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

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- Acacia leucophloea - shade and fodder for livestock in arid environments
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Dalbergia latifolia: the high-valued Indian rosewood

Dalbergia latifolia is a premium-quality timber species internationally known as "Indian Rosewood". It is used to manufacture furniture, paneling, and other ornamental products Medicines and an appetizer are made from tannins in the bark. The tree is commonly called sitsal, beete, shisham or Bombay blackwood in India, and sonokeling or sonobrits in Indonesia.

BOTANY.

Dalbergia latifolia Roxb. (Leguminosae, subfamily Papilionoideae) is predominantly a single-stem deciduous tree with a dome shaped crown of lush green foliage. On wet sites it may remain evergreen. The trees reach a height of 20-40 meters with a girth of 1.5 - 2.0 meters (Prasad et al, 1993). Leaves are alternate, odd-pinnate with 5-7 unequal-sized leaflets originating from the same rachis. Leaflets are broadly obtuse, dark green above and pale below. Flowers are white in axillary panicles, 0.5-1.0 cm long. The brown pods are oblong-lanceolate and pointed at both ends. They contain 1-4 smooth brown seeds and do not open at maturity. The bark is grey, thin with irregular short cracks, exfoliating in fibrous longitudinal flakes (Troup, 1921; Kadambi, 1954). The root system is well developed, consisting of deep tap roots and long lateral roots When near the soil surface, roots produce suckers.

ECOLOGY.

The annual rainfall in D. Iatifolia's native habitat ranges from 750-5000 mm. As a seedling D. latifolia is shade tolerant but sensitive to drought and fire. In maturity, it is tolerant of drought and ground fire, but susceptible to crown fire. It is classified as a moderate light demander (Troup, 1921). Establishment is restricted by frost. It survives maximum temperatures of 37°-50° C, minimum temperature of 15° - 0° C, and relative humidity of 40-100 percent. Dalbergia latifolia occurs from the low plains to roughly 1500 m (Kadambi, 1954). It commonly grows with Tectona grandis, Terminalia sp., Anogeissus latifolia and bamboos.

This species grows on a variety of soil formations including; gneiss, trap, laterite, alluvial, and boulder deposits. It grows best on welldrained, deep, moist soils. Dalbergia latifolia is common on deep loams or clays containing lime. It also grows well on black cotton soils. Shallow dry soils and poor drainage stunt tree growth.

DISTRIBUTION.

The natural range of Dalbergia latifolia stretches from the sub-Himalayan tract to the southern tip of India and the island of Java in Indonesia (Kadambi, 1954). Its best growth occurs in the Western Ghat forests of Karnataka, Kerala, and Tamil Nadu. It has been introduced to Burma, Sri Lanka, Nepal, Nigeria, and Kenya (Kadambi, 1954).

USES.

Wood.

The sapwood of D. Iatifolia is pale yellowish-white often with a tinge of purple.

Heartwood varies in color from light golden brown to shades of light purple with dark streaks, or deep purple with distant black lines. The heartwood darkens with age and weighs about 850 kg per cubic meter. The wood is very hard with no distinct annual rings. It is difficult to work because of its high density. The wood is fragrant and commands a high price. It is used to make premium-grade furniture, panelling, veneers, and interior and exterior joinery Secondary uses of the wood include; knife handles, musical instruments, calico-printing blocks, mathematical instruments, agricultural implements, and boats keels and screws.

Agroforestry.

Dalbergia latifolia is a popular agroforestry species in Indonesia. Trees are spaced widely, 3 x 1 to 6 x 2 m, with intercrops of upland rice, maize, beans, or cassava during the first three years. In other systems D. latifolia is planted with mango, annona, jackfruit, and guava. When the tree canopies begin to close, shade tolerant crops, like turmeric and ginger, are underplanted (Sukandi, 1993). Farmers use the nitrogenrich foliage of D. latifolia as a green manure and fodder.

Leaves, flowers and pods of Dalbergia latifolia

Medicinal uses.

Tannins from the bark are used to produce medicines for the treatment of diarrhoea, worms, indigestion, and leprosy. These tannins also produce an appetizer.

SILVICULTURE.

Propagation.

Under natural conditions, D. Iatifolia reproduces by seed, root sucker or coppice.

Artificial reproduction is common by seed, root cutting, and stump sprout. Direct seeding is possible under moist conditions with good weed control. Root cuttings can be planted directly in the field or raised in a nursery for future transplanting.

Fresh seed germinates at 50-75% within 7-21 days of sowing. Stored in gunny sacks or earthen pots, seed remains viable for six months (Kadambi, 1954). Seed viability can be extended to 9-12 months by drying seeds to 8% moisture content and storing them in airtight containers, however, germination will decrease to 30-40%. One kilogram contains 21,000 seeds (DITSI, 1980).

Although no seed treatment is necessary, soaking seed in coot water for 12-24 hours will hasten germination. Nursery grown seedlings are transplanted to the field after 6 months in Java (DITSI, 1980) or 12 months in India (Kadambi, 1954).

Root cuttings should be taken from trees that are at least 5 years old. Recommended length of cuttings is 20 cm with a diameter of 1-2 cm. Keep cuttings at room temperature for three days before planting them in either nursery beds or polyethylene bags (Soekeri, 1979). Eighteen cm of the cutting should be planted below the soil surface with 2 cm above. Transplant cuttings to the field after 6 months in the nursery (DITSI, 1980).

Dalbergia Iatifolia can be quickly established by stump sprouts. Stumps are made from seedlings of seed or cutting origin. Stump roots and shoots should be 4.5 cm and 2.5-4.0 cm long, respectively. Rootcollar diameter should be 05-15 cm (Deshmukh, 1975). Planting must coincide with heavy rains or survival will be low.

Management.

As pure stands, D. Iatifolia is spaced at 1.2 x 1.2 to 1.8 x 1.8 m (Deshmukh, 1975) or 2 x 1 to 25 x 1 m (Japing, 1936 in Kadambi, 1954). Wider spacing may produce crooked stems. For agroforestry systems spacings of 3 x 1 to 6 x 2 m are common (Sukandi, 1993). Trees are usually harvested in 30 40 years. In Java, to obtain 30 cm of heartwood a 50 year cutting cycle is recommended (DITSI, 1980). Dalbergia latifolia is generally managed by clear felling followed by artificial regeneration. After planting or direct sowing, regular weeding is necessary until trees dominate weed competition. Loosening soil around seedlings also improves growth. Weeding and soil loosening should be done before weeds become dense. The sudden removal of heavy weed growth from around seedlings may cause death from exposure (Kadambi, 1954).

Growth and Yield.

Fertilization, soil moisture conservation and weed control enhance the typically slow growth of this species. In a 25 year old plantation in Purwakarta, West Java average diameter breast at height (1.30 m above the ground) was 26.1 cm and tree height 203 m (Sukandi, 1993). A maximum diameter growth of 3 meters has been reported in Karnataka, India (Prasad et al., 1993).

SYMBIOSIS.

Dalbergia Iatifolia is known to be a nitrogen fixing tree. However, studies on the symbiosis of this species with Rhizobium bacteria have not been made.

VARIETIES.

In Java, two varieties of D. Iatifolia are recognized. The native variety, called sonokeling, seldom produces seeds. The naturalized variety of Indian-origin, called sonobrits, produces seed yearly.

LIMITATIONS.

Dalbergia Iatifolia is very susceptible to crown fires, a common danger throughout the dry ecosystems it occupies. Trees are commonly attacked by fungi (Fusarium. spp.) termites and browsing wild animals (Kadambi, 1954; Suharti and Hadi, 1974). Unfortunately, little is known concerning management options for these pests.

TREE IMPROVEMENT.

Tree improvement programs for D. Iatifolia should involve the selection and breeding of specimens with excellent timber/furniture characteristics. Selection of superior genotypes have been made and an experimental seed orchard established in Karnataka. In-situ conservation has been initiated at Nagarahole, Coorg, India. For more information contact the lead author.

RELATED SPECIES.

Dalbergia sissoides, another endemic species to the western Ghats of India, is closely related to D. Iatifolia. Its wood is not distinguished from that of D. Iatifolia in trade; but it is stronger, harder, and lighter in color with more streaks The wood of D. sissoides does not take as high a polish as the wood of D. Iatifolia, but it commands a high market price for use in premium-grade furniture and cabinets (Prasad and Shilalingadaradhya, 1988).

References:

Deshmukh, D.K 1975. Regeneration of Rosewood (Dalbergia latifolia, Raxb.) Myforest 11 (2):87-93.

Direktorat Reboisasi den Rehabilitasi (DlTSI). 1980. Pedoman Pembuatan Tanaman. Jakarta: DITSI, Ditjen Kehutanan. pp. 75-84.

Kadambi, K. 1954. The silviculture of Dalbergia latifolia. Monograph of Indian trees, No. 1. Government of India, Manager of Publications, Delhi.

Prasad, A G.D. and M.V. Shilalingadaradhya. 1988; Distribution and economic potential of Dalbergia in Karnataka. Myforest 24 (4): 241-47.

Prasad, A G.D., K.S.J.. Chandra and A N.Y. Reddy. 1993. Initiation of a genetic improvement program for Dalbergia Iatifolia in Kamataka India. Paper presented at the International Dalbergia Workshop, 31 May - 4 June, 1993. Hetauda, Nepal.

Soekeri. 1979. A possibility on modification of the sonokeling planting technique. Duta Rirnba 5 (35): 20-26.

Suharti, M. and S. Hadi. 1974. Wilt diseases of Dalbergia Iatifolia in KPH Malang, East Java. Lembaga Penelitian Hutan Report No. 194 (In Indonesian with English summary). Lembaga Penelitian Hutan, Bogor, Indonesia.

Sukandi, T. 1993. Agroforestry-based plantations of Dalbergia latifolia, Roxb. in Java, Indonesia Paper presented at the International Dalbergia Workshop, 31 May - 4 June, 1993. Hetauda, Nepal.

Troup, R.S. 1921. The silviculture of Indian trees, Vol. I. Oxford, Clarendon. pp.318-325.

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casuarina

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Dalbergia melanoxylon: valuable wood from a neglected tree

Dalbergia melanoxylon produces one of the finest timbers in the world. Known in Tanzania as African ironwood, African ebony, mpingo, poyi or mugembe (Brenan and Greenway, 1949; Gillet et al., 1971; Noad and Birnie. 1989), round logs of this species fetch up to US$18,000/m. Yet the trees are seldom planted and little is known about their silviculture.

Botany

Dalbergia melanoxylon Guill. & Perr. (Leguminosae subfamily Papilionoidae) is a small, heavily branched tree, typically 4.5 to 7.5 m tall but occasionally reaching

15 m. The bole is fluted with high narrow ribs separated by deep indentations. Bole length occasionally reaches up to 3.6 m, but normally ranges from 1.2 to 1.8 m. Average diameter at breast height (dbh) at maturity is less than 38 cm, although trees have been found with a dbh of more than 60 cm. The bark is pale gray to grayish-brown, papery, fairly smooth, and flaking in long narrow strips (Bryce, 1967). The stems are often crooked.

Dalbergia melanoxylon Guill. and Perr., from I.R Dale and P.J. Greenway. 1961. Kenya trees and shrubs. Nairobi: Buchanan's Kenya Estates Ltd. p. 361.

Branchlets are clustered at the nodes. Some grow out, while others are short and spine tipped. They are covered at first with short crisp hairs, and are usually glabrous. Leaves are alternate, pinnately compound and 6 to 22 cm long. The

fragrant white flowers are 6 to 9 cm long, occurring in dense clusters. There are usually nine stamens, united or variously divided. Pods are elliptic oblong or irregularly oblong, bluntly pointed, flat and thin. They range from 3 to 7 cm long and 0.8 to 1.4 cm wide. They tend to be papery, glabrous, and laxly and rather diffusely veined, with one or two seeds.

Ecology

Dalbergia melanoxylon grows under a wide range of conditions including semi-arid, subhumid and tropical lowland areas. It is often found on dry, rocky sites at elevations from sea level to 1200 m, but is most frequent in the mixed deciduous forests and savannas of the coastal region. The mean minimum temperature in its native range is 18°C and the maximum is 35°C, with no frost. Annual rainfall averages 700 to 1200 mm, often distributed in a bimodal pattern of three to six months. Soils vary from loamy sands to clayey vertisols ("black cotton soils"). The species is water and light demanding; it is common near water and will not regenerate under heavy cover. Mature trees are fire tolerant.

Distribution

Dalbergia melanoxylon is widely distributed in Africa, from Senegal across to Sudan, Eritrea and northern Ethiopia, Uganda and Kenya. To the south, it ranges from Angola to Zambia, Tanzania and Mozambique, as far south as the Transvaal (Gillett et al., 1971; Redhead and Temu, 1981).

Uses

Traditional uses include fuelwood and charcoal, as well as pestles, combs, knife

shafts, cups and farming implements.

Timber.

The sapwood is white or yellowish-white, often 12 cm wide, and sharply differentiated. The heartwood is purplish black, sometimes darker towards the outside, with light streaks and not always uniform in color. The timber is slightly oily, exceptionally hard and heavy, brittle and somewhat fissile. The heartwood is extremely durable (specific gravity not yet determined) and resistant to all forms of biodeterioration. The sapwood, however, is susceptible to fungal or insect attack (Bryce, 1967). The dry wood is difficult to saw or plane. It blunts saws and cutters and cannot be nailed or screwed without drilling. It is, however, the finest of all turnery timbers, cutting exactly and finishing to a brilliantly polished, lustrous surface, dry and cold to the touch.

Fuelwood.

The calorific value of the sapwood and heartwood is more than 49,000 Kcal/kg. Heat generation is so high that fires of D. melanoxylon have been reported to melt cooking utensils.

Specialized uses.

