
# Nitrogen Fixing Trees Highlights (Winrock, 1990-1997, 100 p.)

- *(introduction...)*
- Acacia koa - Hawaii's most valued native tree
- Acacia leucophloea - shade and fodder for livestock in arid environments
- Alnus acuminata: valuable timber tree for tropical highlands
- Albizia saman: pasture improvement, shade, timber and more
- Casuarina junghuhniana: a highly adaptable tropical casuarina
- Enterolobium cyclocarpum: the ear pod tree for fasture, fodder and wood
- Erythrina variegata: more than a pretty tree
- Inga edulis: a tree for acid soils in the humid tropics
- Pithecellobium dulce - sweet and thorny
- Pterocarpus indicus - the majestic n-fixing tree
- Robinia pseudoacacia: temperate legume tree with worldwide potential

- Acacia nilotica - pioneer for dry lands

## Gleditsia triacanthos - honeylocust, widely adapted temperate zone fodder tree

**Well known as an ornamental street tree, honey locust was widely advocated as a livestock feed early in the 20th century. Silvopastoral cultivar development began in the 1930's at the Tennessee Valley Authority in the United States. Because it can provide a source of fodder, protein, energy, and erosion control, honey locust is being tested in many temperate, Mediterranean and highland tropic regions of the world.**

### Botany

**Gleditsia triacanthos L., family Leguminosae (subfamily Caesalpinioideae), attains a normal height of 15-25 m and 0.51.0 m diameter (maximum height 50 m, diameter 1.8 m). Trees have a short bole and open, narrow or spreading crown with reddish brown to black scaly ridged bark, often covered in clusters of large, branched thorns. Leaves are 10-20 cm long, deciduous, pinnate or bi-pinnate with 15-30 leaflets, 1-3 cm long (Harrow et al, 1996). Flowers are a pale-yellow to greenish-yellow color and appear from early May in the southern United States to late June in the north. Seeds are 0.5 to 1.5 cm long, dark brown in color, smooth, with a hard, impermeable seedcoat. Seeds ripen from mid-September to late October in the United States. Mature pods begin to drop by mid-September and continue to drop throughout the winter.**

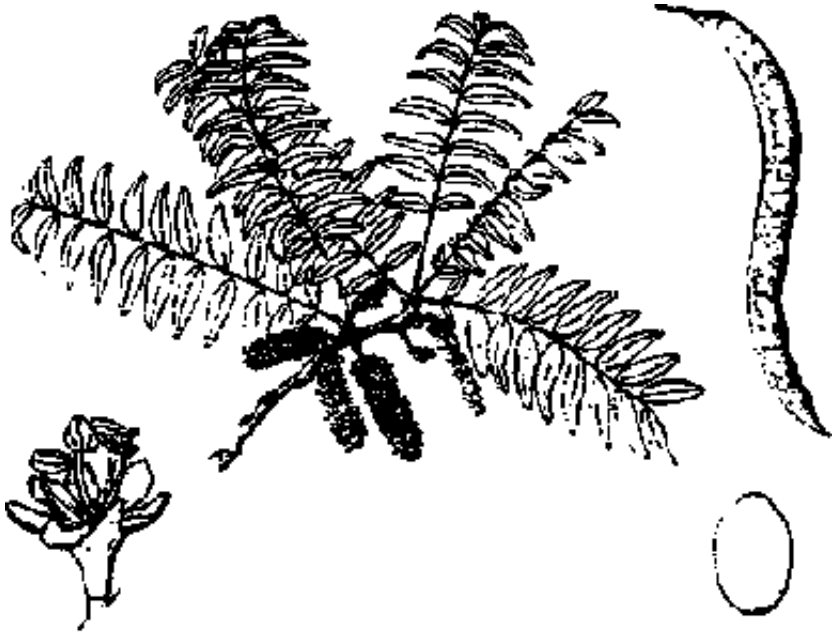
### Ecology

**Within the natural range, a large amount of variation exists in both climate and soil conditions. Honeylocust occurs naturally in humid and subhumid climate regions. Average annual precipitation varies from 510 mm to 1520 mm, the frost-free period varies from a minimum of 150 to 300 days (Blair, 1990). Honeylocust grows naturally to 760 m but has been planted from sea level to 1,500 meters in temperate latitudes and will grow above 2,500 m in subtropical highlands.**

**Honeylocust is a shade intolerant tree, and will only become established in openings. It has a strong taproot and profusely branched root system. Its best growth in the United States is found on deep soils (pH 6.0 to 8.0) in moist, alluvial floodplains between 35° and 40° N. latitude. It generally grows poorly on gravely or heavy clay soils and often fails on shallow soils (Blair, 1990). Honeylocust is resistant to both drought and salinity, and coppices vigorously when cut.**

**Distribution**

**Honeylocust grows naturally in the eastern half of the United States (Blair, 1990). It has become naturalized east of the Appalachian mountains from Georgia to New England in the East, and north to South Dakota in the West (Harrow et al, 1996). As a fodder tree, Honeylocust is being tested in France, Spain, Germany, Greece, Algeria New Zealand, Australia South Africa India Bhutan, Nepal and Guatemala (Wilson, 1993).**



*Leaves, inflorescences, seed pod, seed and flower.*
Source: M. A. Gold

**Gleditsia triacanthos**

## Uses

## Silvopastoral Agroforestry.

**Honeylocust pods have long been recognized for their animal fodder value in silvopastoral systems (Scanlon, 1980). Widely spaced overstory fodder trees (fodder orchard), can be planted for on-farm silvopastoral systems, providing light shade, soil enrichment and stabilization, and should be compatible with a variety of forage, grain, vegetable, woody perennials or animals in the understory. In addition to yields from understory enterprises, the pods function primarily as a late fall/winter animal feed supplement (Wilson, 1993). In France, results from sheep feeding trials using pods as a feed supplement indicate that selected grafted**

**clones produce high quality fodder and good weight gain (Dupraz and Baldy, 1993). Sheep are able to digest the majority of seeds within the pods. However, for complete utilization by sheep, cattle, horses or swine, pods and seeds must be machine processed.**

**Leaf Fodder.**

**Honeylocust leaves are an excellent source of fodder, contain 20 percent crude protein, low lignin and ensile well. Coppice regrowth retains high protein and low lignin levels (Baertsche et al, 1986). However, limited studies indicate very low biomass yield response when planted from seed and harvested with a forage harvester during the first year's growth (Gold. 1984) or when 1-year-old seedlings were coppiced (at age 2) after a full year for establishment and growth (Addlestone, 1996).**

**Wood.**

**Strong, hard and durable. resistant to shock, with attractive figure and reddish-brown color, it is used locally for fence posts, pallets, crating, general construction, railroad ties (Panshin and De Zeeuw, 1970) and by woodworkers for making guitars (A. Wilson, pers. comm). Wood specific gravity is 0.60 green, 0.67 ovendry (Panshin and De Zeeuw, 1970), and is considered an excellent source of fuelwood.**

**Ornamental.**

**It has been widely planted as an ornamental replacement for American elm in the United States and Canada with over fifty recognized cultivars (Santamour and**

**McArdle, 1983). Thornless trees can be produced by budding with scionwood taken from the thornless upper branches of selected cultivars. However, seedlings from such trees are thorny. Thornless seedlings can be selected at a very early age (within ten weeks of germination) for use as ornamental cultivars.**

**Windbreaks.**

**Honeylocust is hardy and drought tolerant, and can be-grown in windbreaks with the added benefit of pod production.**

**Silviculture**

**Propagation.**

**Mature pods can be collected after they drop off, by hitting branches to jar the pods loose, or by clipping pods from the branches. After harvest, pods should be stored at 0° C to prevent fermentation of the pods and. if bruchid seed weevils (Amblycerus robiniae) are present in the pods, it will prevent them from spreading within the pods. A good pod crop can exceed 20 kg of cleaned seed per tree. Results from a rangewide provenance/progeny test show that seed yield averages 5,200 seeds/kg (varying from 3,300 to 14,300 depending on the seed source) with high purity and soundness.**

**To prepare pods for mechanical seed extraction, place them in a convection/seed drying oven for at least 2 hours at 35° C. Honeylocust seed will remain viable for many years if stored dry at 1-4° C. Successful germination requires seed scarification via immersion in concentrated sulfuric acid (60 120 minutes followed by thorough rinsing), hot water (82°C), or by mechanical means. Germination of**

**sound seed should be in the range of 75-95 percent. Seeds should be sown.5 to 1.5 cm deep and if properly scarified, complete germination will occur within 21 days of sowing.**

**Establishment**

**For successful in propagation of honeylocust, chip budding with green wood in August works best, and June budding is also satisfactory. Dormant scionwood results in a low percentage of successful grafts (pers. comm. A. Wilson).**

**One-year-old seedlings (or budded/grafted material) can be outplanted the following spring. Dormant, nursery grown seedlings can be stored, barerooted, at about 0° C for several weeks before outplanting. Due to large variation in pod production from different parent trees, and the presence of both male and female trees, only grafted seedlings are recommended for planting in order to secure consistently high production at an early age. Grafted seedlings begin to bear pods at age three and by age eight will produce 20-75 kg dry weight per tree (Wilson, 1993).**

**Management**

**Male trees (about 10%) must be included in or adjacent to fodder orchards to ensure pollination of female trees. When established in working pastures,young trees need protection via plastic tree shelters or electric fencing (Wilson, 1993).**

**Appropriately managed, average annual pod production at age 10 of 40 kg/tree appears feasible. Planting 75 trees/ha (excluding male trees) would yield 3,000 kg/ha, sufficient to provide 100 sheep a 1.5 kg ration of pods for 20 days. Using**

**conservative yield estimates from grafted trees, economic analyses indicate internal rates of return varied from 9 - 13% (Wilson, 1991).**

## Symbiosis

**Typical of many caesalpinioid genera. Gleditsia triacanthos do not nodulate and lack an ability for symbiotic fixation of atmospheric nitrogen (Allen and Allen, 1981).**

## Limitations

**Thorns on mature trees (twigs, branches and bark) are extremely dangerous as they can puncture tractor tires and injure livestock and increase the difficulty of orchard/windbreak management. Volunteer reproduction of thorny seedlings, usually derived from seeds eaten and not digested by wild and domestic animals. is also a concern. The mimosa webworm, Homadaula anisocentra is a serious defoliant and heavy infestations of spider mites (Eotetranychus multidigituli) occur during dry weather and can also defoliate a tree (Blair, 1990).**

## Research

**Research needs include additional production data from silvopastoral systems, development of consistent, heavy bearing, genetically thomless, high protein cultivars for a range of sites and end uses; and development of high sugar varieties for ethanol production (Gold and Hanover, 1993).**

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**A complete set of references is available from FACTNet**

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- Erythrina edulis: multipurpose tree for the tropical highlands
- Erythrina sandwicensis - unique Hawaiian NFT
- Hippopha rhamnoides: an NFT valued for centuries
- Leucaena diversifolia - fast growing highland NFT species
- Leucaena: an important multipurpose tree
- Olneya tesota - a potential food crop for hot arid zones
- Honey mesquite: a multipurpose tree for arid lands
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## Andira inermis: more than a beautiful ornamental tree

**Andira inermis (Sw.) Kunth ex DC (Berendsohn 1989) is a nitrogen fixing tree that is commonly grown as an ornamental. It has a handsome spreading crown, evergreen foliage, showy pink flowers and responds easily to management. In El Salvador it is known as almendro de rio or river almond because its fruits are similar to the fruits of Terminalia catappa (beach almond). Andira inermis is a multiple use tree that has not been extensively used in agroforestry or other reforestation programs because of relatively slow growth rates; however, it offers refuge for wildlife year-round and could be used as fodder for ruminants and other domestic animals.**

### Botany

**This tree is a legume that belongs to the Papilionoideae subamily. It grows to 35 m in height and more than 90 cm in diameter (Allen and Allen 1981, personal observations). It has pink flowers in racemes that are self-incompatible and outcrossers (Bawa 1974). It has a dense and spreading crown with bright tan young leaves and shiny green mature leaves with entire margins. Leaves are pinnately compound with 7 to 17 leaflets. The stem has a rough outer surface. It**

**has a drupelike fruit with one seed that does not open at maturity, an exception among the legumes (Witsberger et al. 1982, Little and Wadsworth 1964). In the Pacific plains of Guatemala, the trunk frequently forms buttresses up to 3 m tall (Standley and Steyermark 1964).**

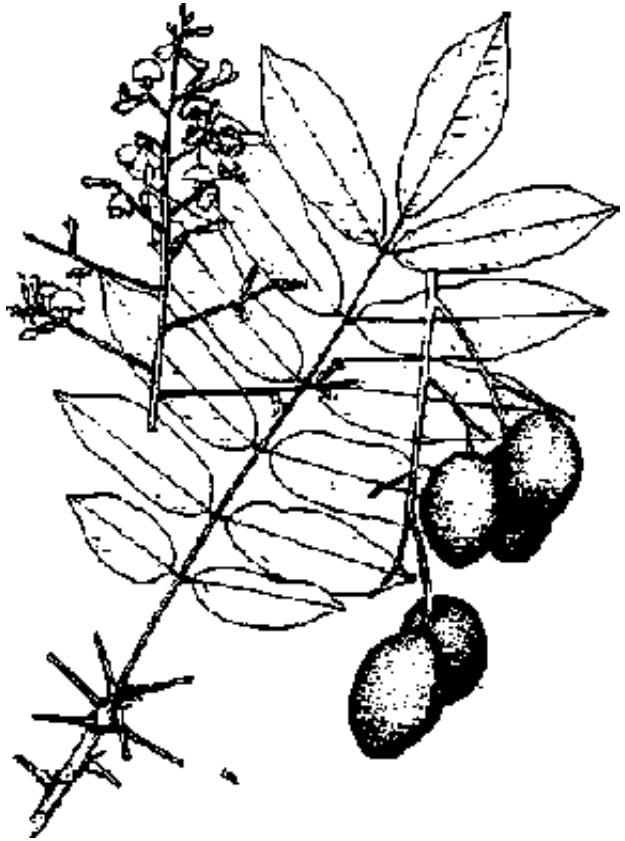
**Synonyms include Andira jamaicensis (W. Wright) Urban and Geoffroya inermis W. Wright (Little and Wadsworth 1964).**

**The number of common names that Andira inermis has is related to its widespread distribution, many uses and botanical characteristics. Names include Almendro de rio (river almond) and amendro macho in El Salvador, Guacamayo in Honduras, came asada in Costa Rica, moca blanca in Puerto Rico, and cabbage angelic, partridge wood or cabbage bark in the United States (Witsberger et al. 1982, Little and Wadsworth 1964).**

**Ecology**

**Andira inermis is found in riparian zones, along rivers and in areas with a high water table. It grows in alluvial forests in Central America but may be found in drier areas. It is found along roadsides, river banks, woodlands and pastures, from sea level to 900 m above sea level (Witsberger et al. 1982, Little and Wadsworth 1964). It requires low light for establishment and high light for development. It is an evergreen tree with the foliage continually being replaced throughout the year, especially before flowering (personal observations). In Puerto Rico, two flowering seasons are observed, one between January and February and the second one, between May and September (Little and Wadsworth 1964). In Barro Colorado Island, Panam, trees may flower for nine months under suitable moist conditions**

**(Croat 1978). This pattern is also observed in trees growing in urban areas in El Salvador where trees flower between December and July (personal observations).**



**Andira inermis. From: Witsberger et al.1982**

## Distribution

**Andira inermis is native from southern Mexico to Peru, Bolivia and Brazil. It has been introduced in the Antilles, Caribbean islands, Florida and Africa (Witsberger et al. 1982).**

