characterized by much more luxuriantly grown savannah grasses, such as *Saccharum arundinaceum*, *Erianthus elephantinus*, *Themeda arundinacea* and in moister places *Pharammites karka*. With fire and grazing excluded, these grasses attain a height of 12' to 20'. When fire enters great damage is done to the sissou, all but a few widely scattered trees being killed. It is considered desirable to allow grazing immediately the sissou gets beyond reach of cattle so that the rank growth of grass can be kept down and fire danger reduced. The chief associates of sissou in these forests are *Acacia catechu*, *Albizia procera* and *Bombax malabaricum*.

Silvicultural characters

Light – A strong light demander

Frost – Decidedly frost hardy; leaves affected by severe frost but the tree is not seriously injured.

Drought – Fairly hardy in its natural state, but in the irrigated plantations suffer badly if water supply is cut off for any length of time. Seedlings are sensitive to drought.

Fire – Not particularly resistant.

Mechanical damage – Is good coppicer, recovers fairly well from mechanical damage.

Grazing and other animal damage – Readily browsed by cattle; goats and camels. In grazed areas seedlings and saplings are browsed year after year and coppice shoots assume a dense bushy growth. Rats and porcupines eat the roots and bark. Subjected to severe damage by wild elephants and so should not be grown in elephant ridden localities.

Weeds – Dense weed growth entirely prevents the establishment of regeneration.

Climbers – Much damage done in alluvial sissou forests by the climber, *Dregea volubilis* which twines round the stems and over the tops of trees; trees get stunted and badly shaped. *Crystolepsis buchmanii* and *Acacia pinnata* are other climber pests.

Root suckers regeneration – Regeneration prolific by root suckers. Felling the tree below ground and exposing the roots by digging to a few inches 2' results in root sucker regeneration. In Changa Manga plantation, this method of regeneration has failed.

Coppicing power – Coppices vigorously; not certain up to what age or size this happens. In Changa Manga coppicing is vigorous upto an age of 20 years. Trimming the stools or bot makes no difference. Independent root systems are produced in either case provided, felled near ground level.

Natural regeneration – Pods disseminated by wind non-riverain tracts and by wind and water in riverain tract; reach the ground from the beginning of December till end of April and lie until they get soaked when the monsoon rains commence in June – July. Early heavy thunder storms results in earlier germination. Numerous seedlings are found after rain in riverain tracts in places well above the reach of floods. The pod valves open easily when moistened and seed tests being thin there is no difficulty about securing regeneration after rains. In non-riverain tracts regeneration is easy on exposed ground such as on new embankments, landslips, soil worked by pigs, abandoned cultivated areas if free from weeds. Dense weed growth prevents establishment of regeneration. Fire grazing are inimical to natural regeneration.

Artificial regeneration – Easily raised from seed, nursery seedlings, stumps (2" of shoot and 12" of taproot) and cuttings.

Seed weight – 500 pods to an oz. or 1500 seeds to the oz. 1¼ lb pods give 1lb clean seeds.

Seed collection – Collect when ripe (December to February) from selected straight grown trees by lopping branches and from the ground. Pods turn black when ripe.

Treatment of seeds – Pods dried in the sun after collection.

Storage – Dried pods can be kept in gunny bags in a dry place until the rains, care being taken against damage by rats.

Sowing – Before sowing, soak pods in water for 2 days. There is not considered necessary in some places and the pods are merely broken into small pieces, 1 or 2 seeds in a piece and sown without any further treatment.

Direct sowing

1) In Bengal sown in May thickly in lines 6' apart. 30 lbs of pods are required per acre. Direct sowing not considered desirable

2) U.P. – sown 10 days before or just at the break of monsoon, gives 90% success. Need weeding and watering for 2 years. Seedlings 6" to 9" after one season and 3' to 4' after two seasons

3) According to Troup, direct sowings are preferable to planting and he recommends line sowing for unirrigated sowings. He suggests lines 10' to 12' apart (required 1 lb pods for 200 ft of line). In the irrigated plantations of the Punjab, sowing were done on the berms of parallel trenches (1' x 1' cross section) dug 10', 11' or 15' apart. The excavated soil is first thrown up in the form of a ridge running along side the trench, a small berm 3 or 4" wide and raised 1" to 2" is made between the trench and the ridge and on this berm the seed is sown. 60 to 80 lbs of seeds were used per acre. Subsequently 40 lbs were found enough. Best results by sowing from March to May. Sowing may continue till September, but later sowings produce much less vigorous seedlings. These plantations have been raised in thorn scrup areas in the plains of W.

Punjab which had carried only *Caparris aphylla*, *Salvadora oleoides* and *Prosopis spicigera*.

Nursery – Pods dibbled 3" x 3" in unshaded beds in March 1 lb pods are required per Kamra (12 running feet x 6' wide –72 sq.ft.)

Germination – In 7 to 15 days with 90% success

Treatment in nursery – Watered daily and constantly weeded.

Planting out – In Bengal planted out 4' x 4' entire with balls of earth round the roots when the plants are small. In Bengal, stump planting from 2 years old nursery plants has been found to be the best method. In U.P., one year old plants recommended for stumping by Howard; for avenues basket planting with 2 year old seedlings (roots cut at 1½' depth) is in vogue. In Assam best growth is said to have been obtained from cuttings, but timber quality is not certain. Stump planting 2 year old seedlings at 6' x 6' has done well ad is probably the best method; particularly so because planting is done usually in grassy areas; weeded in first three years. Fire protection in first four years and afterwards early burning may be attempted. Should not be grown pure; injured and badly damaged by porcupine and badly browsed; also heavy damage from fungus in the case of irrigated plantations. The irrigated plantations of the Punjab were worked under the system of coppice with standards, seedling regeneration being obtained both naturally by cleaning the ground and weeding the young crop. Mulberry came in as a valuable shade bearer for mixture.

Treatment of unstable riverain forests present some difficulty. The only course is to utilize all material as it becomes marketable by extracting all saleable deed and fallen trees at frequent intervals and all growing trees when they reach exploitable size. The riverain sissou forests of the sub-Himalayan tract are worked for the most part either under selection fellings or by simple coppice on a rotation of 20 years, belts being left unfilled along the edges adjacent to the river. In managing the riverain tracts, unstable and stable areas should be differentiated and in the stable areas species regeneration measures should be adopted with regular cleanings and thinnings. The appropriate system will be clear felling with artificial regeneration. The innings which will pay

for themselves may be done in unsuitable areas. In the Changa Manga plantations, the yield had greatly increased in the 2nd rotation because (i) the 2nd rotation was of coppice origin, (ii) larger admixture of mulberry and (iii) general increase in the density of the crop and fertility of the soil in the 2nd rotation.

Age of felling - Yield per acre per annum, stacked volumes thick firewood only (s.c.ft.) 1st rotation 2nd rotation  
1st rotation 2nd rotation

### **Santalum album (Sandal wood)**

Vernacular name – Chandan (Sans.), Chandan, Chandul, Sandal (Hind.), Gandada, Gandha (Kan.), Suket (Guz.), Chandan, Tel, Santharan, Srigandan (Tam.), Chandana (Coorg), Santap (Burma).

Habit – (tree, shrub or herb) – A small evergreen glabrous tree. Neither sporadic nor gregarious. Found in fairly large groups in its habitat.