The wood of D. melanoxylon is used in carving, turnery and marquetry to produce sculptures, musical instruments, ornaments, inlays, chess pieces. walking sticks, gearings and many other products. The main industrial use, long supporting an export trade from East Africa and Mozambique, is the manufacture of musical instruments, especially woodwinds. With its high density and fine texture. D.

melanoxylon wood produces a beautiful musical tone. It is stable, stands up to metal-working processes, and takes an excellent finish (Bryce. 1967).

The roots are used in traditional medicines to treat abdominal pain, diarrhea and syphilis. The smoke is inhaled to treat headaches and bronchitis. The pods and leaves can be used as animal fodder.

Silviculture

Seed treatment.

Seeds (about 42,000/kg) generally remain viable for only a few months, although viability could probably be increased by storage in sealed containers. Seed extracted from pods germinates readily without treatment. However. few seedlings attain maturity under natural conditions due to fire and drought (Mugasha. 1978).

Establishment.

In Tanzania. D. melanoxylon has not yet been planted extensively. Experimental work suggests that survival and growth are improved by planting two-year-old stumps that are 14 cm long, comprising 12 cm of root and 2 cm of shoot. These should be planted in the early or middle rainy season, followed by intensive weeding. Potted seedlings may also be used, but they tend to grow more slowly (Mugasha, 1983). When seedlings are raised in pots, frequent root pruning is mandatory. Delayed pruning leads to seedling shock. Advanced plant-production techniques, such as tissue culture or use of growth hormones, have not been tested.

Management.

Field trials are currently exploring suitable spacing for D. melanoxylon plantations. An initial spacing of 2 x 2 m results in good branching characteristics, while later thinning improves growth. Stem form is improved by raising the trees under medium shade provided by Pinus caribaea Morelet (Nshubemuki, 1983).

Thorough weeding is important at the initial phase of establishment. After 7.5 years, trees planted early in the rainy season on thoroughly weeded plots averaged about 30% taller than trees planted at the same time but only lightly weeded. Trees planted in the middle of the rainy season and thoroughly weeded were taller still-about 45% taller than those planted at the beginning of the rains and lightly weeded (Mugasha, 1983). Intensive weeding is crucial until root-collar diameters measure about 5 cm. Alternatively, the area around the trees should be slashed until root-collar diameters measure 8 to 10 cm. The species is extremely slow growing: trees obtain timber size in 70 to 100 years. Studies on mycorrhizal associations have not been initiated.

Pests and diseases.

Heart rot is observed on some logs, apparently associated with fungal infection following fire damage. Small game may feed on young shoots and leaves.

Limitations

Dalbergia melanoxylon is not gregarious and may be difficult to establish in pure plantations. Rapid loss of seed variability might also make it difficult to establish plantations in new areas. Difficulties in working the wood call for specialized

techniques. perhaps not feasible for cottage industries.

Logs are almost invariably defective and the wastage is considerable in conversion to top-grade dimension stock. End checks appear soon after felling and star shakes develop unless end coatings are applied immediately. Seasoning may take as long as two to three years after pieces are rough sawn.

Future research needs

Dalbergia melanoxylon occurs in three of the four drainage basins found in Tanzania. Observed differences in growth habits suggest the existence of clinal variation resulting from genetic, topographic and ecological influences. Selections for characters such as fast growth. wood quality, volume production and stem straightness have considerable potential. Studies of provenance variation related to end use should form the basis for in-situ and ex-situ conservation.

Research would be useful on improved methods to increase seed viability and shorten the seasoning period. Symbiotic relationships also need to be explored and quantified. HybridCation with related species, such as D. sissoo, should be initiated.

References

Brenan, J.P.M. and Greenway, P.J. 1949. Check lists of the forest trees and shrubs of the British Empire. Part 5: Tanganyika Territory. Oxford (UK): Imperial Forestry Institute. p 418.

Bryce, J.M. 1967. The commercial timbers of Tanzania. Moshi (Tanzania): Tanzania

Forest Division, Utilization Section, p. 139.

Gillet, J.B., Polhill, R.M. and Verdourt, B. 1971. Flora of tropical East Africa. Part 3: Leguminosae, sub-family Papilionoidae.

Mugasha, A.G. 1978. Tanzania natural forests' silvicultural research: review report. Tanzania Silviculture Technical Note (New Series) 39, p. 41.

Mugasha, A.G. 1978. The effects of planting season, different planting materials and weeding methods on early performance of Dalbergia melanoxylon at Kwamarukanga, Korogwe, Tanzania. Tanzania Silviculture Research Note 43,p. 14.

Noad, T. and Birnie, A. 1989. Trees of Kenya. Nairobi: General Printers, p. 219.

Nshubemuki, L. 1993. Recent research progress in the silviculture of Dalbergia melanoxylon in Tanzania. Paper presented to the International Workshop on Dalbergia species, 31 May to 4 June, Hetauda, Nepal.

Redhead, J.F. and Temu, A.B. 1981. Valued timber but neglected tree: mpingo (Dalbergia melanoxylon). Tanzania Association of Foresters Newsletter. 2:8-9.

Tack, C.H. 1962. Nomenclature of East African timbers. Nairobi: East African Timber Advisory Board, p. 16.

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Erythrina edulis: multipurpose tree for the tropical highlands

Cultivated for centuries, Erythrina edulis is an important food source for humans and animals in the tropical highlands of South America. The seed is a component of many diets, and the trees also provide shade in coffee and cacao plantations, support for vine crops, green manure, live fenceposts' wood for construction and fuel, and medicinal preparations.

Botany

Erythrina edulis Triana ex M. Micheli is one of about 115 Erythrina species in the subfamily Papilionoideae of the Leguminosae (syn. Fabaceae) family. Over a normal life span of 30 to 40 years, the leafy trees grow up to 14 m tall with stem diameters up to 37 cm and crown diameters up to 7 m. The stem and branches are covered with stout prickles. The alternate leaves are trifoliate with long petioles and two nectar-producing glands at the base of each leaflet. The flower cluster

(raceme), 'supported on a stout stalk, consists of 180 to 200 short-stalked flowers arranged in threes around the axis. The flowers have a reddish-green calyx and a crimson corolla with an upper petal (standard) and two lateral petals forming the keel. The pistil is surrounded by 10 stamens. The two-petaled flowers face upward. forming a large cup in which nectar gathers (Ruskin, 1989).

Erythrina edulis is cross pollinated by sucking insects, bees, wasps and birds. Seeds mature 65 days after flowering. Fruits hang in bunches of 9 and 18 cylindrical pods. Pod size varies widely, but averages 32 cm long and 3 cm in diameter with six seeds. The seed coat is generally brownish-red but is sometimes yellow or black (Acero, 1989).

Distribution

Erythrina edulis is distributed from Mrida in Venezuela, to the mountain ranges of Colombia and the Andes mountains of Ecuador, Peru and Bolivia. It is commonly known as chachafruto, bal, basul or sachaporoto in Colombia, guato in Ecuador, and pashuro, pajuro, basul sachaporoto or sacha purutu in Argentina and Bolivia (Ruskin, 1989).

Ecology

Erythrina edulis is a pioneer species that grows best in full sunlight, but trees can tolerate some shade in the early stages of growth. In Colombia the species occurs from elevations of 1200 to 2600 m, with an optimum range from 1600 to 2200 m. In Peru, E. edulis grows from 900 to 3200 m (Martel, 1989). In the species's native range, annual rainfall varies from 450 to 1800 mm and temperatures are

between 5 and 25 C. The trees grow well in loose-textured sandy loams and in heavy clay soils. They do not tolerate frequent frosts.

Uses

Human food.

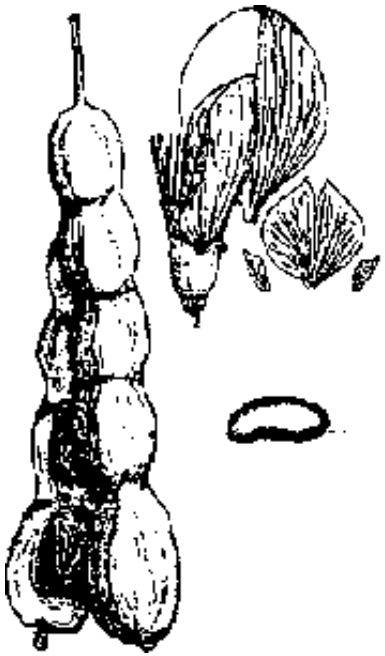
The seeds contain 23% protein, 1% fat, 8% crude fiber and 84% moisture. They have a good balance of amino acids and a digestibility after cooking of about 50%. Seeds must be boiled at least 45 minutes or fried thoroughly before being eaten. As a paste, they provide a nutritious base for tortillas, desserts, pies, soups and food for infants. They are also boiled. sun dried, ground and added to flour. Research indicates that uncooked E. edulis seeds can be toxic if consumed over a long period (Perez et al., 1979). Seeds of all other Erythrina species are highly toxic.

Forage.

The leaves and tender branches can be fed to cattle, goats, horses, pigs, guinea pigs and rabbits. Leaves contain 24% protein. 29% crude fiber (dry weight) and 21% total carbohydrates. They are rich in potassium but low in calcium (Surco, 1987). Seeds and pods can be fed fresh to cattle and goats, but should be cooked before feeding to pigs, chickens, rabbits or fish. The pods contain 21% protein, 23% crude fiber (dry weight), 24% carbohydrates and 91% moisture. Cooked seed can replace up to 60% of the concentrate fed to chickens and fish (Martin and Falla, 1991).

For maximum fodder production, the trees can be planted in protein banks at a

close spacing (1.0 x 0.5 m). They are first pruned at 10 months and then at six- or four-month intervals. A two-year-old protein bank can produce up to 80 tons of leaves and tender branches per ha, or the leaves can be dried and ground to produce 6 tons of chicken feed rich in carotene (Vargas and Ocarnpo, 1991).



Erythrina edulis pod, flower and seed. Not to scale. Prom Krukoff and Barneby (1974) and Martel (1989).

Shade and support.

Erythrina edulis is widely used as a shade tree for coffee or as a support for vine crops such as pepper, betel and grape. In Colombia, trees are spaced at 6 x 6 to 8 x 8 m in coffee plantations or 5 x 5 m with vine crops (Vargas and Ocampo, 1991). Annual pod production from three- to four-year-old trees at a 6 x 6 m spacing can average 30 kg/tree or 8 tons/ha (green weight); annual pod production from 20-

year-old trees can average 177 to 211 kg/tree.

Live fenceposts.

In Colombia, live fenceposts are established from stakes at 2-m intervals and allowed to grow for 30 months before pruning or attaching barbed wire. Stakes should be at least 4 to 6 cm in diameter and 2 m long. Pruned at fourmonth intervals, leafy branches from I km of fencing can provide up to 30 tons of fodder per year; unpruned, the same fenceposts can provide up to 85 tons of fruit (Vargas and Ocampo, 1991).

Medicine.

In Colombia, a soap made from the bark, branches and leaves of E. edulis is used to wash dogs with skin disease. In Peru, the seed is mixed in a liquid concoction to treat inflammation of the bladder. The flowers are used to treat eye irritations (Acero, 1989).

Sllvlculture

Seed treatment.

Erythrina edulis is easily propagated from seed or cuttings, but seedlings tend to root deeper and live longer than cuttings. Seed should be removed from pods immediately and stored in paper bags in a cool, dark place. They lose viability quickly and should be planted within eight days of harvesting. Viability can be extended up to 20 days by dipping seeds for a moment in molten paraffin so that a thin layer of paraffin coats the entire seed. Seed size varies widely: Acero (1989)

reports 60 fresh seeds per kg in Colombia, while Martel (1989) reports 146 fresh seeds per kg in Peru.

Establishment.

Larger seeds tend to produce more vigorous seedlings. Plant seeds in l-kg polyethylene bags with the convex side facing upwards and slightly exposed. Leave room between planting bags to allow space for leaf development (Vargas and Ocampo, 1991). Germination begins in 5 to 10 days. Shade the seedlings in the nursery and reduce shade partially in the last two weeks before outplanting. At 60 days, seedlings may be planted out in holes 30 cm deep.

Erythrina edulis can also be direct seeded. Cultivate the soil thoroughly to a depth of 30 cm and plant two seeds per hole. Thin to one seedling after four or five weeks. Weed periodically in a 1-m circle around the plants. Seedlings grow rapidly (2.5 m in the first year) and begin producing fruit in approximately 24 to 27 months.

Cuttings of 4 to 6 cm diameter, and usually 1 m in length, should be planted to a depth of 30 to 50 cm within three days of harvesting (Vargas and Ocampo, 1991). Cuts should be made with well-sharpened tools to avoid damage that can lead to rotting; the top cut should be at a 45 angle. Sealing the cuts with paraffin, plastic, mud or other material can increase survival rates. Cuttings begin producing fruit about 18 months after planting.

Erythrina edulis forms a nitrogen-fixing symbiosis with Rhizobium in the cowpea miscellany (Acero, 1989). Large nodules form in the upper soil surface and

decrease in size with increasing soil depth.

Limitations

Erythrina edulis does not tolerate long periods of drought, especially during early stages of establishment. It does not grow well in strongly acidic soils (pH below 4.5). Stem borers damage terminal shoots and cause lateral branching. Butterfly larvae (Terastia meticulosalis) bore into seeds. Trees are also susceptible to nematodes (Helicotylenchus sp., Hoplotylus sp. and Meloidogyne sp.) (Francia Varon de Agudelo, personal communication).

Future research needs

The large differences observed in seed size suggest the existence of genetic variation. Rangewide provenance collection and testing is needed to determine differences in fruit yield, biomass production, nutrient content and adaptability. Research would also be useful on improved methods to increase seed viability. Symbiotic relationships need to be explored and quantified. Finally, traditional agroforestry uses of E. edulis and pest and disease management need further documentation.

References

Acero, E. 1989. Informe final silvicultura y productividad del chachafruto Erythrina edulis. Part 1. Bogota: Universidad Distrital-CIID-CONIF.

Krukoff, B.A. and Barneby, R.C. 1974. Conspectus of species of the genus Erythrina. LLOYDIA (Journal of Natural Products).37:359.