## Uses

**Landscaping.**

**Planted in parks and yards Andira inermis is a very attractive tree with a dense, spreading crown. showy pink flowers and bright colored leaves.**

**Agroforestry.**

**It is used as a shade tree in coffee plantations because it has a spreading crown and responds well to pruning (Witsberger et al. 1982).**

**Wildlife.**

**Bats eat the fruits. Flowers are visited by bees, birds, and butterflies (Allen and Allen 1981; Janzen 1976; Little and Wadsworth 1964).**

**Forage.**

**Preliminary studies by scientists at the University of El Salvador showed that the foliage is edible and palatable for ruminants. Research is now being done with rabbits (Jacob Palacios, personal communication).**

**Wood.**

**The wood is very hard, heavy (0.77g/cm$^3$), and very resistant to attack by fungi and termites (Guzmn 1947; Little and Wadsworth 1964; Behrendt et al. 1968; Allen and Allen 1981). Andira inermis lumber has been used for bridges, railroad tracks and waterfront docks and also to make furniture, billiard-cues, umbrella handles and boats (Little and Wadsworth 1964).**

**Other uses.**

**The bark is reported to have vermifuge, purgative and narcotic properties (Guzmn 1947). Prunings from shade trees in coffee plantations are good firewood. In the wild, this tree also offers a suitable environment for some plant epiphytes like orchids, bromeliads, mosses and ferns. In conservation programs, it has been used to restore degraded watersheds where moist conditions are prevalent (El Salvador Forest Service, personal communication).**

**SIlviculture**

**Propagation.**

**Mature fruits are collected and kept under cool conditions. The hard seeds need to be scarified before planting. The El Salvador Forest Service recommends making a cut on the hard fruit endocarp with a file and then planting them in seed beds or plastic bags.**

**A recent seed treatment study for A. inermis compared seeds that were scarified with a file; placed in hot water at two temperatures (70°C and 80°C) for 5, 10, and 15 seconds; or non-treated (Navarrete and Orellana, unpublished).**

**Seeds started to germinate at week five. Maximum germination for all treatments was observed at week 16. Germination was 43% to 56% for all treatments. The lowest germination recorded was 43% and 46% from seeds at 80°C for 15 seconds and non-treated control, respectively.**

**Establishment.**

**One-year-old plants, 50 cm tall or more, can be transplanted during the rainy season. Andira inermis can also be direct seeded. Two or three seeds, per site, are planted directly in the field (El Salvador Forest Service, personal communication).**

**Management.**

**In the field, little or no management is done. Occasionally lower branches are pruned to induce faster growth and a straight trunk. In landscaping, top branches are pruned to control height growth.**

**Syrmbiosis**

**Allen and Allen (1981) reported nodulation of A. inermis in Hawaii. In Brazil, Faria et al. (1987b, 1986) found that A. inermis and six more Andira species showed nitrogenase activity with the acetylene reduction assay. They also report that isolated rhizobial strains showed an infective-host range within the cowpea miscellany.**

**Limitations**

**Andira inermis does not grow well in areas with a marked dry season. It grows very slowly even with suitable moist conditions (Little and Wadsworth 1964). Bark and seeds are reported to be poisonous (Guzmn 1947).**

**Processed wood is attacked by borer insects when used under saltwater (Behrendt et al. 1968). Fruits are attacked by the weevil, Cleogonis sp. (Janzen 1976) with possible effects on seed germination.**

## Related Species

**There are approximately 30 Andira species distributed in Tropical America and one in Africa (Pennington 1995). Some important species in Brazil are A. racemosa Lam., A. fraxinifolia, A. nitida Mart, A. frondosa, A. legalis and A. anthelmia (Vell.) Macbr. (Faria et al. 1987a, 1987b, 1986). Andira galeothiana Standl. and A. vermifuga Mart. are used as fish poison, vermifuge, narcotic or vomiting agents. Andira retusa HBK and A. inermis yield the alkaloids berberine and angelin. Andira araroba, is the source of a fungicide (chrysarobin) used to treat skin diseases (Allen and Allen 1981).**

## Research Needs

**Studies are needed to determine the amount of nitrogen Andira inermis provides to crops in agroforestry systems. Provenance and propagation studies are also needed.**

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## Erythrina poeppigiana: shade tree gains new perspectives

**Erythrina poeppigiana (Warpers) O.F. Cook is a leguminous tree used in several agroforestry systems in Tropical America including shade for coffee, cacao and pastures, living fence posts, forage and fuel wood. It is also a promising species for alley cropping and mulching. Ease of management, high biomass production, nitrogen fixation and multiple uses make E. poeppigiana a suitable tree for farm and community forestry. It is known as "cmbulo" or "barbatusco" in Colombia,**

**"bucare" or "cachimbo" in Venezuela, "amasisa" in Peru, "por gigante", "por de sombra" or simply "por in Costa Rica, "pito" in Guatemala and Honduras, and "immortelle" or "mountain immortelle" in the West Indies; the more formal English name is "coral tree". (Holdridge and Poveda 1975; Russo 1993).**

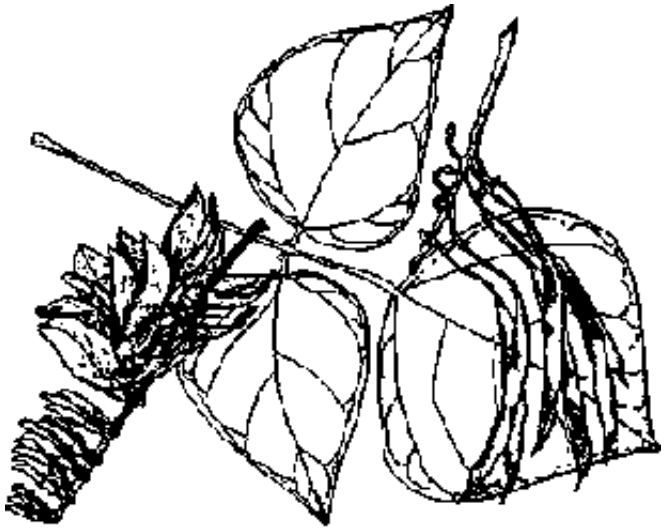
## Botany

**Erythrina poeppigiana belongs to the family Leguminosae, subfamily Papilionoideae, tribe Phaseoleae (Neill 1993). It is a large tree, growing to 35 m in height and 2 m in diameter. The crown is moderately spreading and the bole of large trees tends to be branchless below 10 - 20 m. The bark is grayish brown or gray, with thorn-like protuberances. Leaves are alternate, trifoliolate. The rhomboid-oval or oval foliates are 15 - 25 cm long and generally larger in saplings than in big trees. Glandular stiples below the paired lateral folioles are large and cupshaped. Orange or reddish flowers are produced in racimes. The upper petal is wide and open. Erythrina poeppigiana is pollinated by perching passerine birds. The pods are 10 - 25 cm long. Seeds are brown, about 2 cm long and slightly curved. There are about 4,500 seeds per kg.**

## Ecology

**Erythrina poeppigiana is native to humid and subhumid tropical lowlands, but cultivated and naturalized trees now are found to 2,000 m elevation (Holdridge and Poveda 1975). The average annual rainfall in its native and naturalized range is between 1,000 and 4,000 mm. In subhumid areas, it tolerates a 5 - 6 month dry season. Erythrina poeppigiana tolerates low soil fertility and relatively high acidity (down to pH 4.3), however tolerance varies by genotype (Perez Castelln 1990).**

**In Costa Rica, the phenology of unpruned E. poeppigiana shifts from evergreen to deciduous along a rainfall gradient from the humid lowlands to the sub-humid mountains. The leafless period is quite short, and possibly caused by flowering rather than drought (Borchert 1980). A visible reduction of foliage during the flowering (December - January) also occurs under humid conditions. Pruning trees periodically will prevent complete leaf fall, and pruning trees once-a-year is enough to impede flowering (P. Nygren, pers. obs.).**



*Source: Little and Wadsworth 1964*

**Erythrina poeppigiana**

## Distribution

**Erythrina poeppigiana is native to riverine and upland forests of the Amazon and Orinoco basins from Venezuela to Bolivia, and the moist Pacific forests of Ecuador and Colombia It was introduced to Central America and a number of Caribbean Islands in the 19th century, and it has been widely naturalized in some areas like Costa Rica and Trinidad (Neill 1993).**

**Uses**

**Shade.**

**Planted as a shade tree in cacao plantations in the humid tropics, E. poeppigiana conserves soil and contributes to high and sustainable cacao yields (Beer et al. 1990). Shade trees are partially pruned or not pruned at all. Production of Nrich litter (2.3 - 2.6%, Nygren 1995) is abundant, and the N supply in litterfall exceeds several times the export of N in the cacao harvest (Escalante et al. 1984).**

**In coffee plantations in Costa Rica, E. poeppigiana is usually pruned completely and lopped to a height of 2 - 3 m twice-a-year to promote coffee flowering and ripening of berries. The N supplied through pruning residues left on the ground fulfills the recommended N application rate for Coffee in Costa Rica (Beer 1988). Farmers plant E. poeppigiana at spacings of 8 x 8 m and 6 x 6 m for unpruned and pruned trees. respectively.**

**Mulching alley cropping.**

**The green leaves of E. poeppigiana contain 4.1 - 4.9% nitrogen (Perez Castelln 1990), which makes it an excellent species for green manure production. A ten-year experiment in Costa Rica measured the effects of cutand-carry mulching with 20 tons/ha of E. poeppigiana fresh matter on maize and bean yields in a sequential cropping system. Crops were harvested once-a-year and production was good compared to local on-farm production. Crop production also increased each year of the experiment. The same experiment in Costa Rica evaluated alley cropping E. poeppigiana with maize and beans. Although satisfactory and sustainable for 10**

**years, the maize yield in this experiment was lower than the maize yield in the mulching experiment. The bean yield in the alley cropping system was both high and sustainable (Haggar et al. 1993). In a separate experiment in Costa Rica, E. poeppigiana alley cropping also sustained two maize crops per year over eight years without fertilization. Soil carbon and nitrogen pools creased, but 50% less than in fertilized control plots Dominique 1994).**

**For alley cropping, E. poeppigiana should be planted in dense hedgerows (I - 2 m between trees), with wide alleys (6 8 m) between tree rows (Kass et al. 1993a; Nygren and Jimnez 1993).**

**Forage.**

**The green leaves of E. poeppigiana have a good nutritive value (20 - 22% of dry matter), are high in crude protein (27 - 34%) and have a good range of in vitro digestibility (49 - 57%). However, due to the high cell wall content (55 - 58%), they should be supplemented with energy sources, e.g. tropical grass, which are readily degradable in the rumen (Kass et al. 1993b). The presence of potentially toxic alkaloids in the leaves of E. poeppigiana has not affected the health of cattle or goats, but feeding leaves to non-ruminants may be risky (Kass 1994).**

**Other uses.**

**The wood is light, with low calorific value but it is sometimes used as fuel wood (Russo 1993).**

**Silviculture**

**Propagation.**

**The seeds of E. poeppigiana may be stored for several years in tightly closed containers in a cool, dry place (ca. 5 °C, 30 - 40% relative humidity). Immersion in water at room temperature for 24 h enhances germination. The germination rate is about 70%. Germination takes 5 - 15 days. The seedlings may be planted in the field when they are 20 - 30 cm high (3 - 4 months), preferably at the beginning of rainy season. The seedling survival is generally good, but weed control may be necessary during the first year to enhance growth (Vquez and Camacho 1993; P. Nygren pers. obs.).**

**Air-layering to establish rooted cuttings yields a survival rate of 83% in vegetative propagation of E. poeppigiana. The roots appear about 6 weeks after air-layering. The leaves must be removed before planting, and the top cut made at a 45° angle and sealed with paraffin. Unrooted cuttings should be long (> 1.5 m). Stakes from lower and middle sections of one-and twoyear-old branches give best results. Cuttings are planted at a depth of 30 cm. Inoculation of seeds or cuttings with Bradyrhizobium bacteria is not generally required in and Camacho 199,: P. Nygren pers. obs.). However. inoculation is recommended when introducing the species to new areas.**

**Management.**

**A formation pruning is recommended about 4 - 6 months after planting to remove the lowest branches. Normal pruning management may start 9- 12 months after planting. Tall crops should not be associated with E. poeppigiana before the first complete pruning, but low crops may be planted at the time of the formation**

**pruning. Coffee and cacao may be planted together with the trees. Due to the slow recovery of carbohydrate reserves, pruning of E. poeppigiana more often than twice-a-year causes the risk of debilitation and turnover of trees within a few years (Nygren et al. 1996).**

**Symbioses**

**E. poeppigiana nodulates abundantly with nitrogen fixing bacteria of genus Bradyrhizobium; peak values exceeding 1,000 kg/ha of nodules were reported for unpruned cacao shade trees, but during the driest season nodulation dropped to nil (Escalante et al. 1984). Globular nodules are formed in the site of lateral root emergence. and they have never been observed deeper than 10 cm. (Holdridge and Poveda 1975; Neill 1993; Vquez and Camacho 1993; P. Nygren, pers. obs.). Soil acidity does not impede nodulation, but differences in the efficiency of bacterial strains were detected in a soil with 50% aluminum saturation (Gross et al. 1993). Pruning causes a complete turnover of nodules, and renodulation initiates about 2.5 months after pruning. After initiation, 66-180 kg/ha of nodules may be produced in a month (Nygren and Ramrez 1995).**

**Vesicular-arbuscular mycorrhizae improve nitrate uptake efficiency of unnodulated seedlings (Cuenca and Azcn 1994).**

**Limitations**

**Adult June beetles (Phyllophaga menetriesi, Coleoptera: Scarabaeidae) teed on young leaves of E poeppigiana. Because June beetles lay eggs close to foraging areas, the root-eating larvae are a potential risk for associated crops (Hilje et al.**

**1993). Only minor damage to maize alley cropped with E. poeppigiana has been observed (D. Kass. pers. obs.). but the pest problem requires further investigation.**

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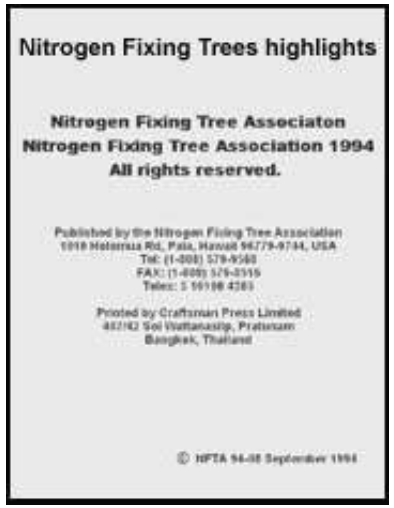


# Nitrogen Fixing Trees Highlights (Winrock, 1990-1997, 100 p.)

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- Acacia senegal: gum tree with promise for agroforestry

# Albizia procera - white siris for reforestation and agroforestry

**Albizia procera is a large, fast-growing tree that occurs on many different sites. Like other Asian Albizias, it occurs in forests and savanna woodlands but prefers moister sites than its relatives. This species provides wood for a variety of purpose nutritious fodder for livestock and shade for tea plantations. It is an important reforestation and agroforestry species. It is commonly called white sins or tall albizia and has many regional names.**

*Source: Little and Wadesworth, 1964*

**Albizia procera**

## Botany

**Albizia procera (Roxb.) Benth is usually 60-70 cm in diameter and 25 meters in height. Troup (1921) reports trees as large as 95 cm in diameter and 36 meters in**