Maximum height – about 50'

Maximum girth – about 8' Trees upto about 2 tons weight have not been known

Flowering period – Ordinarily May – June Another variable flowering from February 15 to March

Fruiting period – Variable ordinarily October – December another fruiting period in July and August.

Leaf fall – True evergreen and there is no definite period of leaf fall. Foliage gets thinner in monsoons and also in very dry season.

Leaf renewal – A flush of new leaves appears in May during the early showers and again after the monsoon in October.

Habitat – General distribution – Indigenous to Peninsular India from Nasik and Northern Circars Southern towards. Principal tracts are parts of Mysore and Coorg and certain districts of Madras. In Bombay the chief sandal region lies in the Dharwar and N. Kahara district along Mysore border. Occurs mainly in open jungle, hedge rows, lantana bushes, bamboo clumps and round the edges of cultivated lands. Abandoned village and cultivation sites fairly level country continuous grazing –

Theory best formation – germination and growth of in the bushes. Javadi and Telegiris (Salem and nearest D & S) – 2000 to 4000 and occasionally down to 1200'. Flourishes best generally on red ferruginous loam of the underlying rock being often metamorphic, chiefly gneiss. Found also on rocky ground stony or gravelly soil. Is not exacting as to depth of soil. Grows best on moist fertile alluvium along banks of stream. Those grown on proper soils are said to form more scented heartwood. Required good drainage and does not stand water logging. Avoids saline and calcareous soil and is not generally found on black cotton soil.

Climate – Rainfall in the chief sandal tracts varies between 25" to 65". Temperature 50o to 75oF.

Economic uses – Valued for its heartwood which is strongly scented. The wood is used for carving and fancy work. Oil distilled and used in perfumery and medicines for which it is the most valuable wood in India.

Light – In early stages the species in partial to shade and thrives under cover of hedge rows and thickets of scrub growth. It shows a tendency, however, to free its head from the surrounding growth. In its middle and later life it is intolerant of overhead shade, but is found growing under comparatively light cover.

Frost – Frost is unknown in the natural habitat of sandal.

Coppice – Young trees coppice well. Older trees are stated not to coppice at all except on ground along the banks of water courses.

Root sucker – Freely produced when root are exposed or out through or where parent tree has been grubbed up.

Drought – Capable of with standing moderate drought, but prolonged drought kills it.

Fire – Extremely fire tender and may be killed out right or injured and rendered unsound.

Grazing and browsing – Moderate grazing does not seem to heavy any adverse effect. Grazing is in fact intimately connected with its occurrence to keep out fires by keeping the grass low. It is readily browsed by cattle and deer and rabbit particularly in the dry season when grass is scarce and this constitutes the real danger to which it is subjected.

Injury by man – Being very much prized for its scented wood, it is always subject to heavy illicit backing.

Insects – The possible danger to the species is from some of the forest insects of spike disease.

Spike disease – This disease is responsible for very serious loss year after year as it ultimately kills the trees in all the stages. It is caused by a virus carried from tree to tree by perhaps some forest insects. Experiments to isolate the insects concerned and to prevent infection are in progress. The culprit is believed to be of the family – cossidae. It is hoped that the ending of the viator-insect of insects measures to keep these insects out from sandal areas will be taken.

Germination – Viability (i.e., seed fertility) is 25 to 40% upto one year – seeds of 28 months gave 6% success. Depulped seeds give better germination per cent. Rate eat away the seeds and so it is usual to roll the main red lead or in Acorus paste. Germination takes place 1 to 3 months after sowing.

Natural operation – Found mainly under bushes hedgerows and scrub but not as a rule in the open. This is due to the following reasons:

- 1) Birds sit on such growth and drop the seeds
- 2) Seedlings require protection from excessive heat of the sun and from browsing animals and
- 3) In the later stages, a host is indispensable and this is not available

Natural regeneration is handicapped by the readiness with which the species is browsed. Seed – dispersal is effected chiefly through birds. Even the areas where the species is newly introduced, it has managed to spread itself freely on its own. Natural regeneration is greatly encouraged by removing other weed growth including grasses under parent trees and ranking up the soil. The seeds cast by the parent trees find a suitable bed and germinate promptly.

Artificial regeneration – Numerous plantation dating from 1870 have been found in Mysore, Coog, North Coimbatore and Nilgiris, partly transplanting and partly by dibbling or sowing in situ. In the majority of cases they failed. One of the chief causes of failure was the incomplete realization of the parasitic nature of sandal. Another reason was the non-availability of shade in the early period, the sowing having been done in the open. Again wrong tending, as by sudden reveal of the lateral covering, which, in the case of young trees, accustomed to lateral shade, results in barkscorching. It commences with cracking and peeling of the bark in thin strips and later develops in long, more or less triangular, blisters which extend to even 3 to 4'. In bad cases wood is exposed considerably and death may result. Browsing and inattention rust have accounted for a number of failures.

Artificial regeneration may be brought about by

1. Direct sowings
  2. Sowing in beds and planting out when 2 or 3 month old. Plant them when 4" or 5" high and have a taproot 6" to 8" long. Another way is to grow plants in baskets in a nursery and after a year to plant them out
  3. Stump planting upto 3 years – 2¼ to 3 years old
- Sandal stumps are better than younger ones from the point of view of storage stumps stored in tins with tight lids have spouted even when stored upto 20 days. Stump – planting has shown as much as 99% success

4. Planting pieces of roots

5. Root suckers

Direct sowings cheap and best way – sown in April. Two recognized methods of procedure (1) sow over a large area at very wide and irregular spacings. Supervise and control difficult. A better method is to concentrate sowing on area with alternate to protection and trust to birds to spread the seeds from trees later. In both the methods make numerous hole ½” deep with pointed stock without disturbing the soil unnecessarily and put one seed in each.

Localities to be regenerated: 1) Open blanks – Hosts to be established in advances, 2) Shrubby jungle – Together with hosts. Hosts are suspected to be highly influential in conferring relative resistance, against spike. E.g., *Strychnus nuxvomica*, *Pongamia glabra*, *Azadirachta* and *Cassia* sames are stated to give high resistance. *Lantana* is good but is suspected to harbour an insect vector.

Tending in earlier stages

1) Maintenance of good host plants and their tending

2) Provision for tree and natural expansion of the crown

3) Feeding of suppressed plants

4) Providing light lateral shade to avoid sun-scorch with free overhead light

In the later stages

1) Tending of hosts and

2) Climber cutting

### ***Tectona grandis* (Teak)**

General description – A large deciduous tree with a rounded crown and under favourable conditions a tall clean cylindrical bole which is often buttressed at the base and sometimes fluted. Branches quadrangular, channeled with a large quadrangular pitch. Leave opposite, large broadly elliptical or ovate usually 1’ to 2’ long but often larger in coppice shoots and young plants, rough above, stamately grey tomentose beneath, with minute glandular dots which are red in young leaves, afterwards turning black. Bark is 15” to 7” thick, grey or light grayish brown, fibrous with shallow longitudinal fissures exploiting in long, thin, narrow, somewhat corky flakes. Wood moderate hard. Sapwood small whitish. Heart wood dark golden yellow sometimes with dark streaks, turning brown with age, oily with a characteristic colour, extremely durable and does not warp or split. It is the most important timber tree of India and unique for ship building. Extensively used for bridges, building, wharfs, piles, cabinet work, railway carriage, carvings, ordnance work, wheel spokes, general carpentry, etc.