Martel, A. 1989. Erythrina edulis Triana, especie de gran potencial Papa asociaciones agrofrestales: advances de su propagatin. Technical Note 01. FAO/Holland/DGFF Project, 30 pp.

Martn, D. and Falla, J.A. 1991. Evaluacin de los efectos biolgicos de la sustitucin de concentrado por harina de chachafruto Erythrina edulis (15 y 30%) en la alimentacin de pollos de engorde bajo un esquema de produccin de economa campesina. Thesis in Zootechnology. Valle (Colombia): Universidad Nacional de Colombia-Palmira.

Patio, J.E.. 1992. Suplementacin de cabras con chachafrutoErythrina edulis. Thesis in Zootechnology. Valle (Colombia): Universidad Nacional de ColombiaPaimira.

Prez, G., de Martinez, C. and Daz, E. 1979. Evaluacin de la calidad de la protena del chachafruto Erythrina edulis. Bogot: Universidad Nacional de Colombia.

Ruskin, F.R. 1989. Basul. In Lost crops of the Incas. Washington, DC: National Academy Press, pp. 164 71.

Surco, J. 1987. Evaluacin de minerales nutricios en las semilla de Erythrina edulis. Cuzco (Peru): Universidad Nacional San Antonio Abad del Cuzco.

Vargas, L.R. and Ocampo, M.P., eds. 1991. El chachafruto o bal protector de aguas y suelos superalimento humano, forraje para el ganado. Extension Bulletin 7. Bogot: Federacin Nacional de Cafeteros de Colombia, p. 22.

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Erythrina sandwicensis - unique Hawaiian NFT

Erythrina sandwicensis, commonly known as wiliwili is the only Erythrina endemic to the Hawaiian Islands. The wood, seed and flowers were traditionally used in Hawaii and the tree is integral to many Hawaiian legends and proverbs. A unique characteristic of the species is the flower color variation within natural populations. Wiliwili is adapted to arid lowland environments and has potential for revegetation of degraded sites.

BOTANY.

Erythrina sandwicensis Degener (syn. E. monosperma Gaud) is closely related to both the E. tahitensis and E. velutina (Neill 1990). Erythrina sandwicensis is a small deciduous tree 5-15 m tall, with a short, stout, crooked or gnarled trunk 30-90 cm in diameter. Spreading branches are stiff, and the broad thin crown is wider than it is high. A champion tree measured on the Island of Hawaii in 1968 was 16.8 m tall with a trunk circumference (cbh) of 3.8 m.

The bark is smooth, light to reddish brown, and has scattered stout grey or black spines up to 1 cm long. With age, it becomes slightly fissured and thin. Twigs are

stout, green with yellow hairs when young and have scattered blackish spines. Leaves are alternate, compound, 13-30 cm long, with a long slender leafstalk. The three leaflets are short-stalked. The end leaflet is larger than the other two. Leaflets are 4-10 cm long and 6-15 cm wide (Little and Skolmen 1989).

Flower clusters (racemes) are on hairy yellow stalks of 7.4 cm or less. Flowers are crowded in a mass and are 7.515 cm long and short stalked. Flower color within natural populations can include orange, yellow, salmon, green and white (Little and Skolmen 1989). This striking color variation is probably unique within the genus (Neill 1990).

Reports vary on flowering and leaf falL Rock (1913) reported that wiliwili loses its leaves in the late summer or early fall (August to October), and leaves appear again during early spring to mid-summer (March to July), usually after flowering has occurred. Observations on Maui indicate that leaves drop during the dry periods of late spring or early summer (May to June). The tree flowers during the fall (September to November). Leaves reappear after the first southerly storms in the late fall (November)(B. Hobdy, Hawaii Department of Land and Natural Resources, personal observation). Differences in observations may be tied to variation of annual soil moisture, and the considerable heterogeneity of flowering, leaf loss, and seed set within a single stand.

Fruits (pods) are approximately 10 cm long and 13 cm broad, flattened, and pointed at both ends. They are blackish and slightly narrowed between seeds. Mature pods are found on the trees during winter months (December to February). Pods contain 1-4 elliptical, shiny red orange seeds 13-15 mm long (Little and Skolmen 1989).

Erythrina sandwicensis leaf, seed, fruit, and flowers (Little and Skolmen 1989).

ECOLOGY.

Wiliwili occurs near sea level to 610 m altitude in arid regions (Little and Skolmen 1989). Annual rainfall in these areas ranges from 500 to 1250 mm and is usually concentrated between November and March. Once an important component of ancient endemic Hawaiian dryland forests (Rock 1913), wiliwili has been replaced by Prosopis pallida in many areas (Little and Skolmen 1989). However, the species is not in danger of extinction.

DISTRIBUTION.

Wiliwili is endemic to the leeward side of the Hawaiian Islands (Little and

Skolmen 1989). It is not known to have been introduced elsewhere.

USES.

Wood:

The wood is reported to be the lightest of Hawaiian woods. It was used for surfboards (Neal 1965), canoe outriggers, and fish net floats, (Degener 1973, Neal 1965). Degener (1973) reports that the practice of using Wiliwili wood for outriggers was abandoned because Hawaiians believed that sharks followed such canoes. They also believed that trees bearing orange-red flowers possessed more durable wood than those bearing lighter colored flowers (Degener 1940).

Other uses:

The bright red seeds were used for making leis (Rock 1913). Captain Cook was reportedly given a lei made of Wiliwili seed when he visited the islands in 1778 (Little and Skolmen 1989). Wiliwili has been planted as living fences (Degener 1940). The species is strongly naked to Hawaiian culture through legends and proverbs. One legend refers to the different appearances of this species in the transformation of three sisters into Wiliwili trees. A bald sister becomes a tree with no leaves, a sister with wind-tossed hair becomes a tree with fluttering leaves, and a hunchbacked sister becomes a gnarled tree (Neal 1965).

Land rehabilitation:

Wiliwili is now being used in revegetation programs using endemic species to rehabilitate highly eroded areas in Hawaii. It survives extended drought and high

winds, but growth is slow under such harsh conditions.

SILVICULTURE.

Propagation:

Wiliwili can be easily propagated by seed or vegetative cuttings. To improve germination, the seeds should be mechanically scarified by nicking the seed coat, and soaked in water (at room temperature) overnight. For nursery propagation 1 liter containers with a 1:1:1 mixture of perlite, vermiculite, and potting soil are suggested. A small amount of 14-14-14 NP-K slow release fertilizer can be added to the potting mix (Chapin 1990). If vesicular arbuscular mycorrhizal (YAM) inoculant is available, it should be mixed in the potting media as well. Plant seeds 4 cm deep. Inoculate with rhizobia by irrigating the seedlings with a suspension of peat inoculant in water. Keep seedlings in a shady area until the first 2 or 4 true leaves appear. Water as needed. Overwatering may cause damping-off. After two weeks, place plants in the full sun. Water with a liquid fertilizer solution containing N-P-K plus micro-nutrients. Moderate fertilizer use will not adversely affect the microsymbionts.

Methods for vegetative propagation of Erythrina variegata (Rotar et al. 1986) may be used for wiliwili. Rotar recommends that cuttings be a minimum of 2.5 cm in diameter and 30 cm long. Before planting, cuttings should air dry, or cure, for at least 24 hours. The base of the cuttings can be coated with rooting hormone. The cuttings should be placed in the ground to a depth of at least 15 cm, and the soil kept moist. Sealing the top surface of the cuttings with wax or tree-wound dressing will help to prevent drying out.

Establishment:

Wiliwili should be planted on sites similar to its natural environment. Sites are recommended that have well-drained soil and receive full sun. Seedlings are ready for outplanting when stems are sturdy and well hardened, after approximately four months in the nursery. Planting holes should contain slow-release fertilizers as recommended by soil nutrient analysis. If possible, water once a week for the first month. If watering is not possible or if conditions are particularly harsh, the leaves of the seedlings may be trimmed or the tops cut off entirely.

SYMBIOSES.

Wiliwili forms a nitrogen fixing symbioses with Bradyrhizobium species. Highly effective strains have been identified (van Kessel et al. 1988). Rhizobial inoculants are available from NifTAL, 1000 Holomua Rd., Paia, HI, 96779 USA.

In highly eroded soils in Hawaii, inoculation of Wiliwili with VAM species Glomus fasciculatus resulted in significantly increased plant growth and decreased requirements for phosphorus amendments. This indicates VAM symbioses is critical to plant success in phosphorus infertile soils.

LIMITATIONS.

Wiliwili seedlings may be susceptible to damping-off problems. Powdery mildew fungi will attack the leaves in humid environments. Stem boring caterpillars have caused seedling mortality. Red spider mites are commonly associated with wiliwili. The tree is not suited for areas with high rainfall.

REFERENCES:

Chapin, M.H. 1990. April plant of the month - Hawaiian 1990. Kauai, Hawaii (USA): Hawaii Plant Conservation Center of the National Tropical Botanical Garden.

Degener, O. 1940. Flora Hawaiiensis: Leguminosae. Honolulu, Hawaii (USA): O. Degener.

Degener, O. 1973. Plants of Hawaii national parks illustrative of plants and customs of the South Seas. Ann Arbor, Michigan: Braun-Brumfield.

Little, E.L. and R.G. Skolmen. 1989. Common forest trees of Hawaii (native and introduced). Agricultural Handbook 679. Washington, D.C.: USDA.

Neal, M.C. 1965. In Gardens of Hawaii. Special Publication 50. Honolulu: Bishop Museum Press.

Neill, D A. 1990. Erythrina. pp 671-2. In: W.L. Wagner, D.R. Herbst and S.H. Sohmer (eds). Manual of the flowering plants of Hawaii, Vol 1. Special Publication 83. Honolulu, Hawaii: Bishop Museum Press.

Rock, J.H. 1913. The indigenous trees of the Hawaiian Islands [USA]. Reprinted in Tokyo: Charles E. Tuttle.

Rotar, P.R., R.J. Joy and P.R. Weissich. 1986. "Tropic Coral ": tall Erythrina (Erythrina variegate L.). Research Extensions Series 072. Hawaii Institute of Tropical Agriculture & Human Resources. University of Hawaii. Honolulu, Wawaii.

van Kessel, C., J.P. Roskoski and K Keane. 1988. Ureide production by N2-fixing leguminous trees. Soil Biology and Biochemistry 20:891-7.

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Hippopha rhamnoides: an NFT valued for centuries

Hippopha rhamnoides L., commonly known as sea buckthorn, is an arborescent shrub of wide adaptability distributed throughout more than 20 countries of Europe and Asia. The species has a history of utilization that goes back at least 12 centuries. An actinorhizal plant, sea buckthorn has the capacity to fix atmospheric nitrogen and thus enrich the soil. It is used successfully as a windbreak and to stabilize sand dunes, and several of its products have high value.

Botany

Sea buckthorn is a deciduous shrub or small tree, with thorns and unisexual flowers. It is dioecious and wind pollinated. Its fruit is a drupe, reddish orange, varying in length from 5 to 12 mm, with a tart, bittersweet taste. Each fruit has one bonehard seed. Shrubs usually begin to bear fruit after three years and give maximum yields after seven to eight years.

Hippopha rhamnoides L., commonly known as sea buckthorn.

The trees have an extensive, shallow root system and rootsuckering is common. Plants degenerate after approximately 15 years and then reproduce by suckering.

Rousi (1971) divided the genus Hippopha into three species. More recently, Lian (1988) revised the taxonomy, dividing the genus into five species. Hippopha rhamnoides is by far the most common and references to Hippopha are usually to this species.

Ecology

Sea buckthorn grows anywhere in temperate latitudes, from sand dunes near the

sea to the Eurasian plateau at 5200 m above sea level. Plant characteristics vary considerably according to this wide range of climatic conditions. For instance, these "shrubs" can reach 18 m in height in certain zones.

This is a light-demanding species. Trees growing in forested areas will die if the canopy density exceeds 50%. However, they are extremely drought tolerant, with extensive root systems that scavenge soil humidity and groundwater aggressively. They grow readily in areas that receive as little as 250 to 800 mm of rainfall annually. For example, there is a large area of natural Hippopha forest on the loess plateau of China, including the semi-arid regions of Shanxi, Shaanxi and Gansu Provinces.

The species is also well adapted to cold climates. There are 18,000 ha of natural Hippopha forest in Siberia where the temperature commonly drops well below 0°C. Sea buckthorn is also tolerant of alkaline and saline soils. It is reported to grow in the Qaidam Basin of China where the salt content of the soil ranges from 0.6 to 1.1% and the pH is 9.5.

Distribution

Sea buckthorn is native to the temperate zones of Asia and Europe, where it is widely distributed. It is also well represented at higher altitudes in the sub-tropical zones of Asia. Russia has approximately 200,000 ha of natural Hippopha forest plus more than 6,000 ha in plantations. With 920,000 ha, China has the largest area under Hippopha of any country, and also the largest variety of Hippopha species.

Uses

Food.

Sea buckthorn fruit is rich in vitamins C, E, K, B1 and B2, as well as niacinamide, pantothenic acid. carotenoids and other substances such as oil, sugar, malic acid, amino acids and pectin. The vitamin C content of the Chinese sea buckthorn Hippopha rhamnoides subsp. sinensis Rousi) fruit can be as high as 1253 mg/100 g.

Numerous food products are made from the fruit of this species. For instance, sea buckthorn wine is well known in Russia. In that country, a new variety has been bred by hybridizing geographically distant plants: it produces as much as 10.000 kg/ha of fresh fruits. In China, poor peasants have become prosperous by collecting and processing the fruit.

Hippopha leaves also contain various nutritious substances and minerals. They are commonly used as tea.

Medicine.

There are records of the medicinal use of sea buckthorn as early as the eighth century A.D. The Tibetan medical classic. Four Books of Pharmacopeia, lists 84 prescriptions for the preparation of sea buckthorn medicines. According to one account, a Tibetan lame considered this plant as a general panacea and made extensive use of its roots, stems, leaves, flowers, fruits and seed. The plant was widely used as a folk medicine in ancient Greece, the Roman Empire, Mongolia and Russia. Oil from the fruit acts as an antioxidant and may thus be used to treat

wounds, frost bite and pathological problems of the alimentary mucous membranes. Serotonin (5-hydroxy-tryptamine) extracted from sea buckthorn possesses antitumor capabilities.