**height. Mature individuals are characterized by a tall clear, erect, so curved trunk and large branches which form a thin, spreading crown The bark is nearly smooth, whitish to light-greenish gray or light brown It exfoliates in thin flakes with red undersides (Troup 1921). Lateral roots are wide-spreading and the taproot stout The bipinnate leaves, reddish when juvenile, mature to a length of 12-25 cm; leaflets are 2 4 cm long and 8-16 mm wide.**

**Flowering varies by geographic location; January to March in Indonesia (Djogo 1992), June to September in India (Troup 1921) September in Manila (Hensleigh and Holaway 1988) and August to October in Puerto Rico (Parrotta 1987). Flowers are borne on racemes 8-25 cm long near the end of a twing.**

**Numerous greenish-yellow flowers form whitish heads 20-24 mm in diameter. Individual flowers, 6-7 mm long, have long white threadlike spreading stamens about 10 mm long (Little and Wadsworth 1964). The reddish-brown flat pods, 10-20 cm long and 18-25 cm wide, are produced in large numbers and ripen 35 months after flowering The mature brown pods, each containing 6-12 seeds, usually remain on the tree until the twig bearing the pods is steed (Troup 1921, Little and Wadsworth 1964). The natural regeneration of white siris is generally good. Following the beginning of the rainy season large numbers of seedlings are common near mature trees. Seedlings, saplings and mature trees coppice vigorously from stumps and roots (Parrotta 1987).**

## Ecology

**White siris is a component of tropical and subtropical moist and wet forest type-c where rainfall is 1000-5000 mm/yr. It develops best when rainfall is above 2500**

**mrn/yr. Growing to elevations of 1200 meters, the species is also common on moisture savannas and swamp forests. In its natural habitat, maximum vary from 37-46° C and minimum temperatures from 1-18° C. Once established white siris is drought tolerant. It is susceptible to frost (Troup 1921, Djogo 1992).**

**Like many nitrogen fixing trees, white siris survives on a variety of soils. It grows best on moist alluvial soils, welldrained loams or clay soils (Brandis 1906, Venkataramany 1968). Its ability to grow on dry, sandy, stony, and shallow soils makes it a useful species for reforestation of difficult sites. Good survival and rapid early growth have been reported in afforestation trials on both saline and alkaline soils (Ghosh 1976). It doe not tolerate suppression, but will survive moderate shade between the seedling and small tree stage Venkataramany 1968).**

**In India, white siris is dominant to co-dominant in mixed deciduous forest or fauna as scattered individuals or in small groups in savanna woodlands (Benthall 1933, Bor 1953). In Puerto Rico, white siris is an aggressive pioneer, forming pure stands on abandoned farms and other disturbed sites It is also common in pastures at elevations below 600 meters, including areas receiving as little as 800 mm of annual rainfall.**

**Distribution**

**The native range of A. procera is South and Southeast Asia between latitudes 30 degrees N to 15 degrees S. The tree occurs naturally in India, Nepal, the the Adaman Burma, southern China, Laos, Thailand, Cambodia, Vietnam, Malaysia, the Philippines, Indonesia, Papua New Guinea, Melanesia and northern Australia (Nielsen 1979). It is naturalized in the Virgin Islands and Puerto Rico.**

**Uses**

**Agroforestry. Natural regeneration of A. procera is often encouraged on farms to provide small timber, fuelwood, charcoal, fodder or shade. Seedlings are planted in family forests or home gardens for the same purposes. Albizia procera can be cultivated as shade for tea plantations. However, Albizia odoratissima is preferred for this purpose because of its rapid early growth, fuller crown and resistance to red spidermites. The protein-rich fodder of A. procera is eaten by cattle, buffaloes, goats, camels and elephants in South Asia and the Philippines. However, the fodder is not utilized in Nusa Tenggara, Indonesia.**

**Wood.**

**Durable, strong and resistant to termites, the wood is fight- to cnocolate-brown with light and dark bands. It is difficult to saw due to interlocking grain and has a specific gravity of 0.60.9. The wood is used to produce wheels, carts, boats, furniture, flooring, posts, agriculture irnplements, boxes and carvings. This species is considered a promising source of pulp for high quality paper (Parrotta 1987).**

**Other Uses.**

**Trees are often planted for shade or beautification along roads Albizia procera is commonly used in traditional medicines Venkalarammany 1968). The bark contains tannins and a reddish gum Also, it can be used to make a poison. The leaves are used to treat ulcers and have insecticidal properties (Parrotta 1987). In the Philippines, the cooked leaves are eaten as a vegetable (Hensleigh and**

**Holaway 1988).**

**Silviculture**

**Propagation.**

**Seeds are small, greenish-brown, elliptical to round, flat and have a hard, smooth seedcoat. There are 20,00024,000 seeds per kilogram (Rosbetho 1997). Insect damage to seed is common in Indonesia (Djogo 1992) but not in India (Troup 1921). Fresh seed germinates readily without treatment (Parrotta 1987). Clean seed can be stored at room temperature for 10 months with minimal loss of viability (Roshetko 1997). Seed that has been stored should be treated before sowing; cut through the seedcoat with a knife or file, or soak seeds in boiled water for 3 minutes. After either treatment soak seed in cool water for 12-24 hour and sow immediately (Roshetko 1997).**

**In the nursery, seed should be sown in containers or beds Seedling growth is favored by loose soil sufficient soil moisture, full sunlight and the absence of weeds. Healthy seedlings produce a thick, long taproot After two months in the nursery containerized or bare-root seedlings should be transplanted to the field. Direct sowing of white sins is successful given abundant soil moisture and regular weed control (Troup 1921). Propagation is also possible by stem or root cutting and stump sprouts. Plantations should be weeded twice in the first year and once during the second. During weeding, soil should not be unduly exposed; only weeds directly interfering with seedlings should be removed (Venkataramany 1968).**

**Growth and Management.**

**In Bangladesh plantation trees have reached heights of 0.3 and 4.5 m in 1 and 5 years. In Burma 6-year-old trees average heights and diameters of 12.8 m and 16 cm, respectively. In Indonesia, 17-year-old trees average heights and diameters of 24.3 m and 22.4 cm, respectively. Total standing volumes of 87 $m^3$/ha have been reported in 8-year-old plantations Burma end of 151 $m^3$/ha in 17-year-old plantations in Indonesia Natural forests are managed for timber production by coppicing on a 40-year rotation. Fuelwood plantations are managed on a 20-year rotation (Venkataramany 1968).**

## Symbiosis

**Albizia procera forms symbiotic association with Rhizobium bacteria enabling it to fix nitrogen and thrive on infertile soils. The application of phosphorus fertilizer can improve nodulation and nitrogen fixation. particularly on infertile soils.**

## Limitations

**Because of its aggressive growth white siris may be a potential weed This is panicularly true in the Caribbean where white siris grows faster than many native species.**

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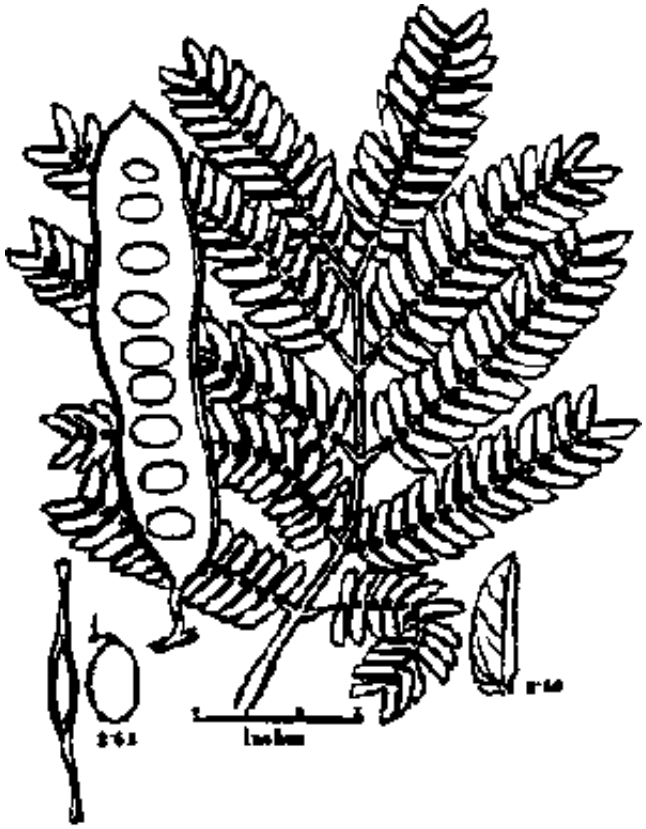
- **Hippopha rhamnoides: an NFT valued for centuries**

## Albizia odoratissima - tea shade tree

**Albizia odoratissima, Benth (Syn. Mimosa odoratissima, Roxb.) is a medium sized tree highly valued for shade and soil improvement in tea plantations of the Asian subcontinent. It is particularly popular in North-east India and Bangladesh. About 75% of total tea shade trees in Bangladesh are of this species (Sane 1989). On the subcontinent it is known as karuvagai, karmaru, bansa bilkumbi (Troup 1921), chamkoroi (Hasan 1963), tetua-koroi (Kamaluddin 1984), and kalasiris (Sane 1=989).**



Source: *Sena, 1989*

**Albizia odoratissima**

## Botany

**Albizia odoratissima Leguminosae, Subfamily Mimosoideae) is a multipurpose woody legume which btains a height of 22-26 m and diameter of 120-150 cm. On good sites five-year-old trees can be 5 in height and 14 cm in diameter. A mean annual diameter increment of 1.3 cm has been recorded for this species (Troup 1921). The bark is dark grey to light brown in color with horizontal lenticels The crown is relatively dense.**

**The dark green leaves are bipinnately compound, downy, with 6-9 pinnae and 16-20 pointed asymmetrical leaflets.**

**Flowers are corymbs, pale yellowish white, fragrant, and generally appear from March to June. Fruits appear in early August and start ripening at the end of October. The thin flat pods are 13-20 cm long and brown when ripe Hasan 1963, Sana 1989). Trees produce large amounts of pods each containing 8-12 seeds. Albizia odoratissima is deciduous, with a short leafless period from December to February. New leaves normally appear before the old ones have completely fallen Branching habit is uniform, but irregularities occur when the tree is damaged.**

**Ecology**

**Albizia odoratissima tolerates a wide range of temperatures an rainfall. In its natural range the maximum shade temperature varies from 37°-50°C and the minimum from 0°-15°C. Normal rainfall varies from 650-3000 mm with a dry season from November to March. It occurs from sea level to 1500 mete' (Troup 1921) and grows sporadically in both dry and moist deciduous forest zones.**

**Growth of A. odoratissima is best in deep, well drained sand soils (Sane 1989). The especies prefers soils with large amounts of organic matter. It tolerates hot humid conditions, but dot not tolerate water-logging. On poor soils growth ifs stunted Young plants are susceptible to frost. Albizia odoratissima i classified as moderately light demanding**

**Juvenile trees require shade. Trees coppice wed, shoots react ing a height of 3 meters in two years. It is susceptible to fire, but resistant to weed competition**

**and drought. It degenerates naturally in sheltered areas with good soil.**

**Distribution**

**Albizia odoratissima occurs naturally in Southern Chin' Burma, Peninsula India, and Tropical Africa. Under tropical conditions the species is not gregarious. It is frequently found on hill slopes and sometimes in valleys.**

**Uses**

**Shade.**

**Albizia odoratissima has been extensively planted as shade tree in tea and coffee e pantations The shade extends the productive life of crop plants and increases annual yield! Recommended spacing vanes from 6x6 to 12x12 m. Albizia odoratissima benefits tea and coffee production in many way' Its well developed mot system decreases erosion and utilizes the subsoil moisture and nutrients not available to tea and coffee plants. Through leaf litter, A. odoratissima provides organic matter and soil nutrients to the rhizophere of understory plants Tree canopies decrease soil desiccation, suppress weed growth and protect plants from hail and rain stones. Albizia odoratissima's presence in the tea monoculture reduces incidence of tea pests, particularly red spider mites and scalet mites. The shade also provides plantation laborers a comfortable working environment under otherwise hot tropical conditions.**

**Wood uses.**

**Albizia odoratissima produces valuable fuelwood Dead and defective branches**

**from shade trees are a major source of fuel for plantation laborers. The heartwood of mature trees is a beautiful dark brown color. The premium quality wood ifs suitable panelling and furniture. It is also used for carts, wheels, farm implements and construction timbers. Wood weight at 12% moisture content is 735 kg/cubic meter. The wood is 2040% stronger than teak (Anon. undated).**

**Other uses.**

**The pods of Albizia odoratissima are eaten by monkeys. The leaves are an excellent green manure and cattle fodder. Sana (1989) reports Albizia odoratissima contributed 16 kgs of nitrogen per hectare from 655 kgs of dry weight leaf liter.**

**Silviculture**

**Seed collection and handling.**

**Pods should be collected while on the tree immediately after they turn brown. Half-opened pods are also collected from beneath trees. Following collection, pods are dried in the sun for 5-7 days. Pods are then lightly pounded with a hammer to extract seeds. Extracted seeds are dried again in the sun for 3 4 days and then stored in bags under well ventilated dry conditions. If seeds are to be stored for a long period, they should be treated with a 5% DDT or Heptachlor dust at the rate of 100 grams per kg of seeds (Anon. 1988). There are approximately 21,000 seeds per kg To break dormancy seed can be soaked; a) in cool water for one hour, b) in 80°C water for two minutes, or c) in boiling water for 30 seconds. Removed from the water, moist seed is stored overnight and sown the following morning.**

**Seedlings emerge within a week Fresh seed may have a germination rue of 99%. Germination of year-old seed decreases to 55-65%.**

**Propagation.**

**Nursery production should be initiated in November or December 4-5 months before the planting season. Well drained sandy loam soil from beneath A. odoratissima trees is recommended far nursery use. If available, well decomposed compost should be mixed with the soil at a ratio of 1:3. Additionally, 500 grams each of triple super phosphate (TSP) and lime should be added to every cubic meter of nursery soil The use of large nursery bags ifs recommended to encourage growth of a deep taproot. In each nursery bag 2-3 seeds should be sown at a depth 5-20 mm and covered with a thin layer of sand Every two weeks seedlings should be fertilized with a well decomposed liquid compost or a standard phosphorus and potassium fertilizer. In large nurseries, 4-10 cm seedlings are sprayed every two wears for protection from insects and fungal diseases. Recommended spray contains 300 ml of malathion and 300 grams of copper oxychloride in 200 liters of water (Anon. 1988).**

**Albizia odoratissima is also established by direct seeding or stump cuttings. Far quick establishment, stump cuttings give the best results. Stumps are prepared in the late dormant season immediately before buds swell. Trees with stem diameters of 57 cm are appropriate far stumps. Selected trees are cut at a height of 1.5-2 meters and all the lateral branches are removed. It is best to select trees with few lateral branches below the 1 5-2 meter cutting height. Trees should have well developed roots. Carefully, expose the mot system to a depth of 90 cm. Sever the taproot at 80-90 cm and prune all lateral roots. Stumps should be planted**

**immediately in pits 90 cm deep and 75 cm wide.**

**Planting and fertilization.**

**At the beginning of the spring rains seedlings are ready far field planting. Seedlings are planted in pits 90 cm deep and 45 cm wide. They should be fertilized during planting. Recommended fertilization rates per seedling are 10 kgs of rotted cattle manure, 200 g TSP, 25 kg wood ash and 1 kg slaked lime. Components should be well mixed with the soil from the planting pit and replaced.**

**Fertilization of young shade trees improves tree growth and plantation production. For trees under 2.5 m height broadcast 300 grams TSP in a 1.5 meter diameter-circle around the tree. For trees up to 4 m height 333 grams TSP is applied to a 3 meter diameter-circle. Fertilization should be repeated three times per year, April, June and August (Anon. 1988).**