General distribution – Indigenous in Burma, India, Peninsula, Siam and Java. In India, it occurs in M.P., Chennai, Coorg, Bombay and Travancore Cochin. Also occurs in Orissa, U.P. and Rajasthan. Introduced in moist deciduous forests of U.P., W.Bengal, Assam, Bihar, Orissa and the Andamans. Outside India it occurs in Indonesia, Japan and Laos.

Climate – A. Southern India tropical moist deciduous forest (3 ACI) – Rainfall, 60” to 80”. Soil – Sandy alluvium to old red soils, excluding laterite soils. Associates – *Terminalia* spp., *Pterocarpus* spp., *Lagerstromia* spp., *Adina*, *Dalbergia latifolia* and *Bambusa bambos*. *Dendrocalamus strictus* appears at dry end.

Topography, geology and soil – Majority of forests are on hilly or undulating country, growing on alluvial ground provided it is well drained.

Geological formation – Trap, basalt and other lime and base rich rocks; sandstone, quartzite and other gondwana rocks which are usually non-calcareous. Alluvial soils specially if derived from traps and lime bearing rocks.

Soil moisture is an important factor. Avoids waterlogged or very dry habitats. Occurs in soils of pH range of 6.5 to 7.5; below 6.0 is practically absent. Beyond 8.5 suffers in growth.

Leaf shedding, flowering and fruiting – In dry situations and season leaves fall from November to January. In moist localities leaves may persist till March or even later. As a rule, trees are leafless for the greater part of the hot seasons new leaves appear from April to June. In wet seasons somewhat earlier, flowers appear during rainy season (June to September). Fruits ripen from November to January and fall gradually, some remaining on the tree for part of hot season. Fruit is hard, bony, regularly globose nut, somewhat pointed at the apex enclosed a thick felty light brown covering, usually 0.4” to 0.6” in diameter, containing 1 to 3, rarely 4 seeds. The nut is enclosed in an inflated bladder like calyx 0.8” to 1.5” in dia. The fruit may be conveniently collected by cleaning the ground under tree in January – February and collecting fruits every few days, sometimes it may be lightly beaten off the tree with sticks. For convenience in storage and transport, remove the bladder like calyx. This is done by half filling a bag with fruit and vigorously rubbing and shaking it. The main parts of calyx are separated by winnowing.

Teak seeds almost every year, occasionally poor seed year occur. Fertile seeds are produced at an early age (20 years). Coppice produces fertile seeds in about 9 years.

Germination percentage – Usually high in selected seeds. Seeds often fail to germinate in the first year and may lie dormant in the ground for one year or more. Seeds stored for a year germinate more freely than fresh seeds. Germination is epigeal. Seedlings are decidedly sensitive to drought and frost particularly during the 1st year when they are killed, frequently out right. Young plants have wonderful power of recovery from damage of fire. Young plants are not readily browsed by cattle and other animals. Teak seedlings are intolerant of shade. In dry localities benefit in early stage by side protection from direct rays of the sun. Very sensitive to suppression by weeds.

Silvicultural characters – Does not tolerate suppression at any period of its life and requires complete overhead light and fair amount of side room for proper development. Produces a large, deep root system. At first a long, thick taproot is formed. This may persist or disappear. In either case strong lateral roots are produced. Requires to be planted in sheltered places with screen belts. Sensitive to frost and drought. It has greater power of resisting the effects of fire than the majority of its associates. Shows remarkable vitality in resisting effects of mechanical injury. Rats and pigs grow and dig up the roots. Elephants break down or uproot poles.

Insect attack – The larvae of a moth (*Duomitus ceramicus*) bore into standing trees causing large bores – erroneously termed ‘bee bores’. Another borer is *Cossus cadambae*. It tunnels down the interior of young stems 1 – 2 years old. The caterpillars of *Hyblea pura* and *Pyrausta machaeralis* are defoliators and skeletonizers respectively. *Hyblea* eats up everything of the leaves except the main nerve. *Pyrausta machaeralis* leaves all the veins. Another defoliator *Padiga damastisales* or the teak leaf borer does considerable defoliation on dry hill side. Fungus does not appear to do any material damage. In some places *Loranthus* attacks teak.

Coppicing power – Coppices and pollard vigorously, sometimes retaining coppicing power to a considerable size. The vitality of teak stumps is remarkable.

Natural reproduction

Factors Influencing Natural Reproduction

- 1) Spread of seed
- 2) Factors influencing germination
- 3) Factors influencing the survival and development of seedling

Spread of seed – On level ground germination takes place under mother trees. In the hillside seed is washed down the slopes.

Factors influencing the germination – Sufficient degree of moisture, temperature and soil aeration.

Factors influencing the survival and development of seedling – Light, soil aeration, soil moisture, weed growth, grazing and fire and important factors. Grazing, if not heavy, appears to favour reproduction of teak by keeping down weeds and grasses.

Fire, in drier types, has adverse influence. In moisture type indiscriminate fire protection has adverse influence on reproduction by encouraging growth of inferior species.

Artificial reproduction – Excepting for dry teak forest which are worked under coppice system all areas in moisture places with adequate advance growth, which on cutting back results in fully stocked new crops.

Availability – Occasionally seed crops are destroyed by storms but otherwise at seeds well every year. The damage mainly occurs between flowering and fruiting. Insects often destroy much of seed crop.

Storage – Not a serious problem. Stored in gunny bags, seal it or even heap upon the ground. Germination capacity is not affected for at least two years. Storage for one year is beneficial.

Dormancy – Under natural forest condition 4 – 5 years is even 10 years.

Seed collection – From December to March depending on locality.

Pretreatment

- 1) Scorching in a light fire of leaves and grasses
- 2) Immersion in hot water for a few hours
- 3) Boiling water treatment, i.e., putting seeds in boiling water and allowing it to cool
- 4) Immersion in cold water for a number of days
- 5) Alternate soaking and drying
- 6) Burying the seed for about a year near and hill so that white ants destroy part of the testa
- 7) Placing seeds in a paste of cowdung and water
- 8) Weathering, i.e., exposing to sun and rain in the open for a few weeks or months
- 9) Acid treatment

Nursery techniques – Commonest type is temporary dry nursery out occasionally with watering facilities. Best situation is near plantation site. Watering is necessary only in very dry zones or in cases of exceptional droughts. Side shade avoided, soil well dug up and mixed with ashes resulting from slash burning. In moisture localities beds raised to avoid water logging. In dry zones beds flush with the ground or slightly sunken, 4' width of bed considered best. Seed covered with ½ to 1" layer of earth. Mulching is useful, in drier parts young seedlings require protection from sun. Seeds sown between February and June.

### ***Ailanthus excelsa* (Maharukh)**

Family: Simaroubaceae

Indigenous in the Indian Peninsula and often planted in different parts of India.

Flowering – February – March

Fruits – Ripen in May – June. Coppices well and produces root suckers. Required light porous soil.

Natural regeneration – Poor



Artificial regeneration – Raised early from seed or from cuttings. Large cuttings strike early. Seed sown in May or June in well raised seed beds in drills about 9” apart, watered sparingly but regularly – germinates in 1 – 2 weeks, regular weeding necessary. Should be protected against frost. Seedlings can be planted out during rains of the second season.

Rate of growth – Plants from sowing in Dehra Dun produced plants 14’ high and 12½” in girth at the end of 4th season.

Uses - Useful matchwood.