Animal feed.

The ancient Greeks named the genus Hippopha or "glittering horse," because they believed that horses became plump and healthy when maintained on pastures with these trees. Today, herdsmen in northwest China often feed sea buckthorn leaves to their animals. In Russia, fodder supplements of sea buckthorn by-products are reported to improve liveweights and coat condition. Feeding poultry with meal made from sea buckthorn fruit and fruit oil has been observed to increase the pigmentation of egg yolks and body fat. The oil also increases flesh pigmentation in rainbow trout.

Ecological benefits.

Hippopha possesses a strong capacity to fix atmospheric nitrogen in its root nodules when associated with the actinomycete, Frankia. Most soils possess enough Frankia to support nodulation. In one stand on the east coast of England, annual nitrogen fixation was estimated as high as 179 kg/ha (Stewart and Pearson, 1967).

All of the plant's characteristics, especially its strong nitrogen-fixing ability and rapid growth, make it a good species for improving soil fertility, controlling erosion, conserving water. and stabilizing sand dunes. In mixed plantings, it can promote the growth and development of adjacent plants. Sea buckthorn also

shows a strong tolerance for toxic pollutants in the soil and air. It can thus be used to revegetate heavily industrialized areas or to reclaim mining sites.

Other uses.

Cosmetics derived from sea buckthorn are widely used in Romania, Russia and China. Massage creams, day creams and a shampoo developed in Romania have received international patents. In addition, the trees yield good-quality fuelwood. In China's western Liaoning Province, a six-year-old sea buckthorn plantation can produce 6.32 t/ha of wood. Sea buckthorn is also useful as an ornamental shrub.

Silviculture

Management varies according to objectives and environment factors. The species propagates well asexually because lignified branches of any age possess a strong ability to form adventitious roots. Hippopha rhamnoides can also be propagated from softwood cuttings under mist. For introduction or breeding trials, seed propagation is the most suitable treatment.

The seeds retain their viability after indoor storage for three to four years. Under suitable conditions,they will germinate during any season of the year. In 1977, a large plantation was successfully established on the loess plateau of China by broadcasting seed from aircraft.

Limitations

The wide adaptability and varied reproductive strategies of Hippopha rhamnoides indicate that it could be a serious weed in some environments. Its extensive,

suckering root system may make it unsuitable for agroforestry technologies that include close tree/crop associations. In addition, thorns on the stem and branches often make it difficult to harvest the fruits.

References

Lian Yongshan. 1988. New discoveries of the genus Hippopha L. (Elaeagnaceae). Acta Phytotaxonomica Sinica. 26(3):235-37.

Rousi, A. 1971. The genus Hippopha L: a taxonomic study. Annales Botanica Fennici. 8(3): 177-277.

Stewart, W.D.P. and Pearson, M.C. 1967. Nodulation and nitrogen fixation by Hippopha rhamnoides in the field. Plant and Soil. 26(2):348 - 60.

1-4: Hippopha salicifolia D. Don. 5-6: Hippopha thibetana Schlechtend. Source: Lian Yongshan, 1988.

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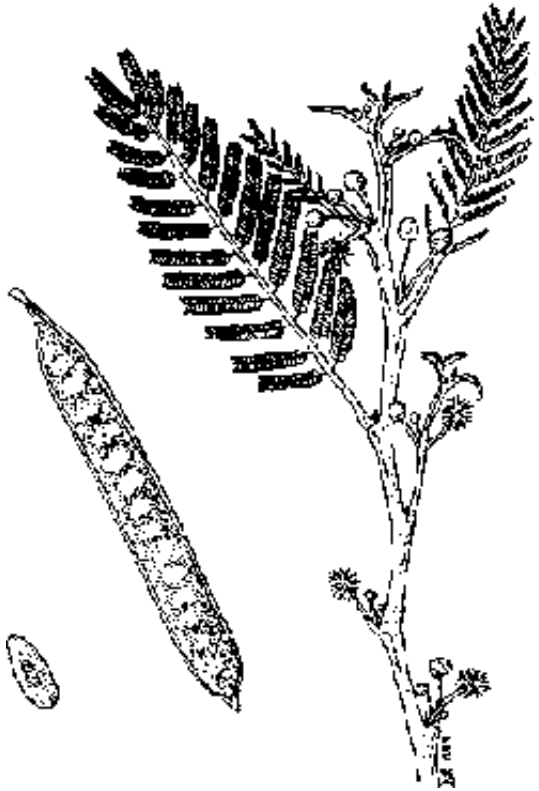
Leucaena diversifolia - fast growing highland NFT species

Leucaena diversifolia is the second-best known species in the genus Leucaena. Through numerous international tree trials, it has gained a reputation for aggressive growth at cool or high elevation sites where L. Ieucocephala performs poorly. It is a common companion tree to coffee in much of Indonesia and Mexico. L. diversifolia has moderate or high resistance to both psyllids and seed beetles, and is low in mimosine. Its forage digestibility is somewhat lower than L. Ieucocephala. It produces straight boles, and is desirable for paper and charcoal production.

BOTANY.

L. diversifolia (Schlecht.) Bentham (Leguminosae, subfamily Mimosoideae) is a mediumsized tree, often growing 10 to 20 m in height and 10 to 40 cm in diameter. L. diversifolia typically grows as a single stem tree with a long straight bole and slender uplifted branches that terminate in horizontal twigs. Some diploids produce branches at 180 degrees to each other, giving the trees a planar or two-dimensional appearance.



Leucaena diversifolia ssp. diversifolia (Dr. Diane Ragone 1984).

The leaves of L. diversifolia are easily distinguished from L. Ieucocephala by high numbers of small leaflets. The leaflets are 1 to 2 mm wide and nearly 1 cm long. The apex of the leaflet is usually off-center and pointed Flower heads are borne in clusters at leaf axils and average under 1 cm diameter (0.51.8 cm) on the day before flowering. Unlike L. Ieucocephala flowers, the styles of L. diversifolia extend past the anther halo. Flowering is profuse, beginning in late spring and continuing until mid-fall. Flower color ranges from bright red to light pink. Young pods can turn bright red in the sun, accounting for the Mexican name "guaje rojo" or red leucaena (Brewbaker 1987b).

Subspecies.

L diversifolia contains two subspecies. The most widely cultivated, L. diversifolia ssp. diversifolia, is line L Ieucocephala being self-fertile and "tetraploid" (2n=104). It is often abbreviated DIV4. The other subspecies, L. diversifolia ssp. trichandra (syn. L d ssp. stenocarpa) is outcrossing and has half as many chromosomes ("diploid"). It is abbreviated DIV2. The subspecific division is important as the breeding methods used to improve each subspecies are very different.

DIV4 pods mature in about 90 days, while those of DIV2 mature in 80 to 160 days. L. diversifolia seed weigh about one third (about 20 seeds/gram) of L. Ieucocephala seed. Seeds of the DIV2 are commonly smaller than those of DIV4.

ECOLOGY.

Unlike L. Ieucocephala, which frequents hot mesic lowlands (sea level to 1000 m), L. diversifolia colonizes higher (700 to 2500 m), cooler, and seasonally wetter sites. Its performance in highland trials is predictably good. Biomass yields of L. diversifolia (DIV4) were five times that of L. Ieucocephala at Mealani, Hawaii 850 m elevation, mean average temperature 18°C (Brewbaker et al. 1988). An Indonesian L. diversifolia diploid performed better than several L. Ieucocephala in Papua, New Guinea (Bray et al. 1988)

L. diversifolia is not frost tolerant. Early indications suggest that L. diversifolia is drought-sensitive. It performs best on fertile (maize-growing) soils, but also colonizes infertile ones. The species is not normally found on acid soils but some

can tolerate moderate acidity (Hutton 1984). Some diploids have been discovered growing among pines near Siguatepeque, Honduras. The species does not appear to be tolerant of saline or sodic soils. It tolerates partial shade and seasonally heavy rain.

DISTRIBUTION.

The native distribution extends from Eastern and Central Mexico (Veracruz and Puebla) south through Guatemala, Honduras and into Nicaragua. The tetraploid is native only in a small region of central Veracruz, Mexico near Jalapa. No diploids grow in this area, although they probably occur in southern Veracruz. The center of diversity of the diploids is Guatemala. Oaxacan (Mexico) diploids are different in tree form (shrubby), pollen (large) and pubescence heavier) from their Guatemalan kin, and may withstand periodic drought.

The naturalized distribution of the species includes the Caribbean, Africa and S.E. Asia. The tetraploid was probably established in Jamaica early in this century. Diploids (probably Guatemalan) were brought into the Ivory Coast, Cameroon and Java, Indonesia in the late 1800s. The Indonesian populations appear to be agronomically superior and may be partially inbred; if so they could be invaluable in hybrid seed production.

USES.

L. diversifolia does not have a history of cropping and much of the information on its value remains anecdotal. The primary uses of L. diversifolia are fuelwood, posts, pulpwood, shade and reforestation. It is also used for soil improvement and

stabilization, alley cropping and agroforestry, pasture improvement and forage.

Forage.

In one study, foliar digestibility of L. diversifolia lines were 10-20% less than that of L. Ieucocephala. The higher tannin content of the foliage may increase bypass protein levels in ruminants. Bypass protein is important to ruminants because the protein is protected from degradation in the rumen, but available for absorption in the small intestine, which is metabolically efficient. Mimosine content (1.5-2.5%) is about half that of L. Ieucocephala (4%). Levels of more than 50% of the forage in animal diets are not recommended.

SILVICULTURE.

Seed can be scarified by, a 5-7 minute soak in concentrated sulfuric acid, a 3 minute soak in 75°C hot water, or mechanical scarification. L. diversifolia fixes nitrogen with Rhizabium, and has a specificity comparable to that of L. Ieucocephala. Little is known about its mycorrhizal needs; these are also assumed to be comparable to that of L. Ieucocephala.

Seedling vigor of L. diversifolia is poor, especially of the tetraploids and small-seeded diploids (Sorensson et al. in submission?. Seeds may take a week to fully vigorous leucaenas. Seedlings are typically transplanted into the field eight to twelve weeks after germination, when they should be 15 to 30 cm tall. Vegetative propagation from cuttings and grafts has generally failed although tissue culture is successful.

PESTS & DISEASES.

L. diversifolia are generally resistant to insect pests in the field. Tetraploids show moderate psyllid resistance, but defoliate during heavy pest outbreaks (Brewbaker 1987a, Bray and Woodroffe 1988). Some diploids are extremely resistant to psyllids.

Both tetraploids and diploids show high resistance to seed beetles Araecerus levipennis and A. fasciculatus (Braze 1988). Damage to unprotected seed from A. Ievipennis in Hawaii is often one-quarter that to seed of other susceptible leucaenas.

HYBRIDS.

Most interspecific combinations between and within L. diversifolia and other species are successful (Pan 1985, Sorensson and Brewbaker in submission). The best known hybrid is that between tetraploid L. diversifolia and L. Ieucocephala. It is called 'KX3'. It has a broader genetic base than either parent and often outyields them. Like the parents, the hybrid is self-fertile and seedy.

PRINCIPLE REFERENCES:

Bray, R.A. and T.D. Woodroffe. 1988. Resistance of some Leucaena species to the leucaena psyllid. Tropical Grasslands 22:11-16.

Bray, R. A., D.G. Cooksley, T.J. Hall and D. Ratcliff. 1988. Performance of fourteen Leucaena lines at five sites in Queensland. Australian J. of Experimental Agriculture 28:69-72.

Braza, R.D. 1988. Two insect pests of L. diversifolia seeds in Surigao del Sur,

Philippines. Leucaena Research Reports 9:88-89.

Brewbaker, J.L. 1987a. Leucaena: A multipurpose tree genus for tropical agroforestry. pp 289-324. In: Agroforestry A decade of development. Editors: HA. Steppler and P.K.R. Nair. ICRAFT. Nairobi, Kenya.

Brewbaker, J.L. 1987b. Guide to the systematics of the genus Leucaena (Mimosoideae). Leucaena Research Reports 7(2):6-20.

Brewbaker, J.L., R.W. Wheeler and C.T. Sorensson. 1988. Psyllid-tolerant highland leucaena yields. Leucaena Research Reports 9:11-13.

Hutton, E.M. 1984. Breeding and selecting Leucaena for acid tropical soils. Pesquisa Agropecuaria Brasilia 19 (special issue):263-274.

Pan, F.J. 1985. Relationships within the L. diversifolia complex Dissertation, Univ. of Hawaii. 297pp.

Sorensson, C.T. and J.L. Brewbaker. Interspecific compatibility among fifteen Leucaena species. Submitted to American J. of Botany.

Sorensson, C.T., H.M. Shelton, M.T. Austin and J.L. Brewbaker. Seedling vigor of Leucaena leucocephala, L. diversifolia, L. pallida and their hybrids. Submitted to Tropical Grasslands.

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Leucaena: an important multipurpose tree

In the early years of its planting, leucaenas were often called "miracles frees" for their success as fast-growing, multipurpose, nitrogen fixing trees in the tropics. Several leucaena species are characterized by rapid growth, are highly palatable to animals, and produce dense firewood. Today, a more balanced view exists of this versatile group of trees. A major pest, the psyllid, has infested leucaena stands around the world with particular susceptibility expressed by varieties of Leucaena leucocephala. Research, however, has identified psyllid-tolerant varieties and hybrids, and psyllid populations in leucaena stands are declining over time, apparently due to natural agents.

COMMON NAMES:

Few countries lack their own names for Leucaena. "Guaje" in Latin America, subabul" or "kubabul" in India, "ipil-ipil" in Philippines, "lamtoro" in Indonesia and "yin hue when. in China are among those better known. The Hawaiians named it "koa haole" (the "foreign koa" (the native Hawaiian koa is Acacia koa), and leucaena varieties developed in Hawaii are named K8, K636, etc., "K" for koa.