**Symbiosis**

**Through a symbiotic relationship with Rhizabium bacteria, Albizia odoratissima fixes atmospheric nitrogen. Under natural conditions seedlings generally bear abundant root nodules. For nursery production it is wise to use soil from under a stand of A. odoratissima. No quantitative data is available on the Rhizabium specificity of this species.**

**Limitations**

**Albizia odoratissima is prone to attack by caterpillars, root bares, and root diseases, particularly as a young tree (Barua 1989). Dieback, branch canker, and**

**red rust are also problems for young trees. Damping-off, a fungus infection, is common in poorly managed nurseries. In India, heart-rot of this species is caused by Ganoderma applanatum (tonne 1992). Albizia odoratissima sometimes produces uneven shade (Barua 1989) which causes management problems under plantation conditions.**

## Tree Improvement

**Tree improvement programs for superior canopy characteristics and resistance to insects and disease should be initiated. In Bangladesh improved planting stock is obtained from root suckers of select varieties Root cuttings of 1-2 cm diameter and 15-20 cm length are placed under heavy shade in a moist rooting bed. One-third of the root is exposed and two-thirds buried in the soil. Spacing between cuttings is approximate 2030 cm. Within a few weeks the stock is ready far transplanting (Anon. 1988).**

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**Dalbergia melanoxylon: valuable wood from a neglected**

## Adenanthera pavonina: an underutlized tree of the humid tropics

**Adenanthera pavonina (L.) (family Leguminosae, subfamily Mimosoideae) has long been an important tree in Southeast Asia and the Pacific Islands. Cultivated in home gardens and often protected in forest clearings and village common areas, this useful tree provides quality fuelwood, wood for furniture, food, and shade for economic crops like coffee and spices. The tree has been planted extensively throughout the tropics as- an ornamental and has become naturalized in many countries. The scientific name is derived from a combination of the Greek aden, "a gland," and anthers, "anther"; alluding to the aCircassianbeananthers being tipped**

**with a deciduous gland The tree is known by a host of common names, including red-bead tree, red sandalwood, and Circassian-bean in English; raktakambal (India); saga (Malaysia); lope (Samoa and Tonga); coralitos, peronias, and jumble-bead (Caribbean).**

**Botany**

**A medium- to large-sized deciduous tree, A. pavonina ranges in height from 6-15 m with diameters up to 45 cm, depending upon location. The tree is generally erect, having dark brown to grayish bark, and a spreading crown. Multiple stems are common, as are slightly buttressed trunks in older trees. The leaves are bipinnate with 2-6 opposite pairs of pinnae, each having 8-21 leaflets on short stalks. The alternate leaflets, 2.02.5 crn wide and 3 cm long, are oval-oblong with an asymmetric base and a blunt apex, being a dull green color on top and a bluegreen beneath. The leaves yellow with age.**

**Flowers are borne in narrow spike-like racemes, 12-15 cm long, at branch ends. They are small creamy-yellow in color, and fragrant. Each flower is star-shaped with five petals, connate at the base' and having 10 prominent stamens bearing anthers tipped with minute glands.**

**The curved pods are long and narrow, 15-22 cm by 2 cm, with slight constrictions between seeds, and dark brown in color turning black upon ripening. The leathery pods curve and twist upon dehiscence to reveal the 8-12 showy seeds characteristic of this species. The hard-coated seeds, 7.5-9.0 mm in diameter, are lens-shaped, vivid scarlet in color, and adhere to the pods. The ripened pods remain on the tree for long periods and may persist until the following spring.**

**There are reportedly 1600 seeds per pound (Little and Wadsworth 1964).**

## Ecology

**This species is common throughout the lowland tropics up to 300-400 m. Adenanthera pavonina is a secondary forest tree favoring precipitation ranging between 3000-5000 mm for optimal growth. Found on a variety of soils from deep, welldrained to shallow and rocky, this tree prefers neutral to slightly acidic soils. Initial seedling growth is slow, but rapid height and diameter increment occur from the second year onward. The tree is susceptible to breakage in high winds, with the majority of damage occurring in the crown. Rapid resprouting and growth following storm damage has been recorded in the Samoan Islands (Adkins 1994).**

## Distribution

**Adenanthera pavonina is endemic to Southeast China and India, with first reports being recorded in India The tree has been introduced throughout the humid tropics. It has become naturalized in Malaysia, Western and Eastern Africa and most island nations of both the Pacific and the Caribbean.**

## Uses

**There are historical accounts from Southeast Asia and Africa of using all parts of tree for traditional medicines (Burkill1966, Watt and Breyer-Brandwijk 1962). Adenanthera pavonina is extensively cultivated as an ornamental for planting along roadsides and in common areas. The fast growth and spreading crown of light, feathery foliage offer attractive shade. Interplanted field and tree crops (spices, coffee, coconuts), along field borders as part of a windbreak or in**

**plantation, A. pavonina is a valuable agroforestry species (Adkins 1994, Clark and Thaman 1993).**

*Source: Little and Wadsworth, 1964.*

**Adenathera pavonina**

**Wood Products.**

**Adenanthera pavonina is esteemed for fuelwood in the Pacific Islands, often being sold in local markets. The wood bums readily producing significant heat, and is used in both above- and below-ground ovens. Good sized fuelwood, larger than 11 cm in diameter, can be produced in five years. The wood is hard and durable having red-colored heartwood with light-gray sapwood. It is close-and**

**evengrained, making it useful for constructing furniture, cabinets, and decorative wood products (Benthall 1946, Clark and Thaman 1993). It is also valued for home building.**

**Seeds.**

**Known as "food trees" in Melanesia and Polynesia, the seeds of this tree are roasted over a fire and eaten by children and adults alike. Nutritional studies have shown one quarter of the seed weight to be oil with a high percentage of protein, and a fatty acid composition favoring high digestibility for both humans and livestock (Balogun and Fetuga 1985, Burkill 1966). Historically, the seeds were used as weight measures for jewelry and goldsmithing due to their small variation in weight (Benthall 1946, Burkill 1966). The bright red seeds are still used today in fashioning necklaces and decorative ornaments.**

**Foliage.**

**The small leaves breakdown easily making for good use as a green manure. As a supplemental source of fodder, the leaves are fairly high in digestible crude protein (1722%), but low in mineral content (Rajaguru 1990).**

**Silviculture**

**The tree is cultivated from seed. The seed coat is extremely hard and requires scarification if even germination is to occur. Untreated seeds can be stored up to 18 months without losing viability (Basu and Chakraverty 1986). Manual scarification, immersing the seeds in boiling water for one minute, or treatment with sulfuric acid has shown to significantly increase germination percentage.**

**Following treatment, seed can be directly sown in the field or in a nursery. Germination occurs within 7-10 days with young seedlings obtaining a height of 8-15 cm in approximately three months. Seedling maturity occurs two to three months later at 20-30 cm in height. Nursery stock transplants well.**

**Growth is initially slow, but increase rapidly after the first year. Following the first year of establishment, average annual growth rates of 2.3-2.6 cm in diameter and 2.0-2.3 m height have been recorded in American Samoa (Adkins 1994). Trees planted 1 x 2 m apart for windbreaks, and at a spacing of 2 x 2 m in plantations can be thinned in three to five years to provide fuelwood and construction materials. As a shade tree, spacing varies from 5-10 m depending on the companion crop and site. The trees resprout easily allowing for coppice management with good survival.**

**Despite an inability to suppress weeds, the seedlings are rather hardy and can survive with minimal maintenance. Adenanthera pavonina is compatible with most tropical field and tree crops, allowing for their usage in integrated production systems.**

**Symbioses**

**Although Allen and Allen (1981) indicate the inability of A. pavonina to nodulate, this legume is generally considered to be nitrogen-fixing. Sparse, fast growing, brown nodules with isolates confirmed to be Rhizobium have been observed by Lim and Ng (1977). The author observed root nodules, both in old nursery stock and in the field, during research conducted in American Samoa. Norani (1983) confirmed the presence of VA mycorrhiza on the roots of nursery stock.**

## Limitations

Despite its susceptibility to crown damage in high winds, the ability to recover is remarkable. No insect or disease problems have been reported.

## Research

Additional investigation concerning the nitrogen-fixing ability on native and naturalized populations is required. Continued research on fuelwood production and fodder usage is necessary.

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**FACT 96-03 June 1996**


## Nitrogen Fixing Trees Highlights (Winrock, 1990-1997, 100 p.)

- *(introduction...)*
- Acacia koa - Hawaii's most valued native tree
- Acacia leucophloea - shade and fodder for livestock in arid environments
- Alnus acuminata: valuable timber tree for tropical highlands
- Albizia saman: pasture improvement, shade, timber and more
- Casuarina junghuhniana: a highly adaptable tropical casuarina
- Enterolobium cyclocarpum: the ear pod tree for fasture, fodder and wood
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- Inga edulis: a tree for acid soils in the humid tropics
- Pithecellobium dulce - sweet and thorny
- Pterocarpus indicus - the majestic n-fixing tree
- Robinia pseudoacacia: temperate legume tree with worldwide potential

- Acacia nilotica - pioneer for dry lands

## Alnus acuminata: valuable timber tree for tropical highlands

**Alnus acuminata is a fast-growing species valued for its wood, watershed protection and soil improvement. Native from Mexico to Northern Argentina, it is known as alive (Mexico, Argentina, Colombia, Ecuador and Peru); aile, ilite (Mexico); ramrm, lambrn (Guatemala, Costa Rica and Peru); jal (Costa Rica); palo de lama (Guatemala) and; cerezo and chequiro (Colombia). Easily propagated from seed or by natural regeneration, A. acuminata is a popular agroforestry species in its native range. It has been successfully introduced into southern Chile and southern New Zealand.**

### Botany

**Alnus acuminata ssp. arguta (Schlectendal) Furlow (Betulaceae) grows to 30 m in height and to 50 cm in diameter (after 30 years) in natural conditions. Maximum age may be 60 years (L Fournier,, personal communication). The leaves are simple, alternate, elliptical, 6 to 15 cm long, 3 to 8 cm wide, border double dentate, deciduous or semideciduos. The upper leaf surface is dark green and the lower surface is pale, whitish to light green. The bark is light-gray or silvery with yellowish lenticels. Crown shape is open rounded to pyramidal. Male and female flowers occur in separate catkins on the same branch. Inflorescences are cone-like with lignified scales, dark brown when ripened, and bearing more than 100 fruits per cone. The fruit is a small membranous-winged samara, 2 to 3 mm long that**

**contains one seed. Dispersal is mainly by the wind. Seeds ripen in February,, March and August in South America (NAS, 1980), and from September to January in Costa Rica (Rotas et al., 1991).**

**There is considerable confusion in the taxonomy of Alnus acuminata. Furlow (1977) reported the species as Alnus acuminata H B.K, but in his last revision (1979) he classified it as Alnus acuminata ssp. arguta. The species also has been described as Alnus jorullensis H.B.K. by Carlson and Dawson (1985). Holdridge (1951) concluded that if subspecies populations exist they apparently intergrade into each other and because of similarities in wood and silvicultural characteristics they may be considered as a single species, at least from a forestry viewpoint.**

**Distribution and ecology**

**Alnus acuminata is native to the American contient ranging from Mexico to Northern Argentina in elevations between 1,200 and 3,200 m.a.s.i. where annual rainfall is 1,000 to 3,000 mm or more. The species occurs where mean annual temperature ranges between 4° and 27°C; however it can withstand temperatures dipping briefly below 0°C (NAS, 1980).**

**Alnus acuminata is a fast-growing pioneer species that regenerates naturally in open, disturbed areas. It grows in moist soil environments' usually along the banks of streams, rivers, ponds, and swamps where it typically forms dense pure stands.**

**It also can be associated with wet flood plains, or moist mountain slopes, although it may be adapted to somewhat drier conditions. However, it is usual'**

**restricted to zones with extra soil moisture such as cool, tropical highlands, and cool, high-ladtude regions with abundant rainfall where mist and cloud cover can be a source of fog-drip precipitation. In tropical highlands of Central and South America, clouds and mist are important in supporting Alnus acuminata and grass, when associated, through the dry season.**

**Alnus acuminata prefers deep, well-drained soils with high organic matter content. However, it is commonly found growing on shallow soils, such as landslides. Rojas et al. (1991) report that it will grow in soil with pH as low as 45.**

**Uses**

**Timber.**

**Alnus acuminata wood is light brown-yellow to pink, odorless' and tasteless' without differences between the heartwood and the sapwood. Reports on specific gravity vary from 034 to 039 (Tuk, 1980) and 05 to 0.6 (NAS, 1980). The calorific value is 19,2501kJ/kg (CATIE, 1986). The wood dries easily and preserves well. It has even grain, seasons fairly well, and is easy to work and finish by hand or machine. Despite its light weight it is tough and strong, and is sometimes used for construction. Timber is also used for fuelwood, posts' poles, light lumber, boxes, broom handles, domestic implements, plywood cores, particle board, and musical instruments. A match company in Colombia evaluated more than 20 native species and found Alnus acuminata wood best suited for making stick matches (In". R. Arismendi, Personal Communication).**

**Agroforestry.**

**Farmers in Costa Rica have grown Alnus acuminata in pastures and as a shade tree for coffee crops for more than 90 years. Trees are regenerated naturally or planted from nursery stock at spacings of 8 to 14 m (about 100 trees/ha).**

**One benefit of including trees in cattle pastures is greater milk production-cows on pastures with Alnus acuminata produce more than cows on pastures without it (Budowski, 1983). Farmers in Costa Rica sometimes construct crude fences around individual seedlings to protect them from livestock-protection is needed until trees grow tall enough that livestock can not browse new growth.**

**Silviculture**

**Propagation.**

**Alnus acuminata is propagated by seeds (more than 2 million pure seeds/kg). Seeds are recalcitrant and must be planted quickly-viability decreases from 70% to 20% in a few months. Seed viability can be extended by storing seed in airtight containers at 5° Cviability is 50% and 31 % after 2 and 3 months, respectively (Rojas et al., 1991).**

**No seed pre-treatment is necessary. Rojas et al. (1991) recommend broadcasting seed in germination beds (15 to 20 g of seed per m² of bed) and covering them with a very thin layer of mixed soil and sand. The germination bed should be a 1:1:2 mixture of fine soil, sand and organic material. Seeds should be watered twice daily with a very fine mist to maintain soil humidity. Overwatering may cause damping-off. Germination starts 6 to 7 days after sowing and is complete within 15 days. The most vigorous seedlings should be transplanted to pots or**

**back plastic bags 20 days after germination. Seedlings may be planted out when they are 20 cm tall (in about four months). Bare-root seedlings and stump cuttings are possible alternatives to container-grawn seedlings. Seedlings do not compete well with weeds so frequent weeding is important (Rojas et al., 1991).**

**Management.**

**Alnus acuminata is grown in plantations mainly in Colombia and Costa Rica, but in other countries as well. In Colombia, an initial spacing of 2.6 x 2.6 m (1,480 trees/ha) is common (Sicco Smit, 1971). In Costa Rica, an initial spacing of 3 x 3 m is preferred. At least two thinnings are recommended, the first after the third year and the second after 10 to 15 years, leaving 250 to 350 trees per hectare. Trees are harvested in rotations of about 20 years. Average annual wood production is 15 to 20 $m^3$ per hectare. According to Canet (1985), a stand of 30-year-old trees with a density of 35 trees/ha yielded 70 $m^3$/ha of timber, 183 ton/ha of dry fuelwood, and 3.6 ton/ha of leaves and fine branches. Alnus acuminata resprouts vigorously from the stump after cutting.**