### ***Tectona grandis* (Teak)**

General description – A large deciduous tree with a rounded crown and under favourable conditions a tall clean cylindrical bole which is often buttressed at the base and sometimes fluted. Branches quadrangular, channeled with a large quadrangular pitch. Leave opposite, large broadly elliptical or ovate usually 1’ to 2’ long but often larger in coppice shoots and young plants, rough above, stamately grey tomentose beneath, with minute glandular dots which are red in young leaves, afterwards turning black. Bark is 15” to 7” thick, grey or light grayish brown, fibrous with shallow longitudinal fissures exploiting in long, thin, narrow, somewhat corky flakes. Wood moderate hard. Sapwood small whitish. Heart wood dark golden yellow sometimes with dark streaks, turning brown with age, oily with a characteristic colour, extremely durable and does not warp or split. It is the most important timber tree of India and unique for ship building. Extensively used for bridges, building, wharfs, piles, cabinet work, railway carriage, carvings, ordnance work, wheel spokes, general carpentry, etc.

General distribution – Indigenous in Burma, India, Peninsula, Siam and Java. In India, it occurs in M.P., Chennai, Coorg, Bombay and Travancore Cochin. Also occurs in Orissa, U.P. and Rajasthan. Introduced in moist deciduous forests of U.P., W.Bengal, Assam, Bihar, Orissa and the Andamans. Outside India it occurs in Indonesia, Japan and Laos.

Climate – A. Southern India tropical moist deciduous forest (3 ACI) – Rainfall, 60” to 80”. Soil – Sandy alluvium to old red soils, excluding laterite soils. Associates – Terminalia spp., Pterocarpus spp., Lagerstromia spp., Adina, Dalbergia latifolia and Bambusa bambos. Dendrocalamus strictus appears at dry end.

Topography, geology and soil – Majority of forests are on hilly or undulating country, growing on alluvial ground provided it is well drained.

Geological formation – Trap, basalt and other lime and base rich rocks; sandstone, quartzite and other gondwana rocks which are usually non-calcareous. Alluvial soils specially if derived from traps and lime bearing rocks. Soil moisture is an important factor. Avoids waterlogged or very dry habitats. Occurs in soils of pH range of 6.5 to 7.5; below 6.0 is practically absent. Beyond 8.5 suffers in growth.

Leaf shedding, flowering and fruiting – In dry situations and season leaves fall from November to January. In moist localities leaves may persist till March or even later. As a rule, trees are leafless for the greater part of the hot seasons new leaves appear from April to June. In were seasons somewhat earlier, flowers appear during rainy season (June to September). Fruits ripen for November to January and fall gradually, some remaining on the tree for part of hot season. Fruit is hard, bony, regularly globose nut, somewhat pointed at the apex enclosed a thick felty light brown covering, usually 0.4” to 0.6” in diameter, containing 1 to 3, readily 4 seeds. The nut is enclosed in an inflated bladder like calyx 0.8” to 1.5” in dia. The fruit may be conveniently collected by cleaning the ground under tree in January – February and collecting fruits every few days, sometimes it may be lightly beaten off the tree with sticks. For convenience in storage and transport, remove the bladder like calyx. This is done by half filling a bag with fruit and vigorously rubbing and shaking it. There mains of calyx are separated by winnowing. Teak seeds almost every year, occasionally poor seed year occur. Fertile seeds are produced at an early age (20 years). Coppice produces fertile seeds in about 9 years.

Germination percentage – Usually high in selected seeds. Seeds often fail to germinate in the first year and may lie dormant in the ground for one year or more. Seeds stored for a year germinate more freely than fresh seeds.

Germination is epigeous. Seedlings are decidedly sensitive to drought and frost particularly during the 1st year when they are killed, frequently out right. Young plants have wonderful power of recovery from damage of fire. Young plants are not readily browsed by cattle and other animals. Teak seedlings are into learnt of shade. In dry localities benefit in early stage by side protection from direct rays of the sun. Very sensitive to suppression by weeds.

Silvicultural characters – Does not tolerate suppression at any period of its life and requires complete overhead light and fair amount of side room for proper development. Produces a large, deep root system. At first a long, thick taproot is formed. This may persist or disappear. In either case strong lateral roots are produced. Requires to be planted in sheltered places with screen belts. Sensitive to frost and drought. It has greater power of resisting the effects of fire than the majority of its associates. Shows remarkable vitality in resisting effects of mechanical injury. Rate and pigs grew and dig up the roots. Elephants break down or uproot poles.

Insect attack – The larvae of a moth (*Duomitus ceramicus*) bore into standing trees causing large boles – erroneously termed ‘bee boles’. Another borer is *Cossus cadambae*. It tunnels down the interior of young stems 1 – 2 years old. The caterpillars of *Hyblea pura* and *Pyrausta machaeralis* are defoliators and skeletonizers respectively. *Hyblea* eats up everything of the leaves except the main nerve. *Pyrausta machaeralis* leaves all the veins. Another defoliator *Padiga damastisales* or the teak leaf borer does considerable defoliation on dry hill side. Fungi does not appear to do any material damage. In some places *loranthus* attacks teak.

Coppicing power – Coppices and pollard vigorously, sometimes retaining coppicing power to a considerable size. The vitality of teak stumps is remarkable.

Natural reproduction

Factors Influencing Natural Reproduction

- 1) Spread of seed
- 2) Factors influencing germination
- 3) Factors influencing the survival and development of seedling

Spread of seed – On level ground germination takes place under mother trees. In the hillside seed is washed down the slopes.

Factors influencing the germination – Sufficient degree of moisture, temperature and soil aeration.

Factors influencing the survival and development of seedling – Light, soil aeration, soil moisture, weed growth, grazing and fire and important factors. Grazing, if not heavy, appears to favour reproduction of teak by keeping down weeds and grasses. Fire, in drier types, has adverse influence. In moisture type indiscriminate fire protection has adverse influence on reproduction by encouraging growth of inferior species.

Artificial reproduction – Excepting for dry teak forest which are worked under coppice system all areas in moisture places with adequate advance growth, which on cutting back results in fully stocked new crops.

Availability – Occasionally seed crops are destroyed by storms but otherwise at seeds well every year. The damage mainly occurs between flowering and fruiting. Insects often destroy much of seed crop.

Storage – Not a serious problem. Stored it in gunny bags, seal it or even heap upon the ground. Germination capacity is not affected for at least two years. Storage forest year is beneficial.

Dormancy – Under natural forest condition 4 – 5 years is even 10 years.

Seed collection – From December to March depending on locality.

Pretreatment

- 1) Scorching in a light fire of leaves and grasses
- 2) Immersion in hot water for a few hours
- 3) Boiling water treatment, i.e., putting seeds in boiling water and allowing it to cool
- 4) Immersion in cold water for a number of days
- 5) Alternate soaking and drying
- 6) Burying the seed for about a year near and hill so that white ants destroy part of the testa
- 7) Placing seeds in a paste of cowdung and water
- 8) Weathering, i.e., exposing to sun and rain in the open for a few weeks or months
- 9) Acid treatment

Nursery techniques – Commonest type is temporary dry nursery out occasionally with watering facilities. Best situation is near plantation site. Watering is necessary only in very dry zones or in cases of exceptional droughts. Side shade avoided, soil well dug up and mixed with ashes resulting from slash burning. In moisture localities beds raised to avoid water logging. In dry zones beds flush with the ground or slightly sunken, 4' width of bed considered best. Seed covered with ½ to 1" layer of earth. Mulching is useful, in drier parts young seedlings require protection from sun. Seeds sown between February and June.