BOTANY:

Leucaena leucocephala (Lam.) de Wit, formerly known as L glauca, became pantropical in the 17th century from its native region in Central America and

Mexico. Not until the 20th century did other species attract interest. Today we recognize 13 species in the genus, and expect others to be validated. In addition to L. Ieucocephala (abbreviated here as LEUC), these are L. collinsii (COLL), L diversifolia (DIVE), L esculenta (ESCU), L. greggii (GREG), L. Ianceolata (LANC), L. macrophylla (MACR), L palIida (PALL), L pulverulenta (PULV), L. retusa (RETU), L. salvadorensis (SALV), L shannoni (SHAN) and L trichodes (TRIC). LEUC, PALL and one subspecies of DIVE are polyploid (104 chromosomes), while the other species are diploid (52 or 56 chromosomes).

Leucaenas vary widely in leaf and tree shape, ranging from shrubs to stately trees. Leaves are alternate and bipinnately compound. Flowers range from bright yellow (RETU, GREG) and pink (DIVE, PALL) to white (all others). Clustered vertical brown pods, 8-25 cm in length, are a distinguishing mark. LEUC and tetraploid varieties of DIVE are self-pollinating, while all others are outcrossing.

ECOLOGY:

The species range naturally from Peru (TRIC) to Texas (RETU), from sea level to over 2000 m elevation, and in areas with annual rainfalls between 500 and 2000 mm. Leucaenas are associated with soils of pH 5-8, and are not found on waterlogged soils. The leucaenas fail on highly acid soils, where aluminum competes with calcium and other cations for exchange sites in the soils.

GENETIC IMPROVEMENT:

The genus is considered an interbreeding complex, and breeding efforts are concentrated on producing interspecific hybrids. LEUC has been crossed

successfully with all other species except GREG. Over 50 species hybrids are now under study in Hawaii for growth, form, psyllid resistance, cold tolerance and fodder quality. Many hybrids have high commercial potential notably in cooler climates and on certain acid soils where LEUC is an economic failure. New varieties are increasingly available from breeding programs in Hawaii Australia, Taiwan and Indonesia.

ESTABLISHMENT:

Depending on species, leucaenas have 10-80,000 seeds/kg. Leucaena seeds have hard coats that need pretreatment to enhance germination. Seeds can be mechanically scarified, either by nicking the seed coat or treating with boiled water. Leucaena can be direct seeded, or planted as container grown seedlings, stump cuttings or bare root seedlings. In areas where they have not grown before, leucaenas require inoculation with specific Rhizobium in order to nodulate and grow well.

USES:

Wood.

Under suitable conditions, leucaenas have produced wood yields similar to the best of tropical trees. Mean annual wood increments fall in the range of 20-60 m^3/yr in short rotation (3-5 yr) trials. Wood of a 4-yr-old tree has about 46% moisture and a specific gravity of 0.52. This medium hard wood serves well for posts, housebuilding, utensils and parquet flooring. It is an excellent pulpwood (Hu 1987), and a preferred fuelwood that burns with little smoke or ash. Charcoal

is of high yield and quality.

Fodder.

Leucaena is perhaps best known as a fodder plant for ruminant animals, with high acceptability and dry matter digestibility (55-70%). Some of the newer species undergoing testing (DIVE, PALL) may have lower digestibilities. Goats and cattle make superior gains on grass supplemented with 20-30% leucaena, which can be fed solely when necessary.

Mimosine is a toxic amino acid in leucaena foliage (2-6% dry matter) that causes hair loss and other damage in nonruminant animals. A breakdown product of mimosine, DHP, can cause problems in ruminant animals. A bacterium found in the gut of ruminants in areas where LEUC is native or naturalized can detoxify DHP. The bacteria can now be obtained from Australian scientists at CSIRO and used for rumen inoculation. Leucaena can be used to color the egg yolks of poultry, due to its high content of vitamin A precursor carotenoids. However, it is not a nutritional supplement to poultry without pre-preparation.

Alley farming, shade and species mixtures.

The leucaenas have been model trees for alley farming, a system in which trees are planted in crop fields and managed as hedgerows. Crops grown in the "alleys" formed by the trees benefit from the nitrogen-rich leucaena leaves applied as green manure. Fresh litter has higher nitrogen (3-4%) than dried leaves (1%). Leucaenas coppice readily; best results are realized from cutting heights of 50 cm or above. The leaves defoliate from cut branches and wilt rapidly after harvest.

Leucaena has soil and rainfall preferences similar to most annual food crops, making a good hedge for maize, sorghum, cassava and the taller grain legumes (Kang et al. 1984).

Leucaena is used to shade crop plants such as coffee and cacao in Indonesia and Costa Rica. It has also been planted in species mixtures in tree plantations in Brazil and Hawaii to increase wood production of non fixing species such as Eucalyptus (Schubert et al. 1988).

Foods, gums and other products.

Green pods of several leucaenas (ESCU, MACR, LEUC) are marketed for food in Mexico, but little eaten elsewhere. Tender young vegetative shoots are often sold as a vegetable in S. E. Asia. Seeds are made into tempeh in Indonesia. More should be known of the goiter-causing DHP before food uses are widely recommended. Gums from leucaena bark have been the subject of extensive study for their similarity to gum arable; gum yields appear high in certain species hybrids. The seed gum of leucaena is also a unique galactomannan with potential medical uses. The production of liquid protein extracts from leucaena leaves is, however, complicated by gumprecipitation problems.

THE LEUCAENA PSYLLID:

Heteropsylla cabana Crawford is a tiny jumping plant louse that attacks leucaenas. It is the subject of a previous NFT Highlight (8805). The psyllid is travelling around the tropics from its home in Latin America, where it does little significant damage to LEUC, probably from control of the psyllid by native insect predators.

Useful predators being deployed abroad include the beetle Curinus coeruleus and the parasitic wasp Psyllaephagus nr. rotundifomis.

Management practices influence psyllid resistance. In some species, repeated cuttings can result in higher damage to juvenile leaves; weather patterns can also affect the degree of damage. Species exhibiting a relatively higher degree of resistance to psyllid damage than LEUC include COLL, DIVE, ESCU, GREG, PALL RETU and SALV. Interspecific hybrids such as KX1 and KX2 have shown high psyllid resistance in Asia and the Pacific.

LITERATURE AND SEEDS:

Serious students of leucaena should peruse Leucaena Research Reports (LRR), published annually by NFTA. Seed sources are listed annually in LRR; seeds for ILTs (International Leucaena Trials) are available from NFTA.

PRINCIPLE REFERENCES:

Brewbaker J.L. 1986. Guide to the systematics of the genus Leucaena (Mimosoideae: Leguminosae). LRR 7(2):6-20.

Brewbaker, J.L. 1987. Leucaena: a multipurpose tree genus for tropical agroforestry. In Agroforestry A decade of Development. HA. Steppler and P.K.R. Nair (eds). ICRAF, Nairobi Kenya. pp. 289-323.

Brewbaker, J.L. and EM. Hutton. 1979. Leucaena - Versatile tree legume. In New Agricultural Crops, GA. Ritchie, (ed). AAAS Selected Symposium. Westview Press' Boulder, Colorado.

Hu, Ta Wei. 1987. Use of Nitrogen Fixing Trees for Pulpwood. NFTA, Waimanalo, Hawaii.

Hutton, EM. 1984. Breeding and selecting leucaena for acid tropical soils. Pesq. Agropec. Bras. 19:263-274.

Kang, B.T., G.F. Wilson and T.L. Lawson. 1984. Alley Cropping - A Stable Alternative to Shifting Cultivation. IITA, Ibadan, Nigeria.

NFTA. 1985. Leucaena Forage Production and Use; Leucaena Wood Production and Use. NFTA, Waimanalo, Hawaii.

NRC. 1984. Leucaena: Promising forage and tree crop for the tropics. 2nd ed. U.S. National Research Council, USNAS, Washington, D.C.

Oakes, A.J. 1982-1984. Leucaena Bibliography. 3 vols. Germplasm Resources Lab., USDA, Beltsville, Maryland.

Pound, B. and L.M. Cairo. 1983. Leucaena: Its cultivation and use. Overseas Development Administration, London.

Schubert, T.H., D.S. DeBell and C.D. Whitesell. 1988. Eucalyptus/legume mixtures for biomass production in Hawaii. Nitrogen Fixing Tree Research Reports 6:26 27.

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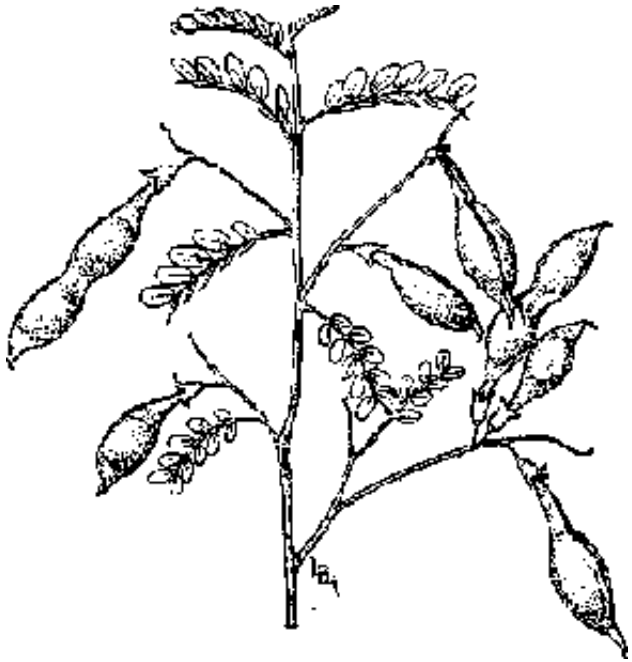
Olneya tesota - a potential food crop for hot arid zones



Olneya tesota by Lucretia Breazeale Hamilton, from Trees and shrubs of the Southwest Desert (Benson and Darrow 1981).

Olneya tesota, called Desert Ironwood, Tesota or Palo fierro, is a conspicuous tree in much of the Sonoran Desert of southwestern North America. Valued for its wood, this long-lived desert tree has potential for development as a tree food crop for hot arid climates.

BOTANY.

Olneya tesota A. Gray (Leguminosae, subfamily Papilionoideae) is the sole member of the genus Olneya. It grows as a small tree to 10 m in height and

spread, commonly with several trunks. The trunks can attain a diameter up to 60 cm on very old individuals. Young twigs up to 10 or 15 mm thick are green. The bark of limbs is gray and smooth, becoming fissured and eventually shredding on older limbs and trunks. Painfully sharp, paired spines, 3-11 mm long occur at each node.

The foliage is cold and drought deciduous but trees in favorable locations may remain nearly evergreen. The oncepinnate leaves are up to 6 cm long with 6 to 20 grayish green leaflets. Leaflets are 7 to 20 mm long. Pink to lavender pea-like flowers, 15 mm long, appear in short, dense racemes or panicles in the late spring. In some years they cover the trees with dense masses of color. While most individual trees flower each year, flowering appears to be heavy only about two years in five. The pods ripen in the summer and contain one to several round seeds 5-6 mm in diameter. Mature pods rapidly dehisce.

ECOLOGY.

Olneya tesota is adapted to hot arid climates. Average rainfall over its range varies from 75400 mm. The tree occurs from below sea level to approximately 900 m elevation, most often in sandy and rocky soils of plains, slopes and along dry washes. Its Ph limits are unknown, but it grows well in soils with a range of 7 to 8.5.

Along its range, O. tesota is a dominant component of many plant communities. In the more arid portions of its range it is restricted to dry desert watercourses where storm runoff increases the available moisture. The largest individuals are found in these habitats, often forming woodlands with other desert trees including

Cercidium floridum, Prosopis glandulosa var. torreyana, P. velutina, Acacia greggii, and others (Felger 1992). Seeds require rainfall or storm runoff during the hot season to germinate. Few seedlings which germinate away from the protective cover of other plants survive rodent predation.

Olneya tesota tolerates some freezing but generally sustains stem damage below -6° C. Prolonged exposure to lower temperatures may cause severe damage or death. It tolerates summer temperatures of 45° C. Because of its preference for warmer sites, O. tesota has been used as an indicator plant in choosing locations for citrus plantations (Little 1950). The trees are long-lived, perhaps attaining 200 years of age. Dead stumps can persist for decades. The trees serve as a source of food and shelter for many species of wildlife. Other desert plants, including shrubs, vines, cacti, and annuals, often grow in the microclimate beneath the canopy of O. tesota.

DISTRIBUTION.

Olneya tesota is endemic to the Sonoran Desert Region. It is found in central and southwest Arizona and southeast California, USA, much of the Baja California peninsula, western Sonoran and extreme northwest Sinaloa, Mexico (Hastings et. al 1972).

USES.

Human Food.

The seeds of O. tesota have been used for food by native Americans. Fresh, uncooked seeds have a taste similar to soybeans (Glycine max). Felger and Moser

(1985) report that the Seri Indians of Sonora, Mexico, cooked the seeds in water, emptied the water and then cooked the seeds a second time in fresh water to remove an unpleasant smell. The cooked seeds were eaten whole, or ground and salted. The seeds contain Canavalin, a mild toxin (Rosenthal 1977). Roasted seeds have been used as a substitute for coffee.

Wood.

The wood is very hard, dense and durable. It will not float in water. Olneya tesota is cut for fuelwood, charcoal and carvings. The heartwood is dark brown and takes a beautiful polish. The trees do not respond well to coppicing. Larger trees are usually killed by this practice and recovery of younger plants is slow. Widespread cutting of O. tesota has seriously reduced the numbers of these trees in areas of Mexico.

Other uses.

Wildlife and domestic livestock browse the foliage to some extent (Allen and Allen 1981). Olneya tesota is cultivated as a landscape tree in hot arid regions of southwestern United States. The nearly evergreen foliage, dense shade, showy flowers and attractive form make it well suited for a variety of landscape functions. Trees up to 8 m tall have been successfully transplanted by side-boxine.