**Symbiosis**

**Alnus acuminata, like other Alnus species, forms a symbiosis with actinomycetes of the genus Frankia. Rojas et al. (1991) report that nodules begin to grow on 13-day-old nursery seedlings. Estimates of nitrogen fixation for Alnus species vary widely between 62 kg/ha/yr for A. sinuata in Alaska and 125 kg/ha/yr for A. glutinosa, to 320 kg/halyr for A. rubra in Oregon (Carlson and Dawson, 1985). In a 2year-old A. acuminata plantation in the Colombian highlands (1200 trees/ha), Carlson and Dawson (1985) estimate an annual increase in soil nitrogen of 279**

**kg/ha. Acetylene reduction values for 120-day-old A. acuminata greenhouse seedlings inoculated with a crushed nodule suspension were between 32.5 and 86.4 µmol of ethylens produced per gram of nodule dry weight per hour (Russo and Berlyn, 1988).**

**Pests and diseases**

**Alnus acuminata is susceptible to attack by defoliators (Nodonota irazuensis and Nodonota cat parvula, Coleoptera, Chrysomelidae). A stem borer Scolytodes alni, (Coleoptera, Scolytidae) has been observed in Costa Rica during the dry season. Vertebrates such as Sciurus sp. (Rodentia, Sciuridae) may cause debarking and Sylvilagus brasiliensis (Lafomorpha, Leporidae) may destroy seedlings. Fungi such as Fusarium sp. and Trichoderma sp. may damage seeds; Colletotrichum sp. and Phomopsis sp. may affect leaves; and Rosellinia sp. may affect stems and roots in mature trees (CATIE, 1991).**

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**Casuarina glauca: a hardy tree with many attributes**

**Chamaecytisus palmensis: hardy, productive fodder shrub**

**Dalbergia latifolia: the high-valued Indian rosewood**

**Dalbergia melanoxylon: valuable wood from a neglected tree**

**Erythrina edulis: multipurpose tree for the tropical highlands**

## Acacia mangium: an important multipurpose tree for the tropic lowlands

**Acacia mangium Willd. is one of the major fast growing species used in plantation forestry programs throughout Asia and the Pacific. Due to its rapid growth and tolerance of very poor soils, A. mangium is playing an increasingly important role in efforts to sustain commercial supply of tree products while reducing pressure on natural forest ecosystems.**

### Botany

**Acacia mangium is in the family Leguminosae, sub-family Mimosoideae. It has rapid early growth, and can attain a height of 30 meters and a diameter of over 60**

**centimeters (MacDicken and Brewbaker 1984). Inflorescences are on loose spikes up to 10 cm long with white or cream colored Bowers. When in full blossom, the inflarescences resemble bottle brushes. The flower has a mild, sweet fragrance. The dark green, glabrous phyllodes can be up to 25 cm long and 10 cm broad. The seed pods are broad, linear, irregularly coiled, and up to 3-5 mm wide and 7-8 cm long. The seeds are dark brown to black, shiny, vary in shape, and range from 3-5 mm long and 2-3 mm wide. Seeds mature 6-7 months after flowering (Pinyopusarerk et al. 1993).**

**Acacia mangium has a chromosome number of 2n=26. Hybrids with A. auiculiformis have the potential to become an important source of planting material for plantation forestry. The hybrid seems to be more resistant to heart rot than A. mangium but tends to be more shrub-like. Moreover, the hybrid has the straight bole and stem of Acacia mangium and the self-pruning ability of A. auicullformis (Tbrahim 1993).**

**Distribution and Ecology**

**Acacia mangium is native to Australia Indonesia and Papua New Guinea, but now has a latitudinal range from 19° S to 24° N and a longitudinal range from 88° to 146° E. Acacia mangium is a low-elevation species associated with rain forest margins and disturbed, well-drained acid soils (pH 4.56.5). Altitudinal range is from sea level to about 100 meters, with an upper limit of 780 meters. It is typically found in the humid, tropical lowland climatic zone characterized by a short dry season and a mean annual rainfall between 1446 and 2970 mm. Acacia mangium can tolerate a minimum annual rainfall of 1000 mm. Mean monthly temperatures range from a low of 13-21C and a high of 25-32° C. Though**

**considered an evergreen species, A. mangium does not grow continuously throughout the year. Growth seems to slow or cease in response to the combination of low rainfall and cool temperatures. Dieback occurs during prolonged frost (5-6° C).**

**When monthly rainfall is below 100 mm, trees exhibit signs of moisture stress (Pinyopusarerk 1993).**

**Acacia mangium tolerates a soil pH as low as 3.8, and has performed well on lateritic soils with high amounts of iron and aluminum oxides. Acacia mangium has survived on soils with as much as 73% aluminum saturation (Duguma 1995). It is intolerant of saline conditions, shade, and low temperatures. Due to dense foliage, broad phyllodes, and shallow mot system, A. mangium is more susceptible to wind damage than other Acacia species.**

**Propagation and Silviculture**

**Although natural regeneration is excellent in clear-felled a' burned fields, nursery propagation is the most common regeneration practice. Hot water treatment for 30 seconds promotes quick seed germination. There are 80,000-100,000 seeds per kilogram. Seed can be sown directly into nurse pots or sown in trays and transplanted to pots aft germination.**

Drawing by Gillian Rankin (courtesy of Queensland Herbarium, Indooroopilly, Queensland, Australia).

**Acacia mangium**

**Seedlings are retained in the nursery for 12 weeks or until they have attained a height of 25-40 cm. Srivastava (1993) recommends two mot prunings and hardening off of the seedlings before out-planting. In low phosphorus soils in the Philippines, Acacia mangium seedlings fertilized with 30 g/tree of phosphorus showed significant increase in growth compared to seedlings that were not fertilized (Manubag et al. 1995).**

**Spacing of the seedlings in the plantation depends on the intended uses and soil**

**fertility. Since natural pruning is poor, trees should be planted at close spacing. Plantations cultivated for pulpwood usually have a 4 x 4 m spacing with 830 trees per hectare. For timber production, seedlings planted at 3 x 3 m spacing provide strong lateral competition and fast diameter growth. Seedlings should be planted at wider spacing to produce heavier branches for chipwood and fuelwood (Srivastava 1993). On infertile sites, final stocking should be around 600 700 stems per hectare.**

**The first weeding should be two months after out-planting. Weeding of noxious plants such as climbers, creepers, and vines is recommended, but less harmful weeds can be left in the field to maintain lateral competition. The number of follow-up weedings will depend upon each site. In areas where Imperata has a stronghold, weedings should be frequent.**

**Pruning schedules also depend on intended use. In agroforestry systems branches are pruned regularly to prevent competition with agricultural crops. To produce quality sawlogs, all branches below the height of 6 meters should be pruned regularly. These branches must be pruned before becoming 2 cm in diameter to avoid fungal infections (Srivastava 1993).**

**On degraded Imperata grasslands, Otsamo et al. (1995) observed that A. mangium had a mean annual volume increment of 10 $m^3$/ha/year. In a 15-year rotation, precommercial thinning should occur at 24 months, followed by a thinning at 36 months Per this schedule, volumes are between 290 and 439 $m^3$/ha after ten years' growth.**

## Uses

**Acacia mangium has a wood density ranging from 420 to 600 kg/m³ and a specific gravity of 0.65 (MacDicken and Browbaker 1984). Due to ease of drilling and turning, it is a popular wood for furniture, agricultural implements, crates, particle board, and wood chips. Acacia mangium is also suitable for manufacturing charcoal briquettes and activated carbon. It has a calorific value of 4,8004,900 Kcal/kg. Acacia mangium's susceptibility to heart rot limits its use for sawn timber, but it is a common pulp and paper crop in Sumatra, Sabah and Vietnam. Nontimber uses include honey production, adhesives, and as an ornamental and shade tree for roadsides or other urban forestry uses. Acacia mangium sawdust provides good-quality substrate for shiitake mushrooms.**

**Since A. mangium can grow on marginal soils, many farmers choose to plant this species to improve soil fertility of fallowed fields or pastures. Since trees with diameters of 7 cm are fire resistant, Acacia mangium plantations can be used as fire breaks.**

**Symbiosis**

**Highly effective Rhizobium strains have been identified for Acacia mangium (de Faria 1995). Acacia mangium teas a relationship with some VAM fungi including Thelephora ramariods, Gigaspora margarita, Glomus etunicaturm, and Scutellispora calospora.**

**Pests and Diseases**

**The major pests associated with A. mangium cause damage to seedlings, branches and stems, or wilting caused by root damage. Damage does not result in death,**

**but may deform or suppress tree growth (Hutacharem 1993).**

**Most disease agents of A. mangium are associated with or caused by fungi. Common disease symptoms are damping off, heart rot, powdery mildew, stem galls, dieback, leaf spots, and root rot (See 1993).**

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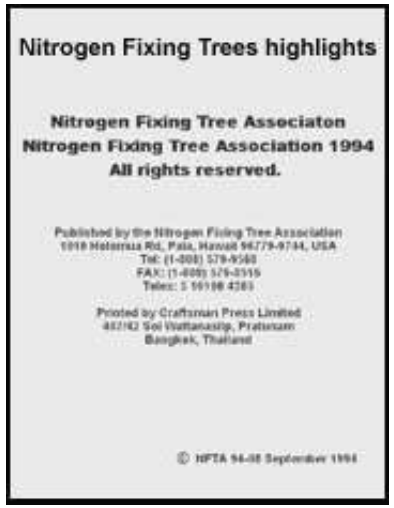


**Acacia koa - Hawaii's most valued native tree**

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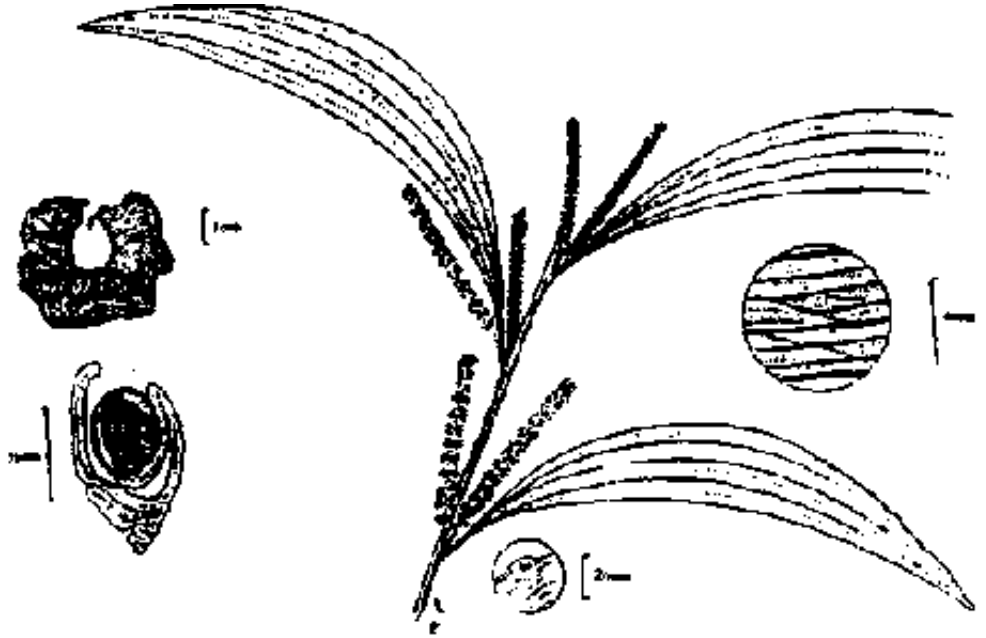
## Acacia auiculiformis - a multipurpose tropical wattle

**Acacia auriculiformis A. Cunn. ex Benth. is a multipurpose, leguminous tree in the subfamily Mimosoideae. It has been planted for fuelwood production, erosion control, ornament and shade in many tropical areas in the world. Its rapid early growth: ability to fix nitrogen; tolerance of infertile, acid. alkaline, saline or seasonally waterlogged soils; and tolerance of moderate dry seasons make it a very useful species for rehabilitation of degraded lands. The scientific name comes from the Latin 'auricula'-external ear of animals and 'forma' form, figure or shape', in allusion to the shape of the pod.**



*Leaves, gland, pod and seed of* Acacia auriculiformis. *(Drawing: Margaret Pieroni)*

**Acacia auriculiformis**

## Botany

**It is commonly a tree, 8-20 m in height, heavily branched with a short bole. On**

**favorable sites it can grow to 30 40 m tall and 80100 cm diameter with a straight, single stem. The bark is gray or brown, more or less smooth in young trees. becoming rough and longitudinal fissured with age. Mature foliage consists of phyllodes, which may be straight or falcate, acute or sub-falcate, 10-20 cm long and 1.5-3.0 cm wide. Phyllodes of sapling may attain 30 cm in length and up to 5.0 cm in width. There are 3 prominent longitudinal nerves running together towards the lower margin or in the middle near the base, with many fine crowded secondary nerves, and a distinct gland at the base of the phyllode (Pedley 1978).**

**Inflorescences are in spikes up to 8 cm long in pairs (seldom three) in the upper axils. Each inflorescence is comprised of about 100 tiny (3.8x4.1 mm) bright yellow flowers (Ibrahim and Awang 1991). Flowers are 5-merous; the calyx 0.7-1.0 mm long, with short lobes; the corolla is 2-2.5 times as long as the calyx. Stamens are approximately 3 mm long. The pods are slightly woody, glaucous and transversely veined, about 6.5 cm long and 1.5 cm wide. They are initially straight or curved but become very twisted and irregularly coil on maturity. The seeds are broadly ovate to elliptical, about 4-6 mm long and 3 4 mm wide. Each seed is encircled by a long red, yellow or orange funicle. There are 60,000 seeds per kg.**

**Ecology**

**Acacia auriculiformis occurs from near sea level to 400 m, but is most common at elevation less than 80 m. It is predominntly found in the seasonally dry tropical lowlands in the humid and subhumid zones. The mean annual rainfall in its natural range varies from 700-2000 mm, and the dry season (i.e. monthly rainfall less than 40 mm) may be 7 months. The mean maximum temperature of the hottest month is 32-34°C and the mean minimum of the coolest month is 17-22°C.**

**The species is commonly riparian, i.e. ringing perennial rivers and semi-perennial creeks, and tends to form discontinuous populations along drainage systems. It is found most commonly on clay soil types, found most commonly on clay soil types however it exhibits the ability to grow in a variety of soils including calcareous sands and black cracking clays. It can also tolerate highly alkaline and saline soils. Seedlings have the ability to compete with Imperata cylindrica during early growth phases and once mature may reduce the grass to a sparse ground cover.**

**Distribution**

**Acacia auriculiformis is endemic to Australia, Papua New Guinea and Indonesia. having a disjunct distribution in three main areas: the lowlands of southern half of the island of New Guinea (Papua New Guinea and Irian Jaya, Indonesia); the lowlands of tropical Northern Territory, Australia; and the Cape York Peninsula of northern Queensland, Australia It has been widely introduced to many tropical countries in South and Southeast Asia Africa and Latin America.**

**Uses**

**Wood.**

**Heartwood varies from light brown to dark red. The wood makes attractive furniture and is suitable for construction work, turnery and carving. Plantation-grown trees have shown promise for the production of unbleached kraft pulp-for bags and wrapping paper; and high quality neutral sulphite semichemical pulp-for corrugating, medium and higher-grade packaging products (Logan 1987). The wood has a high basic density (500650 kg/m³) and a calorific value of 4700-4900**