### ***Ailanthus excelsa* (Maharukh)**

Family : Simaroubaceae

Indigenous in the Indian Peninsula and often planted in different parts of India.

Flowering – February – March

Fruits – Ripen in May – June. Coppices well and produces root suckers.

Required light porous soil.

Natural regeneration – Poor

Artificial regeneration – Raised early from seed or from cuttings. Large cuttings strike early. Seed sown in May or June in well raised seed beds in drills about 9" apart, watered sparingly but regularly – germinates in 1 – 2 weeks, regular weeding necessary. Should be protected against frost. Seedlings can be planted out during rains of the second season.

Rate of growth – Plants from sowing in Dehra Dun produced plants 14' high and 12½" in girth at the end of 4th season.

Uses - Useful matchwood.

### ***Anogeissu latifolia* (Dhauna, Dhan, Dhawa, Bakli)**

Family - Combretaceae

Wood very hard, strong and tough used for cart axles, shoulder poles, axe handles, furniture, agricultural implements, poles and rafters, boat building and other purposes. Leaves are rich in tannin and collected in some places for tanning purposes. Bark also used for tanning and yields a form of gum used in calico printing.

Distribution – Sub-Himalayan tract, Bihar, Chota Nagpur, Central India and throughout the greater part of Peninsula India, upto 4000' (Not in E. Bengal, Assam and Burma).

Characteristic of deciduous forests – usually dry type. Generally avoids moist regions; grown on a variety of geological formations including sand stone, limestone metamorphic, rocks trap and laterite; avoids swampy and badly drained ground, requires good drainage.

Climate Maximum - 102oF to 118oF Minimum - 30o to 60oF

Rainfall - 25" to 90"

Leaf shedding – Leaf turn coppery red to reddish brown about November and fall chiefly in February remaining leafless until April – May.

Leaf renewal – April – May ; Flowers – Flowering May – June – September

Fruit ripens – December – March

Is reported to be used as fodder in Dehra Dun and Saharanpur divisions. Produces root suckers. Coppices and pollards well if cut at the right season; in the rainy season unsuccessful; best time March – May.

Natural regeneration – Fertility of seed generally low and according to Pearson fertile seeds are produced in drier years. Regeneration appears in even masses differing by definite intervals. Regeneration favoured by a clean, bare soil (as after in fire).

Artificial regeneration – The fruits are small, dry and indehiscent crowded in globose heads 0.15 – 0.25" in dia. Compressed, with a narrow wing on each side, yellowish brown, fairly hard. Fruits require to be collected when the heads commence to break up. In fertility of seeds is a big problem 1 or 2 seeds on a thorn grow. Best results would seem to be obtained after dry years when seeds are apparently more fertile. Seedlings can be planted out from nursery.

### ***Terminalia arjuna* (Arjun)**

A large handsome tree evergreen or nearly so with trunk often buttressed. A large crown and dropping branchlets. Bark smooth in thin irregular sheaths, green when newly exposed, turning light grey, pink inside, young bark with chlorophyll. The tree resembles *Terminalia tomentosa*, excepts for its smooth bark the narrower wings to the fruit and its characteristic existence on banks of streams. Sometimes attains enormous girth. One area of 26' and another of 30' girth at 5' from ground level at Jammu (Manapur village). Wood brown, very hard, used for buildings, agricultural implements, carts and boats. Bark used for tanning.

Distribution and habitat – Common throughout greater part of Indian peninsula along rivers, streams, ravines and dry water courses, reaching large size on fertile alluvial loam. Extends northwards to sub-Himalayan tract, common Chota Nagpur, Central India parts of Mumbai and Chennai, extending to Ceylon.

Climate: Maximum - 100oF to 118oF Minimum - 30o to 60oF

Rainfall - 30" to 70" The occurrence depends on moisture supplied by strong and not climate alone.

Leaf shedding, flowering and fruiting – Faster than *Terminalia tomentosa*, in the first season attaining a height of 3" to 12" under natural conditions and 1' to 1 – 9' in nursery. A long taproot develops early, about 1', in two months of germination. During the first few years assumes straggling or branching formation. Seedlings somewhat sensitive to frost, decidedly sensitive to drought both during germinating stages and subsequently. Grows well in full sunlight provided the ground is moist. Stands moderate shade but not dense overhead shade.

Silvicultural characters – Can stand more shade than *Terminalia tomentosa*, has more or less superficial root system and relies for its moisture chiefly in streams. Somewhat tender to frost and drought. Produces root suckers and pollards well. Coppices well upto a girth of about 2¼ beyond, which coppicing power is indifferent.

Natural reproduction – Under natural conditions germination takes place early in the rainy season and may commence with early showers before the monsoon proper.

Artificial reproduction – Transplants will during the first rainy season before the taproot becomes too long. Nursery sowing about April – May, cover lightly and water regularly. Irrigated weeded line sowing have been successful.

### ***Terminalia bellerica* (Bahera)**

A large deciduous tree attaining height of 120' and a girth of 10' or more, usually with a straight tall bole. Large trees often buttressed at the base. Bark bluish or ashy grey with numerous fine longitudinal cracks, yellow inside. Leaves broadly elliptical 4" to 8" long clustered at the end of branchless. Wood yellowish grey, hard not durable, but lasts fairly well under wear. Used for planking, packing cases, boats and other purposes. Fruits used for tanning but inferior to those of chebula.

Distribution and habitat – Found in deciduous forests throughout the greater part of India and Burma but in arid regions. Common associate of sal, teak and other important trees occurring more or less scattered and not gregariously. Occurs most frequently in moist valleys in India. Fairly common in deciduous forests up upper and lower mixed type with or without teak in Burma.

Climate Maximum - 97° to 115°F Minimum - 38° to 60°F

Rainfall - 40" to 120" or more

Phenology – In North India, leaf fall commence in November, some trees being almost leafless by end of the month while other remain in fully leaf till end of January. Remains leafless until March to May when foliage appears. Spikes of small greenish white flowers appear in April – May with the young leaves. They have strong honey like smell which is almost overpowering at times. Fruits ripen November, February and fall both during hot and cold seasons. Fruits greedily eaten by monkeys, squirrels, pigs, deer, goats and other animals and are never allowed to lie long on the ground before being stripped off, their fleshy covering. During the cold and hot seasons small clusters of light yellowish fruit stones may be found lying about the forest disposed by fodder in rumination. The partially of animals for flesh and ripe fruits spread the seed. But much of the fruit crop is rendered ineffective by insects and animals. Immature fruits are attacked by insects during rainy seasons. The hard nuts of fruits are bored by insects while lying on the ground. The nuts frequently broken open by squirrels and other animals for the sake of the kernel. Seedlings stand fairly dense shade during the first two years.

Frost affects the leaves but ordinarily frost do not kill the seedling particularly in grass. Hail tears the large leaves to pieces.

Silvicultural characters – Light demanders, can stand light a shade in young.

Decidedly sensitive to frost. Drought hard to some extent but does not grow in vary localities. Coppices fairly well.

Natural reproduction – In addition to animal dispersal where the fresh is not so consumed, it rots off or is eaten off by white ants. The nuts being wholly or partially buried in the process. Successful germination greatly assisted if nuts are buried by rains, white ants or otherwise, because the radicle of germinating seedling is liable to be eaten by birds, insects or to dry up if exposed to sun.