SILVICULTURE.

Propagation.

Olneya tesota is propagated from seeds. Scarification of the seeds enhances

uniform germination but fresh seeds will germinate without scarification. Optimum temperature for germination appears to be 25-30° C. Fresh seeds often have 80-90% germination. Emergence usually occurs in 412 days. Seedlings can reach 25 cm tall in their first season.

Growth.

Olneya tesota thrives in well-drained soils with infrequent. deep irrigation. Established trees will survive on 200 mm of annual rainfall. Typically slow growing in the wild' established plants can grow up to 6(; cm per year under favorable conditions in cultivation. Olneya tesota shows no tendency to become weedy.

Seed Production.

Optimum conditions for fruit production are not fully documented. Unless supplemental irrigation is available in arid regions, O. tesota grows slowly, prolonging the time it tales for the tree to reach flowering size.

SYMBIOSIS.

Felker and Clark (1981) report that O. tesota seedlings grown in nitrogen free media produced nodules when inoculated with soil taken from beneath wild trees. Allen and Allen (1981) indicate that nodulation has been reported from cultivated trees of O. tesota in Zimbabwe.

LIMITATIONS.

Desert Mistletoe (Phorodendron califomicum) can be a serious problem on O. tesota in its natural range. Heavy infestations can weaken and even kill mature trees. Control can be achieved by periodically removing the clumps of mistletoe.

Young plants may be severely damaged by browsing, particularly by rodents. No significant disease problems have been reported. The plants do not appear to be fire resistant. The spiny stems can be a nuisance to people working around the plants.

RESEARCH NEEDS:

Methods of vegetative propagation should be investigated to provide a convenient method of propagating selected cultivars. Trial plantings are needed to determine how this species may perform under field conditions.

REFERENCES:

Allen O. N. and E. K Allen. 1981. The Leguminosae: a source book of characteristics, uses and nodulation. The University of Wisconsin Press, Madison. 812 pp.

Felger R. S. 1992. Reflections on a desert legume trinity. Aridus 4(4):1-4, 7.

Felger R. S. and M. B. Moser. 1985. People of the desert and sea - ethnobotany of the Seri Indians. The University of Arizona Press, Tucson. 435 pp.

Felker P. and P. R. Clark. 1981. Nodulation and nitrogen fixation (acetylene reduction) in desert ironwood (Olneya tesota). Oecologia 48:292-293.

Hastings, J.R., R.M. Turner and D.K Warren. 1972. An atlas of some plant distributions in the Sonoran Desert. The University of Arizona, Institute of Atmospheric Physics, UA-IAP-TR-72-21, Tucson, Arizona.

Little, E.L. 1950. Southwestern trees - a guide to the native species of New Mexico and Arizona. USDA Handbook No. 9, Government Printing Office, Washington, DC.

Rosenthal G. A. 1977. The biological effects and mode of action of L-canavaline, a structural analogue of Larginine. Quarterly Review of Biology 52:155-178.

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Chamaecytisus palmensis: hardy, productive fodder shrub

Dalbergia latifolia: the high-valued Indian rosewood

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- Erythrina sandwicensis - unique Hawaiian NFT
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- Acacia mangium: an important multipurpose tree for the tropic lowlands
- Acacia auiculiformis - a multipurpose tropical wattle

Acacia leucophloea - shade and fodder for livestock in arid environments

Native to arid areas in South and Southeast Asia. Acacia Ieucophloea (syn. Mimosa leucophloea) is easily identified by its white bark and large wide spreading limbs. It is most often utilized as shade for livestock and as a source of dry-season fodder. Growing well on alluvial or infertile soils,.4. Ieucophloea also has great potential as a reforestation species for degraded sites. Currently, it is not commonly planted for this purpose. Common names for this species often refer to its light color; white-bark acacia (English), safed kikkar (Hind)), safed babul (Bengali). goira (Oriya). sarai, velvelam (Tamil). Other common names include pilang and besok (Indonesian).

Botany

Acacia Ieucophloea (Roxb.) Willd. (Leguminosae Mimosoideae) is a large thorny tree attaining heights of 35 m and diameters at breast height (dbh) of 100 cm (Nielsen 1992, Heyne 1950). It may be deciduous. Mature trees become less thorny and can live to be 100 years old. Trunks are stout, dividing into several large diameter branches. Open-grown specimens have a characteristic wide umbrella-like crown. In India, the trunk is often crooked (Troup 1983), but reported as straight in Indonesia (Heyne 1950). Generally, the bark is white to yellowish gray, smooth and exfoliates in long strips. On old trees. the bark becomes black and rough (Troup 1983. Heyne 1950). In harsh environments and on poor soils this species remains a shrub or small malformed tree.

The feathery green foliage offers a strong contrast to the light-colored bark. Leaves are bipinnately compound having 5-30 pairs of leaflets. Circular glands are found on the rachis below the junction of pairedpinnae (Nielsen 1992, Troup 1983). Spines, 2-5 mm long, occur at the base of leaves. The leaves may fall during the cold or dry seasons and regrow with the rains. The conspicuous flowers are light-yellow to cream in color and are borne in abundance during the rainy season. Flowering occurs July through November in India (Troup 1983) and December through March in Indonesia Djogo 1992). The pods are yellow. green or brown in color. net and fairly straight. They measure 10-20 cm long, 5-10 mm wide and ripen from February to June in India (Troup 1983) and July to September in Timor (Djogo 1992). Pods should be collected before they split and disperse their seed. Healthy pods contain 10-20 smooth oblong seeds of dark brown color and 6x4 mm in size (Kumar and Bhanja 1992).

Ecology

Acacia Ieucophloea is a component of dry-forests, savannas. bush woodlands. and desert ecosystems from sea level to elevations of 800 m. In these areas. rainfall is only 4001500 mm/year and dry seasons may persist for 9-10 months. Temperatures are extreme. varying from -1° to 49° C.

Acacia Ieucophloea is common on sands. infertile rocky soils. limestone soils. organic clays and alluvial areas. Plant growth is usually slow. On fertile soils, I. Ieucophloea seedlings grow quickly, up to 60 cm a year, but on such sites faster-growing associate species usually dominate. Under irrigation height growth may reach 7-10 meters in 5-6 years. Seedlings are light demanding and sensitive to weed competition. fire and frost. In order to exploit sufficient soil moisture. seedling root growth generally exceeds shoot growth. Once established. trees are very tolerant of drought. fire and frost. Reports concerning. i. Ieucophloea tolerance of saline conditions are contradictory. This question needs future investigation. Pruned or injured trees produce thorny branch and stump sprouts.

Distribution

Acacia leucophloea's native range through South and Southeast Asia is non-contiguous. Its largest continuous distribution is and India through Sri Lanka, Bangladesh, Burma and much of Thailand. Other populations occur in southern Vietnam; Java and Bali of central Indonesia; and Timor of eastern Indonesia (Nielsen 1992, Troup 1983). This species has not been widely introduced to other regions.

Uses

Wood.

The wood of this species is strong, heavy and hard with a specific gravity of 0.71. It seasons well and takes a good polish (Troup 1983). The brick-red heartwood is very beautiful and is used to make decorative furniture. The pale yellow sapwood is perishable. Commodities produced from the wood include poles, farming implements, carts, wheels, turnery, construction timbers and fuel. The utilization of this species is limited because its wood has irregular interlocked grain, a rough texture, is difficult to work and is not durable.

Fodder and Pasture.

Acacia leucophloea is an important dryseason fodder and pasture tree throughout its range. Leaves, tender shoots and pods are eagerly eaten by goats, sheep and cattle. Singh (1982) reports that leaves contain 15% crude protein and 19% crude fiber. However, due to hydrocyanic acid toxicity A. Ieucophloea should not be used as a sole feed (Bhadoria and Gupta 1981). During dry seasons, this tree protects livestock and understory pasture from excessive temperatures. Grass beneath the trees remains succulent while exposed grass becomes dry and unpalatable. In eastern Indonesia, populations of this species have declined significantly due to heavy use as a dry-season fodder. Farmers do not replants. leucophloea because of its slow growth.

Other uses.

The inner bark of A. Ieucophloea has a foul aroma. It produces a reddish-brown

stain used to manufacture dyes and tannins (Heyne 1950). Fibers from the inner bark are used to make fish nets and rough rope. Additionally, a water soluble gum of fair quality can be extracted from the bark. The leaves yield a black dye and the bark produces tannin and dye (Heyne 1950, Troup 1983). Heyne (1950) reports the bark is used to distill liquor in India and seed sprouts are eaten as vegetables in Java. The vivid colors of its leaves, flowers and bark make A. Ieucophloea a beautiful, yet underutilized, ornamental tree.

Silviculture

Propagation.

Seeds of A. Ieucophloea (37,000-50,000/kg) have hard seedcoats. Under natural conditions they germinate unevenly. To encourage uniform germination, seed should be scarified. Two methods are recommended: 1) submerge seeds in boiled water until the water cools - roughly 24 hours, or 2) soak seeds in sulfuric acid for 10-30 minutes followed by a cool water soak for 24 hours (Kumar and Bhanja 1992). The visibly swollen seeds should be removed from the water and sown immediately.

Management.

Acacia leucophloea can be established by direct sowing, stump sprouts or seedlings. Direct sowing is preferred because the large roots of seedlings may hamper transplanting. Troup (1983) recommends the following method. Immediately prior to the rainy season, the sowing site should be cleared of weeds and the soil well cultivated. When the rains arrive sow scarified seed at a depth of

1 cm. Germination begins within a week.

Seedlings are sensitive to vegetative competition and browse damage. Weed control must be maintained for a minimum of two years. Livestock must be excluded from plantations until trees are beyond their reach. Annual cultivation around the seedlings improves growth and survival. Interplanting A. leucophloea at low densities with crops or pasture grasses can benefit both crops and trees (Troup 1983, Djogo 1992). Although this species is slow growing it should not be disregarded. Acacia leucophloea is a good reforestation species for poor soils in low rainfall areas. Otherwise underutilized, these sites could become useful fodder and fuel plantations.

Symbiosis

Acacia leucophloea fixes atmospheric nitrogen through a symbiotic relationship with Rhizobium bacteria which enables it to survive on infertile sites. Quantitative information concerning the amount of nitrogen fixed in this relationship is lacking.

Limitations

The wide crown of A. Ieucophloea competes with adjacent crops for sunlight, limiting the trees usefulness on farms. The wood degrades quickly and is difficult to work.

References

Bhadoria, B.K. and R.K. Gupta. 1981. A note on hydrocynic acid content in Acacia leucophloea Roxb. Willd. Current Science 50: 689-690.

Djogo, A.P.Y. 1992. The possibilities of using local droughtresistant multipupose tree species as alternatives to lamtoro (Leucaena leucocephala) for agroforestry and social forestry in West Timor. Working Paper No. 32. EAPI, East West Center, Honolulu, Hawaii, USA. 41 p.

Heyne, K. 1950. De nuttige planter van Indonesie (The useful plants of Indonesia). N.V. Uitgeverij W. van Hoeve, Bandung, Indonesia. pp 713-715.

Kumar, S.V. and M. Bhanja. 1992. Forestry seed manual of Andhra Pradesh. Research & Development Circle, Andhra Pradesh Forest Department, Hyderabad, India. 100 p.

Nielsen, I.C. 1992. Flora Malesiana: Mimosaceae (Leguminosae-Mimosoideae), vol. 11:45.

Singh, R.V. 1982. Fodder trees of India. Oxford and IBH Publishing, Co. New Delhi, India. pp 367-69.

Troup, R.S. 1983. Troup's Silviculture of Indian Trees, vol. IV Leguminosae. Forest Research Institute and Colleges, Dehra Dun, India. pp 33-38.

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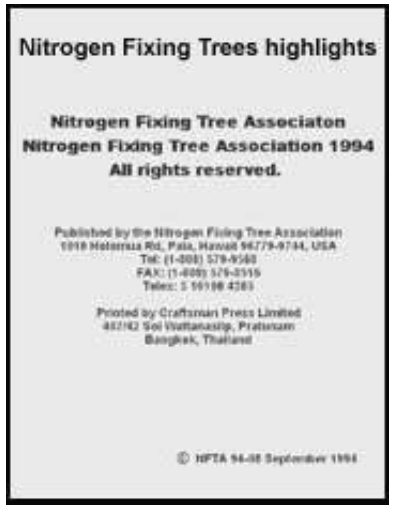
Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw



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Honey mesquite: a multipurpose tree for arid lands

Honey mesquite: a multipurpose tree for arid lands

Native to North America, Prosopis glandulosa Torrey is a small to medium-sized tree, 3-7 m tale with two recognized varieties. Prosopis glandulosa var. torreyana grows primarily in the deserts and drylands of the southwestern United States and northern Mexico (Hilu et al. 1982). P. glandulosa var. glandulosa is found from Mexico north to Kansas and east to Louisiana (Burkhart 1976). Commonly called mesquite, or honey mesquite, this nitrogen fixing tree was a key resource of the native people, providing food drink, alcohol fuel, medicine, and fertilizer.

Honey Mesquite

BOTANY.

Mesquite has spiny branches and leaves with 7-18 sets of paired leaflets. Its seed pod resembles the common pea or bean, 10-30 cm long and 5-10 mm diameter. The flower is a yellow inflorescence with many spikes. Hybridization is common and the taxonomy of mesquite is difficult (Hilu et al. 1982). Genetic variability is high with good potential for selection of individuals and ecotypes and plant breeding. The trees are self-fertile.

ECOLOGY.

Honey mesquite will grow in a wide range of soils and is moderately salt and frost tolerant. It thrives under very high temperatures (>38°C) and survives in areas with very low precipitation (< 200 mm annually), but it is usually found in areas with groundwater reserves. This tree has been found to occur in Death Valley with only 50 mm annual rainfall (Hilu et al. 1982). In its drier, western range it occurs along streams and in low-lying areas; in areas with more rainfall it occurs on open range or in chaparral.