**kcal/kg, which make it ideal for firewood and charcoal.**

**Land Rehabilitation & Landscaping.**

**The spreading, denselymatted root system stabilizes eroding land. Its rapid early growth even on infertile sites, and tolerance of both highly acidic and alkaline soils make it popular for stabilizing and revegetating mine spoils. It is used for shade and ornamental purposes in cities where its hardiness, dense foliage and bright yellow flowers are positive attributes.**

**Other Uses.**

**The bark has sufficient tannins for possible commercial exploitation (Abdul Razak et al. 1981). A natural dye, used in the batik textile industry in Indonesia, is also extracted from the bark. Its flowers are a source of bee forage for honey production (Moncur et al. 1991).**

**Silviculture**

**Propagation.**

**Propagation is generally by seed. Pregermination treatment is essential to promote seed germination. Immersion of seed in ample boiling water for 1-2 minutes is suitable to break dormancy. Germination is rapid after pretreatment and typically exceeds 70%. In general, 3-4 months are needed to raise seedlings to a plantable size, 25 cm in height. Inoculation with appropriate rhizobia may be beneficial, especially when seedlings are raised in sterilized soil.**

**Management.**

**Establishment is successful by containerized seedlings or by direct seeding. Containerized seedlings generally give higher survival, especially in areas of heavy weed competition. In the field, weed control is essential during the first 1-2 years. A small dose of NPK fertilizer in the first year helps improve initial growth - fertilization rates depend on quality. Recommended spacing is 2x2 or 2x4 m. Acacia auriculiformis has the ability to coppice, but it is not a vigorous sprouter. It responds well to pollarding.**

**Yield.**

**An increment in height of 2-4 m per year in the first few years is common even on soils of low fertility (Boland 1989). On relatively fertile Javanese soils receiving 2000 mm annual rainfall, a mean annual increment of 15-20 $m^3$/ha is obtainable but on less fertile or highly eroded sites the increment is reduced to 8-12 $m^3$/ha (Wiersum and Ramlan 1982). Recommended rotation is 4-5 years for fuelwood, 8-10 years for pulp and 12-15 years for timber. One or two thinnings are required with longer rotations, depending on initial spacing, site quality and tree growth.**

**Symbiosis**

**Acacia auriculiformis can fix nitrogen after nodulating with a range of Rhizobium and Bradyrhizabium strains. It also has associations with both ecto- and endo-mycotthizal fungi.**

**Limitations**

**The propensity to produce multiple and crooked stems reduce its utility. It is susceptible to fire; even trees 10-15 years old can be killed. Stressed trees are found to be highly susceptible to attack by leaf insects.**

## Genetics & Provenances

**Isozyme studies revealed marked genetic variation in A. auriculiformis. Three distinct groups of populations corresponding to the geographic distribution in Papua New Guinea, Queensland and Northern Territory (Wickneswari and Norwati 1991). These regional groupings are also apparent in seedlling morphology (Pinyopusarerk et al. 1991). Additionally, field trials have shown marked differences in growth and form. Provenances from Papua New Guinea have the highest production while those from Queensland have a high proportion of single stems. Those from the Northern Territory are inferior in both growth and form (Harwood et al. 1991).**

## Research Needs

**Selection and breeding for superior growth and stem form are now underway in many countries, including Thailand and Vietnam Natural hybrids of A. auriculiformis x A. mangium have shown desirable characteristics; e.g. vigor, fine branching and tendency for a strong apical dominance. These characteristics lead to healthy trees with single stems and a good clear bole. Production and vegetative propagation of these hybrids warrant detailed study.**

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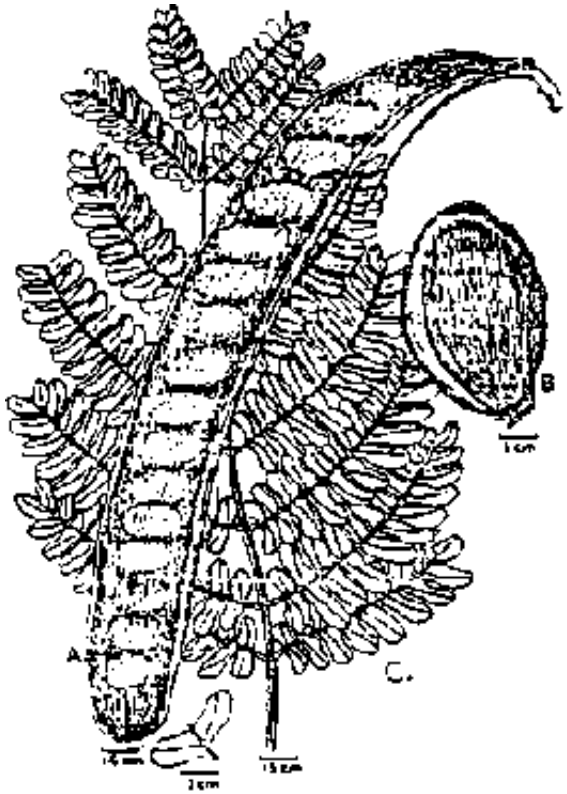
## Pentaclethra microphylla: a multipurpose tree from Africa lwith potential for agroforestry in the tropics

**Pentaclethra macrophylla Benth., the oil bean tree. is the sole member of the genus occurring naturally in the humid lowlands of West Africa. It is a leguminous tree (family Leguminosae, sub-family Mimosoideae), and recognized by peasant farmers in the southeast of Nigeria for its soil improvement properties. A related species viz. Pentaclethra macroloba (Wild) is native to South America (Norris 1969). Pentaclethra macrophylla has been cultivated in Nigeria since 1937 (Ladipo 1984) and for many years in other West African countries where its seed is relished as a food. Pentaclethra macrophylla was not known to nodulate until recently (Ladipo et al. 1993). With the diverse native uses of this species, and the present research effort on it, its utility could be further enhanced for agroforestry development in the humid tropics. The species is relatively fast-growing and seedlings will achieve a height of 1.5 m in the first year on good sites.**

## Botany

**Trees grow to about 21 meters in height and to about 6 m in girth (Keay 1989). The tree has a characteristic low branching habit and an open crown which allows substantial light under its canopy. This characteristic accounts for the trees use in combination with food crops on farms and particularly in home gardens in south east Nigeria.**



Pentaclethra macrophylla *A. Fruit, B. Seed, C. Leaf (Source: Isawumi 1993)*

**Pentaclethra macrophylla**

**The bole produces a reddishorange coloration after a slash is made. Stem form is usually crooked and buttressed. Some straightstemmed and less buttressed trees, which can pass for good timber, are occasionally seen in the forests. Bark is grayish to dark reddish brown (Keay 1989), thin and patchy with irregular pieces flaking off.**

*Natural distribution* of Pentaclethra macrophylla *in Africa*
**Natural distribution of Pentaclethra macrophilla in Africa**

**Leaves possess a stout angular petiole. The compound leaves are usually about 20-45 cm long and covered with rusty hairs giving a scurfy effect particularly along the upper surface but this eventually falls off. There are 1012 pairs of stout opposite pinnae. The middle pairs are 713 cm long and also have rusty hairs along the central grove. There are usually 12-15 pairs of opposite stalkless pinnules (leaflets), each 12-15 cm long 5-10 mm broad, with the middle pairs longest. Leaflets often have a rounded tip but are sometimes notched; the base is unequal. Flowers are creamy-yellow or pinkish-white and sweet smelling. Flowering commences at variable periods within West Africa. The main flowering seasons is between March-April with smaller flushes in June and November. Fruits are available at most periods of the year because the large woody pods are persistent.**

**The pods are 40-50 cm long and 5-10 cm wide. Fruit splits open explosively with the valves curling up. This is the form in which they appear on most trees. Usually, pods contain between 6-10 flat glossy brown seeds which may vary in site. The**

**seed are up to 7 cm long. This is the edible product and source of the oil; hence the name 'the oil bean tree.**

## Table 1: Common uses of Pentaclethra macrophylla in West Africa

| Uses | Part of Plant | Country |
|---|---|---|
| Food | Seed | Nigeria, Ghana |
| Salt substitute | Pod ashes | Ghana |
| Edible oils | Seed | Nigeria, Ghana. |
| | | Togo, Cameroon |
| Fences end parings | Wood | Nigeria, Ghana |
| Charcoal | Wood | Cameroon,Togo, |
| | | Cote d'Ivoire |
| Carving bowls, etc. | Wood | Nigeria, Ghana |
| Seed craft (beadings) | Seed (beadings) | Nigeria |
| Dye (mordants) | Pod ashes | Ghana |
| Mild poison | Bark & seed | Ghana |
| Medicine (convulsion) | Pod | Cameroon |
| Medicine* (abortion) | Crushed seed | Ghana, Nigeria |
| Medicine (convulsion) | Smoke of burnt leaf | Ghana |
| Medicine* (diarrhea) | Leaf/stem bark | Ghana |
| Medicine* (itch) | Bark as liniment | Ghana |
| Medicine(lactogenicity) | Bark decoction | Ghana |

| | | |
|---|---|---|
| Medicine (wound/treatment) | Bark as lotion | Ghana |
| Ornamental | Whole tree | Nigeria |

***Abbiw (1990)**

**Distribution and Ecology**

**Pentaclethra macrophylla occurs from Senegal to Angola and also to the Islands of Principe and Sao Tome. This multipurpose tree is endemic to the humid and some parts of the sub-humid zones of West Africa. It does not occur in the highlands although, growth can be good where rainfall is adequate and temperatures are never cooler than 18°C. The annual mean temperature requirement is about 25°C and rainfall between 1000-2000 mm. After about 2-years growth in the forest, trees become relatively fire resistant and resprout readily when lopped.**

**The natural distribution of P. macrophylla suggests that it is endemic to relatively acid soils. The species will also tolerate water logging as in the low altitudinal riverine areas of southeast Nigeria, Togo and Cameroon.**

**The unusual feature of leaf loss during the wet seasons has been observed in the field on some individual trees of Pentaclethra macrophylla and this could be an important trait for selection for farmers. Although no provenance trials of this species have been conducted. tree phenotype in natural populations shows considerable variation in crown shape, fruit morphology and seed size.**

**Uses**

**Pentaclethra macrophylla is planted on the fringes of compound farms mainly for its edible seed. Its empty dry fruit pods are used as fuelwood for cooking. Leaves are shed during the dry season and farmers believe this contributes to soil fertility within the home garden. Pentaclethra macrophyilla wood is highly suitable for fuelwood and charcoal making (other uses are listed on Table 1). Farmers protect this species on farms because of its open crown form which does not inhibit crop plants grown under its canopy. Litter drop is appreciable. The species is believed to enhance soil nutrient and organic matter content.**

**The seed is large with approximately 50-80 seeds per kg. Because seeds are edible, they are not usually available for seedling production. When available in the open market, they are usually non-viable because of their short longevity (recalcitrant). Consequently seed should be planted immediately. Storage at 15°C can extend longevity for about three months.**

**Seed pre-treatment is required. Mechanical scarification and soaking in water for 24 hours will enhance germination.**

**Adult trees are easily marcotted (air layered), but only juvenile stem cuttings will root if treated with IBA (20 ppm). Seedlings produced in nurseries and hardened-off before out-planting make the best planting material.**

**Pests & Diseases**

**No serious pest and disease problems are known but stem borers have been recorded on some old trees and mild defoliation of juvenile seedlings is not uncommon. The species is reported to be termite resistant.**

## Seed Sources

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- Leucaena: an important multipurpose tree

- Olneya tesota - a potential food crop for hot arid zones
- Honey mesquite: a multipurpose tree for arid lands
- Pongamia pinnata - a nitrogen fixing tree for oilseed
- Guazuma ulmifolia: widely adapted tree for fodder and moreli
- Faidherbia albida - inverted phenology supports dryzone agroforestry
- Gleditsia triacanthos - honeylocust, widely adapted temperate zone fodder tree

- Andira inermis: more than a beautiful ornamental tree
- Erythrina poeppigiana: shade tree gains new perspectives
- Albizia procera - white siris for reforestation and agroforestry
- Albizia odoratissima - tea shade tree
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- Myroxylon balsam and much more
- Ougeinia dalbergioides: a multipurpose tree for sub-tropical and tropical mountain regions

## Myroxylon balsam and much more

**Native to Central and South America, representatives of Myroxylon are used in folk as shade trees for cultivated crops, ornamentals, and for fine timber. Balsam and its essential oil are used to flavor baked goods, candy, chewing gum, gelatin, ice cream, pudding, soft drinks and syrups, and as incense in churches. Balsam oil is also used in perfume, cosmetic and soap industries. Seeds are used to flavor aguardiente, a popular alcoholic beverage in Latin America (Duke 1981). Common names include: blsamo, palo de blsam (Spanish America in general), cedro chino, nabal (Mexico), chirraca, sndalo (Costa Rica), tache, tofu (Colombia), estoraque (Peru), cabreva vermelha (Brazil), incienso, and quina (Argentina)(Chudnoff 1984).**

## Batany

**Myroxylon balsamum (L.) Harms (family Legununosae, subfamily Papilionoideae) grows to 34 m in height and 1 m in diameter. The bark is generally gray and**

**spotted with yellow rough areas. The 3-11 leaves are alternate, evergreen and oddly pinnate, 6-9 cm long and 3-4 cm wide (Duke 1981), and have scattered, translucent, glandular oil dots or lines (Allen and Allen 1981). Flowers are whitish, and the corolla contains 5 petals (Fuentes, 1993). The winged pod is 8-13 cm long and 2.5 cm broad and contains one seed at the tip (Duke 1981).**

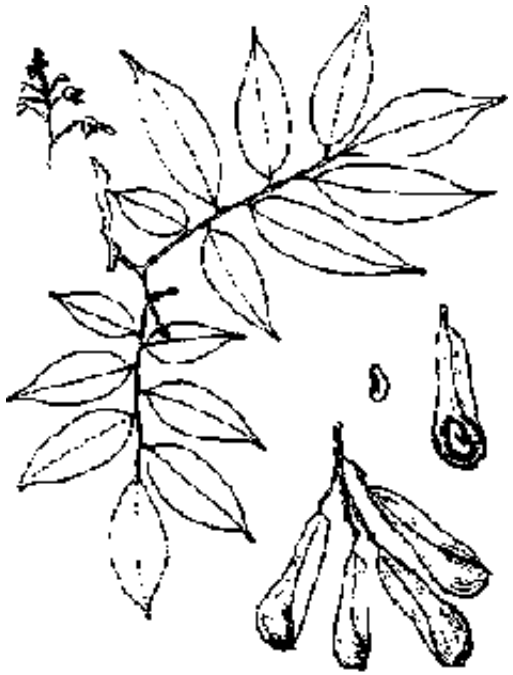
**There is confusion about the number of species and varieties in the genus Myroxylon. Wiersema et al. (1990) reports two species: M. balsamum (L.) Harms native to southern Mexico, Central America, Colombia and Venezuela and; M. peruiferum L.f. native to northwest Argentina, Bolivia, Brazil, Colombia and Peru. Duke (1981) reports one species in South America M. balsamum (L.) Harms. In Brazil Lorenzi (1992) reports M. balsamum (L.) Harms end M peruiferum L.f. as synonymous.**

**Wiersema et al. (1990) also reports two varieties: M. balsamum var. balsamum in Panama, Colombia and Venezuela; and M. balsamum var. pereirae (Royle) Harms from southern Mexico through Central America. Duke (1981) reports only one variety-M. balsamum var. pereirae (Royle) Harms-distributed along the Pacific Coast jungles of Central America.**

**Ecology**

**Myroxylon balsamum grows in areas with annual precipitation ranging from 1350-4030 mm (average 2640 mm), annual mean temperature of 23-27°C, and soils with pH 5-8 (Duke 1981). In northwestern El Salvador it grows from 450-700 m altitude in an area known as the ''balsam zone" (Fuentes 1993).**