Artificial reproduction – Direct sowing has not been tried to any appreciable extent. Transplanting during the first rainy season before the taproot has become too long has become successful. Nuts or the whole fruit should be sown in nursery in March – April, covered with earth and watered regularly. Germination takes place about one or two months after sowing. Transplanting should be done in wet weather either after pruning the stems, roots or not. Pruning considerably checks the growth than otherwise.

### ***Eucalyptus* (spp.)**

An Australian genus comprising 140 species, most of which are found in Australia and some in Tasmania, New Guinea and other islands. Eucalyptus are evergreen species, all more or less aromatic and containing oil glands in their leaves, oil distilled from leaves is of medicinal value. They contain several of the most important timber trees of the Australian continent where they form large tracts of forest, some growing pure and other mixed.

Some of them reach gigantic size. Blue gum (*Eucalyptus globulus*) and Peppermint gum (*Eucalyptus regnans*) attaining heights of over 400'.

Eucalyptus appear to have attracted attention in their home in the early part of 19th century. Then for the most part blue gum were planted in the S. Europe for ornament. Then their economic value was realized and plantations were formed in the Mediterranean countries, California, Florida. Hawaii and several other parts of the W. Hemisphere in S. Africa and in several other sub-tropical and warm temperature regions throughout the globe. Introduction in India probably dates from 1843 and when a few trees were planted experimentally in the Nilgiris to find out their suitability as fuel. Regular plantations chiefly of *E. globules*, were commenced in 1956 and have since been extended on a large scale. Numerous species of the genus have since been tried in all parts of India, on the hills and the plain. On the whole species or other of Eucalyptus can be grown in any part of India except (i) very moist tropical regions where seedlings damp off in spite of all precautions and (ii) elevation above the winter snow-line where snow break is to be feared.

As timber trees Eucalyptus have not come up to expectations in India, but as producers of fuel they are far superior to any indigenous species. The globe gum conferred an inestimable boon on the Nilgiris. Numerous failures have occurred in attempts to introduce Eucalyptus in India because the conditions suited for the different species were not looked into. For low elevations in India only those species which grow in warm tropical parts of Queensland and adjacent northern regions (which carry such well known Indian trees as Bombax, Eugenia, Jambolana, Barringtonia, Alstonia, Mallotus, Frema, Ficus glomerata and Casuarina) would be suitable. For planting in higher elevations species growing in Tasmania and the southern parts of Australia should be suitable. Example of the latter is the blue gum which has succeeded well in Nilgiris.

#### Silvicultural characters

Light – As a rule, intolerant of shade. Many species, however tend to branch in the open. Also, in early young seedlings endure a little shade for a time. Many species coppice well, the most vigorous probably being *E. globules*.

Root system – Spreading Generally wind firm, but many species are liable to become bent, gnarled and stunted in exposed situations. Species tried at higher elevations in the Himalayas are found to suffer from snow break. Thick barked trees do not suffer much from fire but thin barked ones and young trees suffer badly. Those with barks exfoliating in long, dry strips, like blue gum suffer much as the fire ascends through the strips to the crown. Most species have high power of recovery from fire damage. Those damage by produce primordial leaves (e.g., blue gum plantation proofing silvery blue owing to such leaves). The more aromatic Eucalyptus are not readily browsed by cattle. Two species *E. corynocalyx* (whose leaves are sweetish) and *E. gunnii* (whose leaves are not strongly aromatic) are browsed by cattle.

Deer – Has been responsible in Dehra Dun and elsewhere for rubbing against young trees and causing damage. Fencing may be necessary where this form of damage is prevalent. In the Changa Manga plantation, Nilgai browsed seedlings in winter and gnawed the bark in the case of saplings and poles whose leaves were out of reach. The requirements of soil and climate for various species vary considerably. Generally speaking, most of them do not all Eucalyptus grow best on deep fresh soil with a fair amount of subsoil moisture. Many however, accommodate themselves to unfavourable conditions and in such cases their growth is affected.

Natural regeneration - To a limited extent noticed in the blue gum plantations in Nilgiris. In Australia, regeneration succeeded by cutting under growth passing fire over the area and there after giving protection from fire an grazing for the 1st few years.

Artificial regeneration – Planting more common than sowing. Coppice areas which have gone through three rotations will roughly be planted in addition to new areas. 3rd and 4th crops (if their yield fall by more than 15% of the potential outturn as read from local yield tables). Pre-planting will also be more where blue gum crop is over 40 years.

*Eucalyptus globulus* seed ripen from January or March. The ripe capsules fall to the ground and are collected and dried for four days when they open. The open capsules are then sieved in a basket. The small seeds fall through.

Nursery treatment – Vary considerably from place to place and local experience alone should decide the practice. Best time for sowing about February – March and even as early as January for June planting. This enables seedlings of the best size being obtained for planting early in the beginning of rainy season.

Raised beds filled in with a mixture of leaf mould and soil surface is smoothed well and moderately worked. Seed is sown broadcast on the surface and lightly covered with a layer of fine earth. Cover must be given 12” above bed level from the beginning. Shade should be removed during rains as seedlings are very susceptible to drip. Beds should never be flooded. Flat boxes 4 or 5” deep are preferable to seed beds. For new species with little seed, boxes should be adopted normally. Whether raised in beds or in boxes, the seedlings should be pricked out 2” to 3” apart either in nursery or in boxes when seedling attain a height of 2 to 4”. Pricking out requires much care as seedlings are sensitive to any damage to root or stem. May require pricking out on reaching 6” height, preferably this may be done by putting the seedlings in baskets or pots made of stiff paper or bamboo tubes. In the Nilgiris the system of mossing is in vogue, the roots of the seedlings being encased in a ball of earth and wrapped up with moss. This is done when the seedlings are 8” height. This enables retention of moisture. The mossed plants are placed on the ground under partial shade, regularly watered and shifted every few days to prevent roots fixing in the ground.

Planting – Best time in the beginning of rain when seedlings are about 12” – winter planting is more successful than rain planting. Pits dug 2 or 3 months in advance and the soil weathered. In Nilgiris, the area is burnt in April of the year following felling. To ensure good burn removal of slash should be restricted. In low lying or swampy ground, planting in mounds is desirable.

Spacing – For blue gum varies from 6’ to 9’ x 9’. 9’ x 9’ is better.

Subsequent tending – First one or two years frost protection is necessary for backward plants in hollows by cowls of grass or bracken. This should be done as soon as the N.E. monsoon rains stop and removed in March. Weeding necessary in 1st year. Interfering coppice should be cut back. First thinnings needed in 6th to 11th year.

System – Nilgiris and Palnis in Chennai – simple coppice 1 to 15 years rotation. Coppice with standards system was tried but abandoned owing to poor yield (coppice growth on 10 to 15 years rotation for blue gum may range from 100 to 150 tons per acre).

### ***Casuarina equisetifolia* (Beef wood)**

Family - Casuarinaceae

Vernacular name – Chowku, Savukku (Tamil & Telugu)

General description – A large evergreen tree with a straight stem and feathery foliage consisting of numerous long, slender, drooping, jointed, 6-9 angled leafless branchlets arising from rough, woody branches. The jointed branchlets, which are partly deciduous are green and function as leaves. In general appearance Casuarina resembles a feathery conifer.

Bark – Brown, rough, fibrous, exfoliating in longitudinal strips.

Wood – Very hard, much liable to crack and split used some times for poles and rafters, but chiefly for fuel for which purpose it is excellent. The purchasers on the Bombay coast also use it as fishing rod in boats.