USES.

Food:

Honey mesquite pods were a primary food of the residents of the SW North American deserts (Felger 1977). Pods are quite sweet and whole pod composition is 80% carbohydrate, 13% protein, 25% fiber, and 3% fat (Zolfaghari et al. 1982). The pods are easy to collect and store and, unlike most beans, are edible without cooking. Mesquite pods are still used as a food and beverage in Mexico. Processing and use is described in Meyer 1984 and Meyer et al. 1986. Pods could prove useful

for production of flour, wine, tempe, and tofu products. R.S. Felger has proposed that the pods of this dryland-adapted tree will one day become as important as corn, rice, and wheat to the world food system. Bees favor the Sowers, and mesquite honey is highly valued for its flavor.

Fodder:

Grinding improves the use of honey mesquite pods for fodder. Sheep, goats, and pigs are able to use a higher percentage of mesquite pods in their diet than are cattle and horses. In 1965, 40,000 tons of pods were used as feed in Mexico (Lorence 1970). Leaves of mature honey mesquite are browsed by cattle only on deteriorated rangeland.

Fuel:

Mesquite wood (17,000 BTU/kg), chips, and charcoal are excellent fuels, and the wood smoke lends a pleasant flavor to cooked foods. Annual production on dry, low quality sites may be < 1 t/ha, but with sufficient water (even though slightly saline) trees can grow rapidly and yield >5 t/ha/yr (Felker et al. 1983).

Hardwood:

Mesquite wood is very dense, specific gravity 0.7+, and has very balanced shrinkage on drying (Rodgers 1986). These properties make it excellent for woodworking. Mesquite is also used for fencing.

Other products:

Mesquite has been used for a variety of medicinal purposes, including lice control, treatment of sore throats, and treatment of skin sores and ulcers (Felger 1977). Mesquite produces quality gums which may be economically valuable (Meyer 1984).

Soil improvement:

The refinement of a modern management system of intercropping with mesquite based on traditional practices (Lawson and Bean 1968) should receive high priority. The deeply-rooted, open-canopied trees may provide little competition for field crops and can fix 30 40 kg N/ha with 30% canopy cover (Jarrell et al. 1982). Soils under honey mesquite are enriched with nitrogen (Abrams et al. 1990). Mesquite may be established as tree crops for alley cropping, windbreaks, or timber belts.

The distributional range of Prosopis glandulosa in sw North America

PROPAGATION.

Mesquite pods ripen simultaneously. They should be picked when the seed rattles in the pod, and stored in a dry place. Bruchid beetles can be killed by freezing or fumigating the pods. Mesquite seeds store well, maintaining excellent viability for years or even decades. There are about 30,000 seeds/kg. A modified commercial meat grinder with a plate with holes 1 cm in diameter is recommended for cleaning. The seeds have a very tough coating which must be scarified for germination by chipping or cutting, acid treatment, or exposure to boiling water. Acid, however, will damage seeds if cuts in the seed coat are made by mechanical cleaning. Seeds germinate best at temperatures between 20-40°C and can germinate within six hours of wetting at 34°C (Bainbridge and Virginia 1989). Preliminary studies of honey mesquite propagation from cuttings, tissue culture, and air layering suggest that these vegetative reproduction techniques are possible Bainbridge and Virginia 1989).

Scarified or sprouted seed should be planted in a welldrained soil mix. If small containers are used. transplant seedlings 2-3 weeks after germination to avoid disturbing the dominant tap root. Young seedlings can have root to shoot ratios as high as 10:1 (Mooney et al. 1977). Larger transplants can be grown in deep containers (7.5 cm wide by 100 cm deep) or in plant bands (4 cm x 40 cm).

SILVICULTURE.

Although mesquite is very drought tolerant, best growth is achieved in areas where the root system can reach groundwater. In areas with low rainfall, especially in fast-draining soils, irrigation may be required during establishment. Buried clay pot and deep pipe irrigation have considerable potential for establishing mesquite in hot desert regions (Bainbridge and Virginia 1989). Soils

with compacted or hard pan layers should be deep ripped or worked with an auger to 1-3 m and planting strips cleared of competing vegetation. Direct seeding is also possible, if adequate soil moisture can be maintained for germination.

ROOT SYMBIOSES.

Mesquite forms symbioses with rhizobia and VA mycorrhizae. The active root nodules can occur many meters deep (Virginia et al. 1984, 1986: Jenkins et al. 1989). Nitrogen levels in the soil under plantationgrown mesquite were much higher than same-aged P. chilensis or P. alba (Abrams et al. 1990). Seedling rhizobial inoculation can be done with a liquid culture, clay or peat based inoculum, or with small amounts of soil from the active root zone under healthy, established trees nearby (Bainbridge and Virginia 1989). Fertilizer (especially phosphorus) may increase mesquite growth on poor soils, but both P and N can depress microbial symbionts and fertilization may be detrimental in the long term.

PESTS AND PROBLEMS.

Pods are commonly damaged by bruchid beetles. Mesquite hosts mistletoe and infection may be extensive on older trees. Trees rarely suffer significantly from other diseases and pests. although psyllids may be a problem in some areas, and spider mites have been a problem in glasshouse studies. When planted in southern Texas, var. torreyana from California, but not var. glandulosa, is subject to stem fungal diseases (P. Felker, pers. comm. 1990). Fencing or seedling protectors will usually be needed to protect young, transplanted mesquite seedlings from rabbits or other grazing animals. To ensure good tree form, the leader should be protected against grazing. As with other Prosopis species. mesquite can become a

serious invader on disturbed lands or overgrazed rangelands.

PRINCIPAL REFERENCES:

Abrams, MM, W. M. Jarrell, HA. Smith and P.R. Clark 1990. Nitrogen accretion in soil and biomass production by three Prosopis species. Agrofor. Systems 10:93-97.

Bainbridge, DA. and R.A. Virginia. 1989. Mesquite, Species Notes 1. Systems Ecology Research Group, San Diego State University, San Diego, CA. 14 p

Burkhart, A. 1976. A monograph of the genus Prosopis. J. Arnold Arboretum 57:450-525.

Felger, R.S. 1977. Mesquite in Indian cultures of the Southwestern North America. In B.B. Simpson (cd). Mesquite: Its biology in two desert scrub ecosystems Dowden, Hutchinson & Ross. Stroudsburg, PA. p. 150-176

Felker, P. 1979. Mesquite: An all-purpose leguminous arid land tree. In GA. Ritchie (ed), New Agricultural Crops. American Association for the Advancement of Science, Westview Press, Golden, CO. p. 89-132.

Hilu, K.W., S. Boyd, and P. Felker. 1982. Morphological diversity and taxonomy of California mesquites (Prosopis, Leguminosae). Madrono 29(45):237-254.

Lawton, H.W. and L.J. Bean. 1968. A preliminary reconstruction of aboriginal agricultural technology among the Cahuilla Indian Historian 1(5):18-24,29.

Meyer, D., B. Becker.. M.R. Gumbmann, P. Vohra, H. Neukom, and R. Saunders. 1986. Processing composition, nutritional evaluation and utilization of mesquite (Prosopis spp) pods as a raw material for the food industry. I. Agric. Food Chem. 34(5):914-919.

Mooney, HA., B.B. Simpson. and O.T. Solbrig. 1977. Phenology, morphology, physiology. In B.B. Simpson (ed). Mesquite: Its biology in two desert scrub ecosystems. Dowden, Hutchinson & Ross, Stroudsburg, PA. p. 2443.

Virginia, R.A. and W.M. Jarrell. 1983. Soil properties in a mesquite dominated Sonoran desert ecosystem. Soil Sci. Soc. Amer. 1. 47:138-144.

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- **Nitrogen Fixing Trees Highlights (Winrock, 1990-1997, 100 p.)**
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Pongamia pinnata - a nitrogen fixing tree for oilseed

Pongamia pinnata (L.) Pierre has also been called Derris indica (Lam.) Bennet and Pongamia glabra Vent., all three of these names are still commonly found in literature. Pongamia pinnate is one of the few nitrogen fixing trees (NFTs) to produce seeds containing 30-40% oil. It is often planted as an ornamental and shade tree. This species is commonly called pongam, karanga, or a derivation of these names.

Botany

Pongam (Leguminosae subfamily Papilionoideae) is a mediumsized tree that generally attains a height of about 8 m and a trunk diameter of more than 50 cm. However, Troup (GOI 1983) reports trees attaining heights of 18 m. The trunk is generally short, with thick branches spreading into a dense hemispherical crown of dark green leaves. The bark is thin, gray to grayishbrown, and yellow on the inside (GOI 1983). The taproot is thick and long, lateral roots are numerous and well developed.

The alternate, compound pinnate leaves consist of 5 or 7 leaflets which are arranged in 2 or 3 pairs, and a single terminal leaflet.

Leaflets are 5-10 cm long, 4-6 cm wide, and pointed at the tip. Flowers, borne on racemes, are pink, light purple, or white. Pods are elliptical 3-6 cm long and 2-3 cm wide, thick walled, and family contain a single seed. Seeds are 10-20 cm long, flat, oblong, and light brown in color.

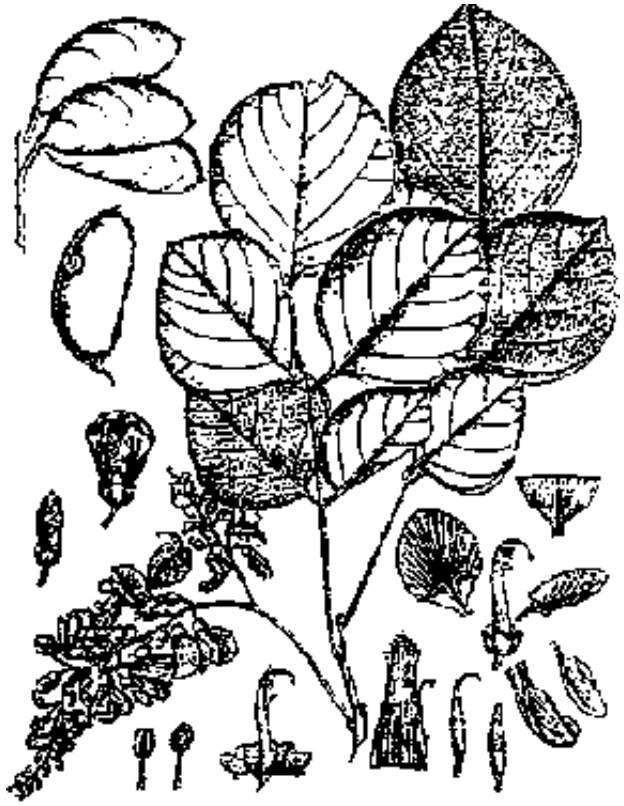
Ecology

Native to humid and subtropical environments, pongam thrives in areas having an annual rainfall ranging from 500 to 2500 mm In its natural habitat, the maximum temperature ranges from 27 to 38°C and the minimum 1 to 16°C. Mature trees can withstand waterlogging and slight frost. This species grows to elevations of 1200 m, but in the Himalayan foothills is not found above 600 m (GOI 1983).

Pongam can grow on most soil types ranging from stony to sandy to clayey, including Verticals. It does not do well on dry sands. It is highly tolerant of

salinity. It is common along waterways or seashores. with its roots in fresh or salt water. Highest growth rates are observed on well drained soils with assured moisture. Natural reproduction is profuse by seed and common by root suckers.

Distribution The natural distribution of pongam is along coasts and river banks in India and Burma. Native to the Asian subcontinent this species has been introduced to humid tropical lowlands in the Philippines, Malaysia, Australia, the Seychelles, the United States (Little undated), and Indonesia.



Source: Beddome 1869-74.

Pongamia pinnata

Uses

Wood.

With a calorific value of 4600 kcal per kg, pongam is commonly used as fuelwood. Its wood is beautifully grained and medium to coarse textured However, it is not durable, is susceptible to insect attack, and tends to split when sawn. Thus the wood is not considered a quality timber. The wood is used for cabinet making, cart wheels, posts (NAS 1980), agricultural implements, tool handles and combs (GOI 1983).

Oil.

A thick yellow-orange to brown oil is extracted from seeds. Yields of 25% of volume are possible using a mechanical expeller. However, village crushers average a yield of 20% (ICFRE, undated). The oil has a bitter taste and a disagreeable aroma. thus it is not considered edible. In India, the oil is used as a fuel for cooking and lamps. The oil is also used as a lubricant, water-paint binder, pesticide, and in soap making and tanning industries. The oil is known to have value in folk medicine for the treatment of rheumatism, as well as human and animal skin diseases. It is effective in enhancing the pigmentation of skin affected by leucoderma or scabies (ICFRE undated).

Fodder and feed.

Opinions vary on the usefulness of this species as a fodder. Troup (GOI 1983) reports that the leaves are eaten by cattle and readily consumed by goats. However, in many areas it is not commonly eaten by farm animals. Its fodder value is greatest in arid regions. According to Singh (1982) the leaves contain

43% dry matter, 18% crude protein, 62% neutral detergent fiber, 40% acid detergent fiber, and in vitro dry matter digestibility of 50%. The presscake, remaining when oil is extracted from the seeds, is used as a poultry feed

Other uses.

Incorporation of leaves and the presscake into soils improves fertility. Dried leaves are used as an insect repellent in stored grains. The presscake, when applied to the soil has pesticidal value, particularly against nematodes. String and rope can be made from the bark fiber.

Pongam is often planted in homesteads as a shade or ornamental tree and in avenue plantings along roadsides and canals. When planted as a shade or ornamental tree' branch pruning may be necessary to obtain a trunk of appropriate height. It is a preferred species for controlling soil erosion and binding sand dunes because of its dense network of lateral roots. Its root, bark, leaf, sap, and flower also have medicinal properties.