**Myroxylon balsamum var. pereirae is reported to grow on poor but well-drained soils, at altitudes up to 600 m (Duke 1981).**



Myroxylon balsamum (L.) Harms
*Source: Duke 1981*

**Myroxylon**

## Distribution

**Representatives of the genus are found in southern Mexico Central America, Venezuela, Colombia, Ecuador, Peru, Bolivia, Argentina and Brazil. Myroxylon balsamum var. pereirae has been introduced to southern Florida, Ceylon, India and West Africa (Duke 1981).**

## Uses

**Gum.**

**Myroxylon balsamum var. balsamum and M. balsamum var. pereirae yield gums called tofu and Peru balsam, respectively. These gums are used mainly as a flavoring in cough syrups, soft drinks, confectioneries, ice cream and chewing gums (Duke 1981).**

**Trees are wounded to collect gum by three methods. 1) V-shaped cuts are made in the bark taking care not to girdle the tree and cups are placed under cuts to collect gum. 2) Trees are burned at the base. Strips of bark are pulled off, crushed and placed in hot water to soften the balsam and facilitate its flow. The cooled balsam sinks to the bottom and can be separated (Duke 1981). 3) Sections of the tree trunk are beaten with a wooden club and then vertical incisions 8 cm wide are made in the bark. A few days later the incisions are heated with fire to stimulate gum flow incisions are not burned. Rags are placed over the incisions and removed when they are saturated. Crude presses are used to extract gum from the rags (Fuentes 1993).**

**Gum harvesting begins on 20 to 30-year-old trees with minimum diameters of 12-15 cm (Fuentes 1993). Twentyyear-old trees yield about 3 kg of gum per year (Allen and Allen 1981). With proper management trees yield gum for 30 to 40 years. Prices per half kilogram of unrefined and refined gum in El Salvador in 1993 were approximately 17 and 24 colonel, respectively (Fuentes 1993). This is US$2.003.00 at current exchange rates.**

**El Salvador, a major producer of Peru balsam, exported about 48 MT annually in the late 1970's and early 1980's. Tolu balsam is produced in Colombia, the main**

**source, Venezuela and the West Indies (Duke 1981).**

**Oil.**

**Balsam gum contains about 60% cinnamein, a volatile oil extracted by steam distillation. The oil is used in highgrade perfume, cosmetic and soap industries (Duke 1981).**

**Wood.**

**Balsam wood is used for flooring, furniture, interior trim, turnery and railroad ties. It is moderately difficult to work but can be finished smoothly with a high natural polish. Heartwood is reddish brown, turning deep red or purplish upon exposure, and very resistant to attack by decay fungi. Specific gravity is 0.74-.0.81. Shrinkage values from green to ovendry are very low for a wood of this density (Chudnoff 1984).**

**Folk medicine.**

**Tolu balsam is used as a feeble expectorant in cough mixtures, and as an inhalant for catarrh and bronchitis. Peru balsam is used extensively as a local protectant, rubefacient, parasiticide in certain skin diseases, antiseptic, and applied externally as an ointment, or in alcoholic solutions. It is rarely used internally as an expectorant. Alcoholic extracts of tofu and Peru balsam inhibit Mycobacterium tuberculosis (Duke 1981).**

**Agroforestry.**

**Myroxylon balsamum (L.) Harms is used in El Salvador as a shade tree in coffee plantations. There are no government initiatives to promote formal planting of the species-it is propagated mainly through natural regeneration (Fuentes 1993).**

**Silviculture**

**Seed collection.**

**Seeds are wind dispersed and may be collected from the tree as they begin to mature. Balsam tree' in Brazil flower from July to September and set seed in October and November. There are approximately 1,700 seer per kilogram (Lorenzi 1992).**

**Propagation.**

**Seed should be planted in a mixture of clay and organic matter to a depth of.5 cm, covered with fine soil and watered daily. Germination beds or container' should be partially shaded. Seeds germinate (greater than 50%) in 1530 days. Seedlings are ready for outplanting in 5 months. Seedlings grow to 2.5 m in 2 years (Lorenzi 1992).**

**Symbiosis**

**Allen and Allen (1981) report nodulation of Myroxylon balsamum. Nodulation of M. balsamum has not been reported in Brasil (S.M. de Faria, personal communication).**

**Limitations**

**Myroxylon balsamum (L.) Harms var. balsamum and M. balsamum (L.) Harms var. pereirae are attacked by a number of fingi: Meliola xylosmae, Myiocopron pereirae, Pecksia pereirae, Phylosticta myroxyli, Phomopsis sp. and Tabutia xylosmae (Duke 1981).**

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## Nitrogen Fixing Trees Highlights (Winrock, 1990-1997, 100 p.)

- Guazuma ulmifolia: widely adapted tree for fodder and moreli
- Faidherbia albida - inverted phenology supports dryzone agroforestry
- Gleditsia triacanthos - honeylocust, widely adapted temperate zone fodder tree
- Andira inermis: more than a beautiful ornamental tree
- Erythrina poeppigiana: shade tree gains new perspectives
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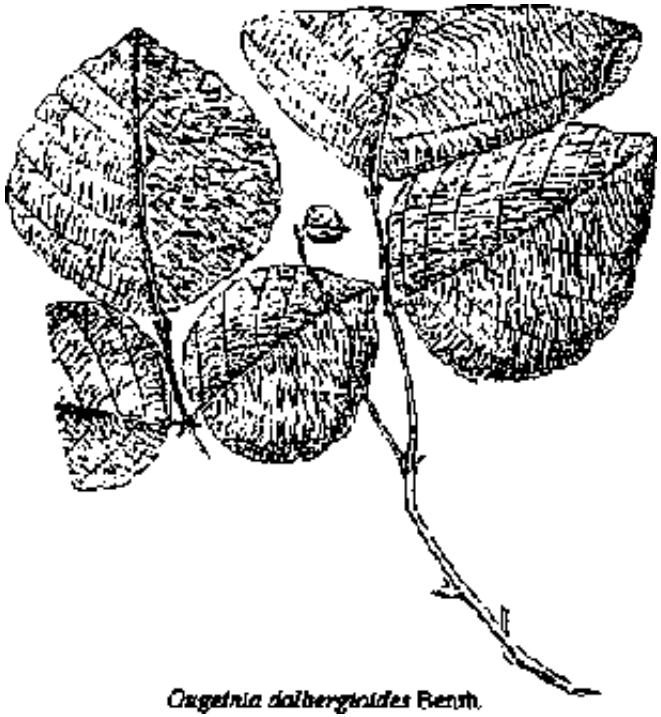
- Albizia odoratissima - tea shade tree
- Adenanthera pavonina: an underutlized tree of the humid tropics
- Acacia mangium: an important multipurpose tree for the tropic lowlands
- Acacia auiculiformis - a multipurpose tropical wattle
- Pentaclethra microphylla: a multipurpose tree from Africa lwith potential for agroforestry in the tropics
- Myroxylon balsam and much more
- Ougeinia dalbergioides: a multipurpose tree for sub-tropical and tropical mountain regions
- Prosopis alba and prosopis chilensis: subtropical semiarid fuel and fodder trees
- Sesbania sesban: widely distributed multipurpose NFT

## Ougeinia dalbergioides: a multipurpose tree for sub-tropical and tropical mountain regions

**Ougeinia dalbergioides Benth. (Leguminosae, Subfamily Papilionoideae) is a monotypic genus formerly classified as Ougeinia oojeinensis and Dalbergia ougeinesis. It is a valuable timber and fodder species restricted to India. The natural forests containing this tree have been severely degraded by timber exploitation. Ougeinia dalbergioides is most commonly called sandan.**




**Ougeinia dalbergioides**

## Botany

**Ougeinia dalbergioides is a medium-sized semi-deciduous tree, commonly attaining 40-50 cm in diameter breast height (DBH) and 7-14 meters in height (Troup 1921). The stem is often crooked, but in some areas the tree is straight. The bark, varying from pale pinkish-brown to dark bluish gray, is somewhat rough and exfoliates in irregular thin soft scales. Leaves are pinnately trifoliate, smooth above and lightly pubescent below. The obovate leaflets are generally 6-12 cm long and 2-15 cm wide, but size varies greatly. Leaf margins are entire.**

**The light-pink to white flowers emerge in clusters from February to May. The previous years branches generally do not bear flowers. Branches bearing flowers**

**are leafless, while others retain leaves. Flowering trees are conspicuous and afford a beautiful sight. Pods have a distinct seam, are 5-10 cm long and 1 cm wide. They mature and ripen in May to June and fall chiefly in June. Normally, pods remain closed until seeds germinate. Mature pods yield 2-5 viable seeds. The smooth brown seeds are 10-12 mm long and 5 mm wide. Trees do not seed heavily each year (Troup 1921).**

## Ecology

**Ougeinia dalbergioides is native to sub-tropical regions of India. It is common at elevations of 300-1500 m. At higher elevations it remains a small tree. The optimum mean annual temperature in its habitat ranges from 20 20-47°C with a relative humidity from 49-90%. The optimum rainfall appears to range from 950-1900 mm. This species is not found in wet regions. Characteristic of limestone soils, sandan grows well on dry exposed sites and eroded hills (Troup 1921). It also occurs on alluvial soil, red clay, black cotton, and rocky soil. Its best growth and greatest size is attained in the lowlands on alluvial soils. Sandan is a component of mixed deciduous and sal (Shorea robusta) forests. It is associated with pines at the higher limits of its elevation range.**

## Ditribution

**Ougeinia dalbergioides is found in the sub-Himalayas foothill and plains of the Punjab eastwards to Bhutan. It is also common in Central and Northern India and in some parts of Southern India It is an important species in Uttar Pradesh and Madhya Pradesh.**

## Uses

## Wood.

**Ougeinia dalbergioides yields a valuable timber. The sapwood is grey and narrow, the heartwood is light golden brown, hard, strong, heavy and elastic-specific gravity is 0.84 and average weight is 865 kg/cubic meter. The wood airseasons slowly without much degradation. The wood can be kilnseasoned without difficulty, but requires slow and careful drying. Planks 2-5 cm thick require 16-20 days to season (Pearson and Brown 1932; Trotter 1944). The wood does not require preservative treatment. It is difficult to work, but turns well and takes polish readily. Though originally considered difficult to peel, it is now frequently utilized for plywood. The timber of this species is superior to teak (Tectona grandis) in terms of shock resistance, shear strength and hardness (Pearson and Brown 19321. Sandan timber is used in the manufacture of agricultural implements, construction timbers, furniture and textile mill implements. It is also a specialty timber for marine. It is a good fuel with a calorific value of 4900-5200 Kcal/kg (Krishna and Ramaswami 1932).**

## Fodder.

**The leaves are highly valued as cattle feed. Farmers lop side branches, but often spare the main limbs to assure good growth and future supplies of fodder. In some areas, natural stands of this species are such important fodder resources timber harvesting is forbidden. Leaves contain 12- crude protein (Singh 1982).**

## Other uses.

**Bark fibers are suitable for making rope (Pearson and Brown 1932; Trotter 1944). The bark is used as a fish poison and to reduce fevers. A sap exudate is used to make a medicine to treat dysentery. The tree is a host-plant for lac producing insects. The resulting shellac is of high quality (Purkayastha and Krishnaswamy 1958).**

## Propagation

**Ougeinia dalbergioides is readily propagated from seed. The seeds do not retain their viability for long and should be used within 12 months of maturity. Once collected seed should be properly dried and stored in sealed containers. A kilogram contains 28,000-33,000 seeds. To maximize germination, pods should be broken into fragments containing one seed and soaked in water for 24 hours before sowing (Uniyal and Nautiyal 1992). Seed should tee sown 1 cm deep. Germination occurs in 3-8 days. Direct sowing is very successful and highly recommended (Troup 1921; Kadambi and Dabral 1955).**

**Nursery-propagation accelerates seedling growth, however the large taproot of sandan makes transplanting difficult. Establishment by stump sprouts gives good results. One-year old seedlings with root-collar diameters of 5 cm are recommended. For stump production, seedlings should be cut 23 cm above the root-collar and 20-25 cm below. Propagation by root cuttings is successful, but stem cuttings yield poor results.**

## Sitviculture

**Young trees and seedlings need a moderate amount of shade. However, once**

**established O. dalbergioides requires full Asunlightlight for its best development. Although young trees are throught and frost sensitive, mature trees are hardy. A tree spacing of 3 x 6 m is recommended for timber production.**

**Mean annual growth increment averages between 3-20 mm in DBH. Trials in Srinagar indicate keeping seedlings free of heavy weed competition for 3-4 years will improve growth and survival. Under this management scheme, trees attained heights of 4-5 m and DBH of 10.5 cm in 6 years. Conversely, heavy weed competition can kill seedlings. Sandan coppices well and produces abundant root-suckers. This characteristic is particularly useful for controlling erosion along steep banks and eroded hillsides. Fast-growing coppice and root-suckers attain 7-10 m in height and 12-17 cm in DBH after 20 years. Coppice and root-suckers can be managed for timber production. In Madhya Pradesh forests are commonly managed simultaneously for sandan and teak production. The exploitable diameter for O. dalbergioides timber is generally 30 cm.**

## Limitations

**Sandan is very susceptible to heart rot (Fomes caryopnhylla), buff brown pocket rot (Polystictus nilgheriensis) and white spongy rot (Asterostromella rhodospora). The tree is also susceptible to a number of defoliators and borers. The latter also attack dead wood (Kadambi and Dabral 1954). Timber exploitation has degraded the natural stands of this species. To reverse this condition, improved natural forest management and the establishment of large-scale tree plantations are necessary.**

## Symbiosis

**As with many other leguminous plants, Ougeinia dalbergioides forms nitrogen fixing symbiosis with Rhizabium bacteria. Reliable estimates of its nitrogen fixing capacity are not available.**

## Genetic Variation

**A variant of this species has been reported to occur at a frequency of 4% in Srinagar. Variants differ morphologically from the normal plants by producing narrower leaves with 46 leaflets instead of three. The morphological difference has been retained by trees established in an arboretum in 1985 (Purohit et. al 1987). These plants grow 30% slower than the normal plants. Detailed investigations on the physiology of variant plants are in progress.**

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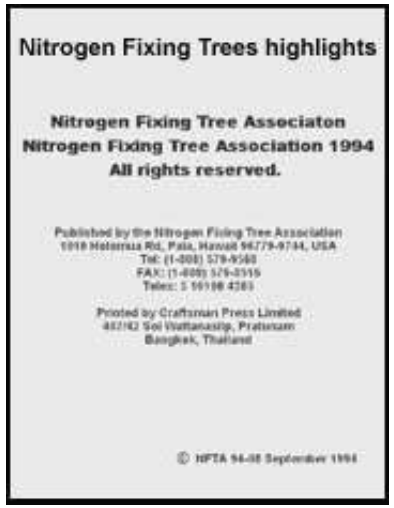
**Nitrogen Fixing Trees Highlights (Winrock, 1990-1997, 100 p.)**

***(introduction...)***

**Acacia koa - Hawaii's most valued native tree**

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- Inga edulis: a tree for acid soils in the humid tropics
- Pithecellobium dulce - sweet and thorny
- Pterocarpus indicus - the majestic n-fixing tree
- Robinia pseudoacacia: temperate legume tree with worldwide potential
- Acacia nilotica - pioneer for dry lands
- Acacia saligna - for dryland fodder and soil stabilization
- Acacia senegal: gum tree with promise for agroforestry
- Acacia seyal - multipurpose tree of the Sahara desert
- Acacia tortilis: fodder tree for desert sands
- Alnus nepalensis: a multipurpose tree for the tropical highlands
- Casuarina equisetifolia: an old-timer with a new future