Size – Under favourable conditions attains a height of 100’ and over. Trees of 131’ have been measured in North Kanara.

Leaf fall – Evergreen, pieces of the jointed branchlets, re shade throughout the year and in plantations from a thick layer on the ground.

Flowering – Ordinarily flowers twice a year from February to April and from September to October. Flowers are unisexual and are arranged in spikes. Fruits – Ripen in June and again in December. In Karwar, fruits from the 2nd flowering are said to be ripe by September to October. Globose woody cones 0.75” in diameter containing a number of winged achene’s each enclosing a solitary seed. The seed is light brown, terminating in a membranous wing, 0.2” to 0.3” long. Achenes very light about 2000 weighing one ounce, a gunny bag of 12 lbs fruits give 1 lb seeds. The seeds retain their viability for a few months and if well stored to some extent for a year, tests at Dehra Dun gave a fertility of 5% for seed kept one year but sown after 18 months the fertility was nil. Always desirable to use fresh seed. Trees on coast commence bearing seed when about 4 to 5 years old, the seeds are very liable to attack by ants.

Germination – Epigeous. In the nursery the germination is seen within 7 to 9 days. Growth is rapid in coastal regions and average height of 18” to 2’ being reached in the first season, i.e. when about 5 months (14th February to 15th July). Seedlings are very sensitive to drought and to excessive moisture.

Silvicultural characters – (a) Light – A strong light demander, suffering badly from suppression, (b) Soil – Requires well drained sandy soil, grows poorly in heavy soils and does not tolerate clay, (c) Water requirements – It is very sensitive to drought. On the coast it survives a long dry season, but this apparently due to the high water table in those areas, (d) Wind – Occasionally uprooted by wind or branches broken, but has relatively high resistance to monsoon winds. On the sea coast it is usually to plant up four rows closely as protection against winds, (e) Fire – Very fire tender. Removal of the fallen twigs which is common tends to lessen the damage from fire though it involves the removal of the only available source of organic matter in the soil, (f) Frost – Seedlings of tropical literal species are ordinarily frost-tender, but Casuarina is quite frost hardy, (g) Coppicing power – Generally poor but high stools sometimes produce vigorous shoots. Excellent coppice re-growth has been noticed on the seaside in North Kanara from trees which were 10 to 12 years old when felled. Vigorous shoots have been obtained from layering and coppicing in the East coast also, (h) Root suckers – Root suckers sometimes occur in profusion in coastal plantations, but this is not by any means universal, (i) Trees also reproduce by natural layers from the branches, (j) Actinomycetes nodules are characteristic of Casuarina. The nodular bacteria are known as the Frankia. They live symbiotically with the species and help nitrogenous nutrition. Where these are not present in sufficient numbers growth is habited and artificial introduction of the will be called for.

Natural regeneration – Distribution of seed effected, to some extent at least, by wind. The seed is produced in large quantities and it has been suggested that it has been carried by seed originally from Australia to Java. Borneo and other islands and hence to the coast of the Malay peninsula and Burma.

Natural regeneration by seeds is scanty or absent in the coast plantations of India, but in N. Kanara natural seedlings appears in large quantities in open space along the edge of old plantations towards the end of the monsoon. Natural reproduction is facilitated by the following factors:

- 1) Abundance of light
- 2) Porous sandy soil free from weed growth
- 3) Absence of heavy rain during germination and early life of the seedling
- 4) Sufficient moisture in the soil to prevent mortality from drought during the first two or three years
- 5) Absence of serious damage by ants and other insects as well as crabs

Artificial regeneration – All the most important Casuarina plantations are situated along the sea coast on the East and West of the Peninsula. Regeneration is by transplants 18” to 24” tall and about 9 months old.

Seed collection – Collection in September/October from 8-10 year old trees by shaking the branches.



Seed treatment – The ripe cones are evenly spread out in shade and covered with gunny bags. After 3 or 4 days the fruits dehisce and the winged seeds come out. The covering is then removed and the empty cones separated out. Healthy seeds are dark brown in colour with slightly yellowish wings.

Seed storage – Seeds sown soon after collection. If storing is necessary, this should be done in earthen pots after mixing the seed with wood ash and properly covered up to keep off ants.

Nursery – This consists of germination beds and pricked out beds.

Germination beds – These are bamboo mats held up through fashion on stilts in pools of water so as to keep off ants. Sand is filled to a depth of 9” to 1’ on the mat and Casuarina seeds sown in October/November. Regularly watered by means of rose cans. Germination starts after 5 – 10 days and is complete in three weeks. These germination beds may also be erected on the ground, but in this case the stilts are coated with tar.

Pricking out beds – When the seedlings are 4” to 6” high, i.e. about a month old, they are pricked out 4” apart in lines of 6” apart into ground nursery beds which are a little sunken. They are regularly watered every morning and evening. By monsoon the plants are 1½” to 2’ high.

Planting – The area is aligned and staked 12’ x 12’ by the last week of May or early June and the transplants put out as soon as the first showers of the monsoon are received. Along the sea coast three or four rows are planted at 6’ x 7’. During the rains the plants are liable to be bent and so they are tied on the stakes. During any long spells of dry weather during the rains and after the Cessation of rains, from October till the beginning of the rains, regular watering once a day is necessary. The cost of formation (during the first 2 years) is Rs.110/-, watering along accounting for Rs.85/-.

Early tending – No weeds on coastal sand; elsewhere weeding may be necessary. In the Padugais of Chennai, pruning is done when the crop is three years old, this extends upto 6½” height and consists in removing the lateral branches, with a slanting upward out leaving about 1’ from stem. After the pruning cattle are allowed to graze. Thus pruning is done here primarily to minimize damage from grazing animals.

Thinning – When planting is done to 6’ x 6’ thinning is necessary at 4 years age or even at 3 years. No thinning is prescribed in the Padugais, Karwar; 15 years rotation – thinning in the 5th and 10th years; 20 years rotation – thinning in the 7th and 14th year.

Pests and diseases – Ants carry off seeds. Where the damage is serious it is necessary to poison the seeds. Superficially copper sulphate may be tried. Spreading ashes over the beds has some preventive effect on ants and other insects Cricket (*Brachyypes achnatus*) another pest. They are destroyed by burning fires in the area at height. The crickets are attracted to the fire and get killed. In Mumbai, a fence of 3’ to 4’ high is put up around the nursery and cleaned 20 years wide. These insects cannot as a rule hopper the fence. *Arbela tetraoris*, the bark eating caterpillar and *Coelosterna scabrata* a longicorn, damage Casuarina, young plants in Madras have been much damaged by the grubs of the rhinoceros beetle; *Cryctes rhinoceres*. Burning all rubbish before planting has proved a check. Crabs nibble at the seedling. In Karwar nursery beds are raised on stilts in pools of water. These stilt beds, spread over with ash, give protection against crabs and ants.

More serious than alkali the root fungus, *Trichosporium vesiculosum* which appears to be favoured by excessive watering and congestion; thinnings commenced early and continued regularly have a checking effect. Leaving old stools increases chances of this attack. Hence stools are encouraged to be grubbed out by villagers. Insects the fungus attacks are dealt with by removing affecting trees and grubbing up the stumps, but even this is not fully effective.