- **Casuarina glauca: a hardy tree with many attributes**
- **Chamaecytisus palmensis: hardy, productive fodder shrub**
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## Prosopis alba and prosopis chilensis: subtropical semiarid fuel and fodder trees

**Prosopis alba and Prosopis chilensis are native to the semi-arid regions of northwestern Argentina and northern Chile. Locally they are called el arbor or, the tree, because of their widespread occurrence and importance. Since these species**

**have often been confused in the literature, it is useful to treat them together. Once leaf patterns have been observed, differences between species become obvious.**

**BOTANY.**

**Prosopis alba (Grisebach) and P. chilensis (Molina Stuntz) (subfamily Mimosoideae, family Leguminosae) are small to medium-sized trees up to 12 m in height and 1 m in diameter. Both species have thorny and thornless variants. The most distinguishing feature between the two are the number and spacings of leaflets.**

**The trees have compound leaves each with numerous leaflets along several pairs of pinnae. P. alba usually has 2-3 pairs of pinnae (but up to 4 or 5) with 30-50 sets of 10 mm long leaflets per pinnae (Burkart 1976). P. chilensis generally has fewer leaflets per pinnae (about 10-29) and usually no more than two pair of pinnae per leaf. In P. alba, the 1-2 mm wide leaflets nearly touch the pinnae, while in P. chilensis, leaflets are about 1 cm apart.**

**Abundant, greenish-white to yellow flowers occur on spike-like racemes. Pods of both species are beige to offwhite, from which the species name alba, or white, originates. In contrast, other Argentine species have redtinged to dark purple pods (P. flexuosa and P. nigra).**

**The pods of P. alba are typically 20 an long, 4-5 mm thick, and 20-25 mm wide. They are sickle-shaped with the entire pod occurring in the same plane. Although P. chilensis pods are the same color, they are shorter (about 15 cm) and not as wide (about 15 mm). The pods of P. chilensis are seldom flat and have a tendency**

**to be rolled up along the long axis. P. alba pods also usually have a thicker mesocarp indicating a greater pod sugar content. The name P. chilensis has been incorrectly applied to the North American species P. glandulosa and P. velutina, and to the naturalized P. juliflora that occurs in the Sudan.**

**ECOLOGY.**

**Over 20 species of Prosopis occur in the semiarid and arid regions of northwestern Argentina, making Argentina the center of genetic diversity for Prosopis, although probably not the center of origin (Burkart 1976). P. alba is native to the plains and low sierra of subtropical Argentina, extending into Uruguay, Paraguay, southern Brazil, and Peru (Burkart 1976) up to 1,500 m elevation.**

**In Argentina, P. chilensis grows in regions that experience lower winter temperatures and lower rainfall than P. alba (E. Marmillon, pers. comm.). In areas with groundwater between 3 and 10 m below the surface, such as in drainage channels and along groundwater sinks, P. chilensis may occur in areas with less than 250 mm rainfall. If no groundwater is available, annual rainfall must exceed 350400 mm for large trees (25-100 cm diameter) to occur. Trees of both species have been identified that grew in seawater salinity (Rhodes and Felker 1987).**

**Over most of the trees' range the climate is subtropical with annual temperatures averaging about 20°C. In northern Argentina along the border with Paraguay, the frosts are light (-3 or -4°C), but further south near Cordoba occasional frosts of -12°C occur. When grown in Texas, nearly all spineless trees of P. alba froze to ground level with frosts of -12° C. Both species occur in areas that experience**

**45°C, so high temperature stress is not a problem.**

**USES.**

**Wood:**

**The wood of these trees is relatively dense (about 700-800 kg/m³) and makes an excellent fuel whether burned directly or first converted to charcoal (Tortorelli 1956). The timber is valued for furniture, doors, cobblestones, and parquet floors. The reddish/brown wood has a volumetric shrinkage much lower (ca. 5%) than that of other quality furniture woods (ca. 15%). As a result, joints in furniture have much less tendency to open during conditions of changing humidity.**

**Fodder:**

**The pods but not the leaves of the trees are readily eaten by domestic livestock. Pods are high in sugar (about 35%) (Oduol et al. 1986) and contain 10-12% crude protein. Seeds are sometimes ground into a concentrate for animal feed. Large trees, 40 cm in basal diameter and 7 m in canopy diameter, may produce 40 kg of pods under optimal conditions. Because of water constraints, tree spacings must be considerably greater than canopy diameters.**

**Food:**

**The pods of both trees are eaten by native peoples, especially as a ground flour. Contemporary milling techniques and product formulations with Prosopis flour has been described (Sounders et al. 1986). Bees produce honey from the flowers.**

**Other uses:**

**The large size of the trees and more rapid growth than other Prosopis (e.g., P. glandulosa) have led to widespread use of P. alba and P. chilensis for shade, windbreaks, and as ornamentals in Argentina and in Arizona and California, USA. They also contribute nitrogen and organic matter to soils (Johnson and Mayeux 1990). These trees are candidates for erosion control and soil stabilization in arid lands.**

**SILVICULTURE.**

**Establishment:**

**Seeds are difficult to extract from the gummy pulp. Prosopis pods can be ground in a meat grinder after drying pods in an oven at 52°C overnight, which will also serve to scarify the seeds. For good germination seeds require scarification of the seed coat with a file or knife. There are about 36,000 seed/kg.**

**Outstanding trees have been cloned using roofings or cutting techniques that require control over light intensity and air temperatures (Klass et al. 1984). To obtain the highest survival under semi-arid controls, seedlings are grown in long (38 cm) narrow (3.8 x 3.8 cm) cardboard plant bands and planted with the container still on (Felker et al. 1988). Machanical and chemical weed controls to maximize growth are available (Felker et al. 1986).**

**Yield:**

**Biomass yields of trees grown under short rotation systems (3 yrs) on dose**

**spacings (1.5-3.0 m) have been high. Field trials in Texas, USA, using a high productivity P. alba clone, produced 39 dry metric tons/ha in three years at a site with 650 mm annual rainfall (Felker et al. 1989). Trees grew about 2.2 m in height per year. However, excellent weed control coupled with mechanical cultivation was required to achieve these high yields.**

**SYMBIOSES.**

**A single rhizobia strain that effectively nodulated 13 Prosopis species (Felker and Clark 1980) is available from LiphaTech (3101 West Custer Ave., Milwaukee, Wisconsin 53209). Rhizobium for Prosopis species is also available from NifTAL through NFTA.**

**PROBLEMS AND PESTS.**

**Twig girdling insects (Oncideres spp.) cause minor damage to these trees. An undescribed "disease" causes the terminal shoots to die. Over a period of years this necrosis gradually spreads downward and eventually may kill the entire tree. These Prosopis can become weeds in heavily grazed areas.**

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**Inga edulis: a tree for acid soils in the humid tropics**

**Pithecellobium dulce - sweet and thorny**

**Pterocarpus indicus - the majestic n-fixing tree**

**Robinia pseudoacacia: temperate legume tree with worldwide potential**

**Acacia nilotica - pioneer for dry lands**

**Acacia saligna - for dryland fodder and soil stabilization**

**Acacia senegal: gum tree with promise for agroforestry**

**Acacia seyal - multipurpose tree of the Sahara desert**

**Acacia tortilis: fodder tree for desert sands**

**Alnus nepalensis: a multipurpose tree for the tropical highlands**

**Casuarina equisetifolia: an old-timer with a new future**

**Casuarina glauca: a hardy tree with many attributes**

**Chamaecytisus palmensis: hardy, productive fodder shrub**

**Dalbergia latifolia: the high-valued Indian rosewood**

**Dalbergia melanoxylon: valuable wood from a neglected tree**

**Erythrina edulis: multipurpose tree for the tropical highlands**

**Erythrina sandwicensis - unique Hawaiian NFT**

- **Hippopha rhamnoides: an NFT valued for centuries**
- **Leucaena diversifolia - fast growing highland NFT species**
- **Leucaena: an important multipurpose tree**
- **Olneya tesota - a potential food crop for hot arid zones**
- **Honey mesquite: a multipurpose tree for arid lands**
- **Pongamia pinnata - a nitrogen fixing tree for oilseed**
- **Guazuma ulmifolia: widely adapted tree for fodder and moreli**
- **Faidherbia albida - inverted phenology supports dryzone agroforestry**
- **Gleditsia triacanthos - honeylocust, widely adapted temperate zone fodder tree**
- **Andira inermis: more than a beautiful ornamental tree**
- **Erythrina poeppigiana: shade tree gains new perspectives**
- **Albizia procera - white siris for reforestation and agroforestry**
- **Albizia odoratissima - tea shade tree**
- **Adenanthera pavonina: an underutlized tree of the humid tropics**
- **Acacia mangium: an important multipurpose tree for the tropic lowlands**
- **Acacia auiculiformis - a multipurpose tropical wattle**
- **Pentaclethra microphylla: a multipurpose tree from Africa lwith potential for agroforestry in the tropics**

## Sesbania sesban: widely distributed multipurpose NFT

**Sesbania sesban is a many-branched, soft-wooded tree that grows rapidly and is useful for fodder and green manure. This species has long been used for browse and soil improvement in India and Africa. Recent interest in multipurpose, nitrogen fixing trees has caused it to be collected, studied, and recommended for fodder ''banks" and alley cropping.**

### Botany

**Sesbania sesban (L.) Merrill is a tree that grows to 8 m height. This papilionaceous (pea-like flowered) legume bears racemes of 4-20 yellow flowers that may be lightly to heavily streaked with purple. Sesbans have pinnate leaves with 20-50 opposite pinnules on a rachis 3-12 cm long. The leaf rachis and the underside of the leaflets are often pubescent. The pods are usually 10-20 cm long**

**and contain up to 40 seeds that are brown, or dark green mottled with black. The trees usually have one main stem, but they may develop many side branches if they have space. Sesban's many branches often give the tree a shrubby appearance. It tends to have a spreading habit due to its wide branching angle (as wide as 4560°).**

**Within its genus, sesban is classified in the subgenus Sesbania, and thus is more closely related to the annual sesbanias grown far green manure (such as S. cannabina, others?) than to the - other well known perennial species of the genus, S. grandiflora, which is in the subgenus Agati (Evans 1990). Several varieties of sesban are recognized. The botanical distinctions among sesbanias are often difficult far non-botanists to see, and sometimes sesban is confused with the annual types of sesbania.**

## Ecology

**Sesban occurs naturally in semiarid to subhumid areas with 5002000 mm of rainfall. It seems to do well under bimodal rainfall distributions, where heavy rains and even flooded conditions are followed by a pmgressively drier season. It grows from sea level to 2000 m elevation, but the upper limit is uncertain. It does not tolerate frost. It is uniquely well adapted periodic waterlogging and flooding. Soil alkalinity and salinity is tolerated to a considerable degree. Some research suggests that certain sesban types may grow well on acidic soils. Sesbans are relatively short-lived, and under intensive browsing or cutting management will not last more than 3-5 years. Their rapid seedling growth is conducive to short-term fallows and to replanting if management should reduce growth vigor.**

## Distribution

**Sesban is found throughout the tropical and subtropical parts of Africa, Asia, and Australia It is not widely distributed in the Americas. Africa is its center of diversity, and sesban probably originated there; its former name is S. aegyptiaca. From northeastern Africa, S. sesban var. sesban and its variants were spread across southern Asia, possibly by man. Within Africa, S. sesban var. nubica is the type most commonly found, and there arc several sesbanias closely related to sesban, such as S. goetzei and S. cinerascens (Gillett 1963).**

From A. Cronquist (1954), "Galegeae," *In* Flore du Congo Belge et du Ruanda-Urundi, Vol. 5, p. 77, Brussels.

**Sesbania sesban**

## Uses

**Sesban is mostly used as fodder and for soil improvement. its wood is used only to a lesser extent (Evans and Macklin 1990).**

**Fodder.**

**The leaves and tender branches of sesban are high in protein (20-25% crude protein) and have high digestibility when consumed by ruminants, such as cattle and goats. Antinutritional factors are suspected to be present in sesban fodder. Feeding sesbania fodders to monogastric animals (such as chickens, rabbits, and pigs) is not recommended.**

**Reports of feeding sesban to ruminants conflict. Trials in Australia feeding sesban to heifers showed live weight gains, but trials with young goats in Samoa found a lack of weight gain. Until further research provides clear guidelines, caution should be used in feeding ruminants with sesban fodder at more than 10-20 percent of diet.**

**Soill lmprovement.**

**Sesban establishes quickly and grows rapidly. In Africa it is often allowed to grow scattered throughout annual crop fields for the nitrogen it provides. It has been used in experimental alley cropping systems to provide mulch and greenleaf manure to intercrops. Sesbans can be somewhat shallow rooted, and may compete with adjacent crops.**

**Wood.**

**Sesban's wood is light in weight compared to the woods of Calliandra and Leucaena, but it is often harvested for firewood in Africa and India It has been used in India to make charcoal. The wood is not durable and should not be considered for timber use. The branches have been used as poles in temporary structures such as sheds and mud daub huts.**

**Because sesban grows so rapidly, it has potential for pulpwood production. Plantings at about 10,000 tree/ha have produced 15-20 tons of woody biomass (dry weight) in one year.**

**Food.**

**Flowers of sesban are known to be added to stews and omelets in some regions, perhaps mainly as a decorative element.**

**Other uses.**

**Various medicinal uses for sesban have been recorded in Africa and Asia (Evans and Rotar 1987, Evans and Macklin 1990). The leaves and flowers are used in medicinal poultices and teas. which are said to have the effect of astringence, or contraction of body tissues. Bark exudates from sesban produce a gum of medium commercial quality.**

**Culture and Management**

**Sesban is generally propagated from seed, although it has been rooted from cuttings, and research has revealed that it can be established by tissue culture. Seed scarification usually improves germination. Recommended hot water scarification is a 30second dip in water heated to just below boiling. Seed weights range from 55-80 per gram for S. sesban var. sesban to 80-130 per gram for var. nubica.**

**Plants grown for fodder production can be placed as close as 30-50 cm apart in rows 1 m apart. Appropriate distances between rows in alley cropping will depend**

**on the variety grown, the ecology of the site, and intensity of management.**

**Experimental fodder cutting trials have yielded 20 tons/ha dry matter in the first year. However, sesban cannot be managed with the severity that Leucaena tolerates in fodder and wood biomass production systems. If sesban is cut too low (below 50-100 cm) or too frequent (more than 4-6 cuttings per year) death of the plants can result. When cutting sesban it is recommended to leave 10-25% of the foliage on the plants.**

**In some climates, such as the highlands of Kenya, sesban may have a sparse canopy and weed competition can be a problem. This characteristic makes sesban a good intercrop. Sesban has been grown with the fodder grass Brachiaria mutica in India, and to provide shade to young coffee plants in Kenya In climates where sesban grows more vigorously, weeds are shaded out and companion plants may be adversely affected; this type of growth has been observed in Hawaii and Jamaica (Roshetko et aL 1991).**

**Symbiosis**

**The rhizobia strains that nodulate sesbanias are somewhat specialized and may not be present where sesbanias have not been grown previously. Test plantings should be done to see if effective rhizobia are present in the soil. If not, use of a rhizobia inoculant at planting will be necessary.**

**Limitations**

**Sesban is not a tree for timber or reforestation in the ordinary sense of forestry or silviculture. Because the range of its ecological adaptability is not yet well known,**

**test plantings should be done before large-scale plantings are planned. Sesban has been observed occasionally to die back under cutting management; fungal infection may be the cause. Leaf-feeding insects sometimes limit production. Seed chalcids can reduce seed recovery.**

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