Biological control by planting in mixture with other species like *Azadirachta indica*, *Inga dulce*, *Sapindus laurifolius*, *Eugenia jambolana*, *Anacarium occidentale*, *Pongamia glabra* and coconuts has been tried. These trees besides assisting in segregation are useful in attracting insectivorous birds, for in a dense Casuarina plantation bird life is remarkably scarce. *Loranthus* attacks Casuarina occasionally. Infected trees should be removed in thinnings.

Treatment – The species is managed under clear felling with concentrated artificial regeneration under rotation varying from 7 to 20 years. As an exception case, it is worked on coppice in parts of Mysore.

### ***Bambusa bambos* (Thorny bamboo)**

General – A large bamboo with bright green, fairly thick walled culms, attaining a height of 80 – 100 ft or more and a diameter produce quantities of thorny branchlets interlacing into a dense mass and rendering the culms difficult of extraction from the clump.

Distribution and habitat – Found throughout the greater part of India, except in the driest regions; particularly along river valleys and in other moist situations. It occurs in ravines near water in the sub-Himalayan tract of Kumaon, but has probably been introduced, it is not considered to be indigenous to the Indo-Gangetic plain or north of it, but is largely cultivated in northern India and elsewhere. It is abundant in the forests of the West Coast from North Kanara southwards, particularly on flat ground near rivers and streams. In Burma, it is common in parts of Pegu and Martaban, in the Moulms in neighbourhood and in the Salween and Thaungy in drainages, often along the banks of rivers. Somewhat scarce in lower Assam, Eastern Bengal and Chittagong. Probably found in its largest size and finest condition in the hills of the circars, especially about the Godavari on the hill ranges of the eastern and southern and southern scraps of the Mysore plateau and in the Nilgiris.

Flowering – Occasionally flowers sporadically but and is characterized by marked gregarious flowering. Flowers at intervals of 32 – 34 years. Requires more than 20 years for the clump to reach full bearing, but culms large enough to float timbers are produced in twelve years. Too heavy thinning results in bending or breaking of remaining culms.

### ***Dendrocalamus strictus* (Male bamboo)**

Family : Graminae

A densely tufted deciduous bamboo with strong thick walled or solid culms varying much in size according to locality, usually form 20 to 50 ft high and 1-3 inches in diameter. Culms glaucous green when young, losing their glaucous appearance in the second year and often yellowish when old. Branchlets from the nodes are ordinarily produced almost throughout the entire length of the culm; the lower few nodes often produce rootlets. In dry localities, on poor soils, the culms, though small in size, are solid or nearly so, whereas in more fertile localities, although they reach larger dimensions, they are, as a rule, hollow. Extensively, used for building, furniture, lance shafts, walking sticks, mats, basket work, axe handles and numerous other purposes. Best known, commonest and most widely distributed of all Indian bamboos, occurring in deciduous forests throughout the greater part of India, except in northern and eastern forests throughout Burma. Found typically on hilly country, ascending to 3500 ft and occurring gregariously, sometimes almost to the exclusion of tree growth, but usually forming understorey to or mixture with deciduous trees, not uncommon in certain type of sal forests in hilly country. Abundant in many parts of Siwalik tract and outer Himalayan from the Punjab eastward to Nepal, occurring most plentifully between the Ganges and Ramganga rivers. Also common in most of the hilly parts of the Indian Peninsula, except in the very moist regions. In Burma, typical of drier types of upper mixed deciduous forest with or without teak, also extends into 'Indaing' (dry dipterocarp) forests. Hardest of all Indian bamboos, thriving in regions suffering, periodically from excessive drought. With its habitat, is forest hardy.

Phenology – Commonly flowers sporadically, in isolated clumps or in small groups, almost every year, also flowers gregariously over large tract at long intervals – the gregarious flowering usually taking some years to complete – end often progressing in a definite direction in successive years. Actually it is difficult to distinguish between sporadic flowering on a plentiful scale and gregarious flowering – there being all stages between the two.

Flowers, in dense globular heads, appear from November to February, the ripe seeds fall from April to June according to locality. 800-900 seeds to an oz. In years of abnormal drought, flowering and fruiting may occur earlier. Old leaves fall, as a rule, from December to March and new foliage appears from April to June. New

culms are produced in rainy season, in northern India, they do not, as a rule, attain full length until September, but further south they develop earlier. In years of favourable rainfall, as many twenty new culms may be produced from fair sized clumps.

### ***Albizia lebbeck* (Siris)**

Family : Mimosaceae

Natural habitat is difficult to determine. Has run wild – Himalayan valley and sub-Himalayan tract. Bengal, Chota-Nagpur, Peninsula, Burma and the Andamans upto 4000’.

Leaf fall – North India : October – November, Elsewhere from December end to February

Leaf renewal – April or early March Flowering – April and May

Fruiting – Full sized by August, ripen by December or January. Ripe pods hang on till blown about by wind in March and later. A light demander but is a moderate shade bearer in seedling stage. Not exacting as to soil. Root system largely superficial and therefore not wind firm – as a rule does not produce root sucker – may do so if roots are exposed and injured. Seedlings frost tender. Coppices fairly well.

Natural regeneration – 400 pods to the lab, 350 clean seed to the ounce collected in February from tree. Pods dried in the sun until they open. Seeds also dried in the sun. Stored in gunnies, seeds sown direct thickly in lines 6’ apart in May preferably after soaking in water for 48 hours which increases germination percentage.

Nursery – Sown in February 3” apart or broadcast thinly, cover seeds with leaf mould. Germination 80%. Commencing in 4 days is complete in 2 months. Weeding and watering is required. Not pricked out in the nursery. Planted out with a handful of earth round the roots in early July of the 1st rains when about 1’ – 6’ high.

Tending – Fast growing and so requires very little of early tending.

### ***Albizia procera* (Safed siris)**

Through the sub-Himalayan tract from Jamna eastwards, Assam, Bengal Chota Nagpur, Peninsula, etc.

Climate Maximum temperature - 98o to 115oF

Minimum temperature - 30oF to 65oF

Rainfall - 40” to 200”

Leaf shedding – Leafless for a short time between April and June

Leaf renewal – Soon after leaf fall

Flowering – Fruit from October to January, ripen for February to May, falls during the hot season viable for at least a year, germinate readily.

Silvicultural characters – A light demander, stands moderate shade in young. Fairly drought resistant, is affected by very severe frosts. Throws up root suckers when tree is felled and coppices fairly well.

Natural regeneration – Far more satisfactory than *A. lebbeck*, abundant along streams and on alluvial ground.

Artificial regeneration – 550 to 680 seeds to the oz. Pods collected from the trees – dried in the sun till pods open – seeds obtained by hand or by thrashing – soaking seeds in hot water immediately before sowing quickens and increases germination, stored in sacks in dry ventilated shed.

Sowing – Direct sowing in lines 6’ apart has given excellent results – May – June. In nursery sown in May germination in 3-4 days and continued up to 3 weeks, 70% germination.

Planting – If sown in May plants are 5” to 6” in July and ready for planting out, transplant entire with or without earth on wet days – direct sowing cheapest – stump planting with one or two year old nursery stock has given cent per cent success and is very useful for filling blanks.

***Anogeissus pendula***

Family- Combretaceae ; Vernacular names- Button Tree, Dhaura, Dhau, Dhoy

This is genus of trees native too South Asia,

It is moderate size tree with small leaves which fall early in the dry season. Leaves are up to 3cm appear in nearly opposite pairs. Tiny yellowish green flowers occur in spherical heads about 1cm wide.

Flowering – June to September

Fruiting –