Silvicullture

Pongam is easily established by direct seeding or by planting nursery-raised seedlings or stump cuttings of 1-2 cm rootcollar diameter. Propagation by branch cuttings and root suckers is also possible. In peninsular India, the seeding season is April to June, and the seed yield per tree ranges from about 10 kg to more than 50 kg. There are 1500-1700 seeds per kg Seeds, which require no treatment before sowing, remain viable for about a year when stored in air-tight containers.

Seed germinates within two weeks of sowing. Seedlings attain a height of 25-30

cm in their first growing season. Transplanting to the field should occur at the beginning of the next rainy season when seedlings are 60 cm in height (GOI 1983). Seedlings have large root systems. Soil should be retained around the roots during transplanting. Seedling survival and growth benefit from annual weed control for the first three years after transplanting.

The spacing adopted in avenue plantings is about 8 m between plants. In block plantings, the spacing can range from 2 x 2 to 5 x 5 m. Pongam seedlings withstand shade very well and can be interplanted in existing tree stands. This species can be regenerated by coppice management Information on management practices to maximize seed or biomass production is not available and should be investigated Because it tolerates moderate levels of salinity, Pongam is an ideal candidate for saline soil reclamation.

Symbiosis

Nodulation is reported in Pongam (Dayama, 1985). In nurseries and in the field the presence of nodules on uninoculated pongam seedlings is common. Therefore, this species may not be specific in its Rhizabium strain requirement

Limitations

Pongam attracts many pests and diseases. Some of the important pests are Parnara mathias, Gracillaria sp., Indarbela quadrinotata Myllocerus curvicornis, and Acrocercops sp. (Anon. 1994). Attacks by these insects cause whitish streaks and the formation of galls on affected leaves. The lateral spread of roots of this species. about 9 m in 18 years, is greater than most other tree species (Misra and

Singh 1987). Moreover, it produces root suckers profusely. Because of these characteristics, pongam is unsuitable for agroforestry and has the potential to become a weed if not managed carefully.

References

Anon. 1994. Biological control agents of social forestry insects. Entomology Research Institute, Loyola College, Madras India 11 p.

Beddome, R.H. 1869-74. The flora sylvatica for Southern India 2 volumes, illustrated Madras India.

Dayama, O. P. 1985. Effect of sucrose on the growth, nodulation and nitrogen content of Pongamia pinnata Nitrogen Fixing Tree Research Reports 3: 9.

GOI (Government of India). 1983. Troup's The Silviculture of Indian Trees, Volume IV, Leguminosae. Government of India Press, Nasik, India. 345 p.

ICFRE (Indian Council of Forestry Research and Education). Undated. Pongamia pinnata Forest Research Institute, Dehra Dun, India 12 p.

Lewis, G. P. 1988. Notes on NFT nomenclature. Nitrogen Fixing Tree Research Reports 6: 23.

Little, E. L. Jr. Undated. Common fuelwood crops. Communi Tech Associates Morgantown, West Virginia. 354 p.

Misra, C. M. and Singh, S. L. 1987. Ecological evaluation of certain leguminous

trees for agroforestry. Nitrogen Fixing Tree Research Reports 5: 5.

NAS, 1980. Firewood crops: shrub and tree species for energy production, volume 1. National Academy of Sciences Washington, D.C. 237 p.

Singh, R.V. 1982. Fodder trees of India Oxford and IBH Publishing Co. New Delhi, India 663 p.

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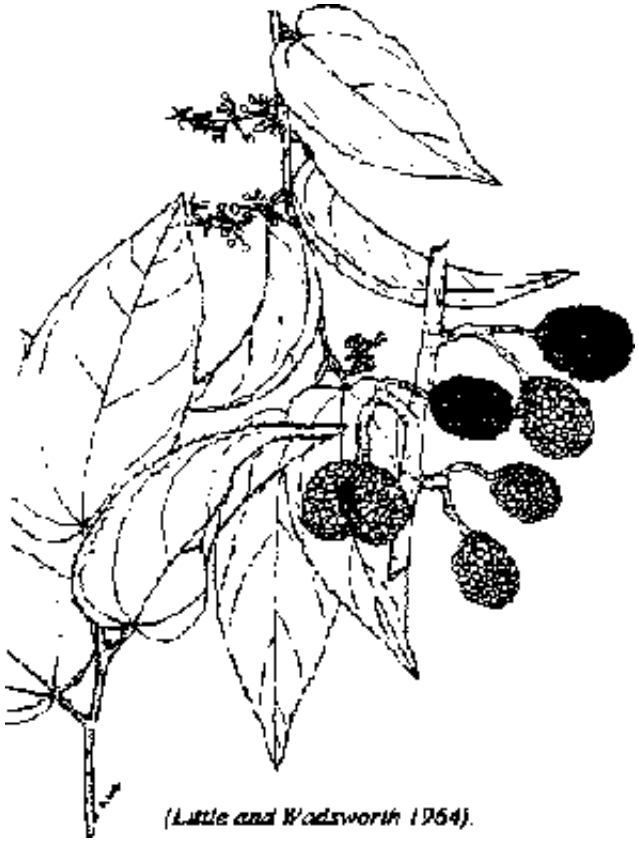

Guazuma uimifolia

A small to medium-sized tree, Guazuma ulmifolia is widely distributed throughout the Caribbean, Mexico, and Central andSouth America The wood is used for posts, general carpentry, light construction and charcoal. It is an important source of livestock fodder in many areas, particularly during the dry season when pasture grasses are unavailable.

Common names include gucima gucimo (Spanish); tablote, majagua de toro (Mexico); tapaculo (Guatemala, El Salvador); cualote (Guatemala Honduras, El Salvador, Colombia); contamal (Guatemala); chicharrn (El Salvador); kamba aka

guasa (Paraguay); iumanasi papayillo (Peru); coco (Bolivia); camb-ac guazuma (Argentina); bacedar, bastard cedar (Jamaica, Trinidad); bois d'orme, West Indian Elm (Trinidad); pigeon wood (Tobago); bay cedar, caulote, pixoy (Belize); bois d'orme. orme d'Amrique (French); mutamba fruta-de-macaco. embira poj (Brazil) (Little and Wadsworth 1964, Lopez et al. 1987, Lorenzi 1992).

Botany

Synonyms include Guazuma guazuma (L.) Cockerell, G. tomentosa H.B.K., G. polybotrya Cav., and Theobroma guazuma (L.) Poveda.

Guazuma ulmifolia Lam, family Sterculiaceae, grows to 30 m in height and 30 40 cm in diameter with a round-shaped crown. The alternate. ovate to lance-shaped leaves are 5-7 cm long and 2-5 cm wide. with finely saw-toothed margins. The flowers are brownish-yellow and form in clusters at the base of the leaves. The seeds are black, round to elliptic, 1.5-3 cm long, and hard. Seed capsules contain 5 cells which open at the apex and contain many seeds, 3-5 mm in diameter (Little and Wadsworth 1964, Lopez et al. 1987).

Young twigs are covered with rust-brown or light-gray starshaped hairs. The bark is gray or gray-brown and becomes furrowed and rough or slightly shaggy (Little and Wadsworth 1964).

Ecology

Guazuma ulmifolia is widely adapted, growing in alluvial and clay soils, and in humid and dry climates. A pioneer species that grows best in full sunlight, it colonizes recently disturbed areas and is also found growing along stream banks

and in pastures. It is a common species in secondary forest growth.

Guazuma ulmifolia grows mainly at elevations below 400 m with mean annual temperatures often above 24°C (Dunsdon et al. 1991). It is occasionally found growing up to 800 m in Brazil (Lorenzi 1992), 1000 m in Costa Rica (Vallejo and Oviedo 1994) and 1200 m in Guatemala (Witsberger et al. 1982). In its natural habitat annual rainfall is 600-1500 mm, but it grows well in areas with annual rainfall as high as 2500 mm (Dunsdon et al. 1991).

Leaves remain on the tree all year except in very dry areas where the leaves drop at the end of the dry season. In Puerto Rico, G. ulmifolia flowers from March to October and produces seed all year (Little and Wadsworth 1964). In Paraguay, it flowers in January and produces seed from July to August (Lopez et al. 1987). In Brazil, it flowers from January to September and produces seed in August and September (Lorenzi 1992).

Distribution

Guazuma ulmifolia is found in the Caribbean, Mexico, Central America and Colombia Ecuador, Peru, Bolivia Paraguay, Argentina and Brazil. It has been cultivated in India for over 100 years. It has been introduced recently to Indonesia.

Uses

Wood.

The wood is used for posts, interior carpentry, light construction, boxes and

crates, shoe horns, tool handles, fuelwood. and charcoal. The sapwood is light brown and the heartwood is pinkish to brownish. The wood is easy to work. with a specific gravity of 550-570 km/m³ (Little and Wadsworth 1964,Lopezetal. 1987).

Fodder.

In dry areas throughout its native range, G. ulmifolia is an important source of fodder for livestock, particularly at the end of the dry season when pasture grasses are not available. Naturally regenerated trees are left scattered in pastures to provide shade. Trees are also planted as live posts for fences around pastures. In Puerto Rico, immature fruits and leaves are fed to horses and cattle, and fruits are fed to hogs (Little and Wadsworth 1964). Guazuma ulmifolia is a preferred fodder tree in Jamaica Farmers feed the leaves and fruit to cattle, usually during the dry season (Morrison et al. 1996). Crude protein content of young leaves and stems ranges from 16-23% and 7-8%, respectively. In vitro dry matter digestibility for young leaves and stems ranges from 56-58% and 31-36%, respectively (Araya et al. 1994, Medina et al. 1994). Basal leaves contain 2.4% tannins (dry matter) (Araya et al. 1994).

In a study in Honduras. G. ulmifolia pruned four times in one year produced 10 kg/tree dry matter (leaves and young stems). Of the dry matter, 38% was edible (Medina et al. 1994).

A study in Guatemala compared the weight gain of young goats fed fodder of G. ulmifolia, Cordia dentata, and Panicum maximum. The average weight gain with G. ulmifolia was 71 g/day, compared to 60 g/day with C. dentata, and 42 g/day with P. maximum (Medina 1994).

Medicinal uses.

A beverage of crushed seeds soaked in water is used to treat diarrhea, dysentery, colds, coughs, contusions, and venereal disease. It is also used as a diuretic and astringent (Vallejo and Oviedo 1994).

Other uses.

The seeds are edible, fresh or cooked. The tough, fibrous bark and young stems are used to make rope and twine. Honey bees forage on the flowers (Little and Wadsworth 1964).

Silviculture

Propagation.

Guazuma ulmifolia can be established by direct seeding or by planting cuttings, root-stumps or bare-root seedlings. Seeds require scarification before planting. Pour boiling water over seeds, let them soak for 30 seconds and then drain the water (Dunsdon et al. 1991). For fresh seeds, germination occurs in 7-14 days at a rate of 60-80%. Seedlings are ready for outplanting when they reach a height of 30-40 cm (about 15 weeks). For root stumps, plants are left in the nursery for 5-8 months or until they reach a stem diameter of 1.5-2.5 cm. There are between 100,000 and 225,000 seeds per kilogram (Vallejo and Oviedo 1994, Lorenzi 1992. Dunsdon et al. 1991).

Pests

Hilje et al. (1991) reviews pests of G. ulmifolia in Central America Phelyypera distigma is a common defoliating insect. Arsenura armida and Epitragus sp. are defoliators that cause problems occasionally. Automeris rubrescens. Hylesia lineata, Lirimiris truncata and Periphoba arcaei are defoliating insects that have been observed at least once. A stem borer Aepytus sp. is an occasional problem.

References

Araya, J., J. Benavides, R. Arias. and A. Ruiz. 1994. Indentificacin y caracterizacin de rboles y arbustos con potential forrajero en Puriscal, Costa Rica. In: J. E. Benavides (ed), Arboles y arbustos forrajeros en America Central. Volumen 1. Serie Tcnica Informe Tcnico N° 236. Centro Agronmico Tropical de Investigacin y Ensenaza (CATLE). Turrialba, Costa Rica p. 31-63.

Dunsdon, A.J., J.L. Stewart, and C.E. Hughes. 1991. International trial of Central American dry zone hardwood species. Species descriptions and biomass tables. Oxford Forestry Institute. UK. p. 39-41.

Hilje, L., C. Araya and F. Scorza 1991. Plagas y enfermedades forestales en America Central: guia de campo. Serie Tcnica, Manual Tcnico N°4., CATIE. Turrialba, Costa Rica p. 185.

Little, E.L., and F.H. Wadsworth. 1964. Common trees of Puerto Rico and the Virgen Islands. Agricultural Handbook No. 249. USDA Forest Service. Washington, D.C., USA. p. 338-340.

Lopez J.A., E.L. Little, G.F. Ritz J.S. Rombold, and W.J. Hahn. 1987. Arboles

comunes del Paraguay. Peace Corps. Washington, D.C., USA. p. 364-365.

Lorenzi. H. 1992. rvores Brasileiras. Manual de identificao e cultivo de plantas arbreas nativas do Brasil. Editora Plantarum LTDA. Nova Odessa, SP, Brasil. p.327.

Medina, J.M. 1994. Observaciones sobre el consumo de follaje de gucimo (Guazuma ulmifolia), Tiguilote (Cordia dentata), y Pasto Guinea (Panicum maximum) por cabras semi-estabuladas. In: Arboles y arbustos forrajeros en America Central. Volumen 1. p. 249-256. See Araya et al. 1994.

Medina J.M., B. Rouyer, M. Tejada M. Layus, and B. Boiron. 1994. Evaluatin preliminar de la produccin de biomasa de especies leosas bajo crecimiento natural en la zone Sur de Honduras. In: Arboles y arbustos forrajeros en America Central. Volumen 1. p. 181 -188. See Araya et al. 1994.

Morrison, B.J., M.A. Gold., and D.O. Lantagne. 1996. Incorporating indigenous knowledge of fodder trees into small-scale silvopastoral systems in Jamaica. Agroforestry Systems 34: 101-117.

Witsberger, D., D. Current, and E. Archer. 1982. Arboles del Parque Deininger. Direccin de Publicaciones, Ministerio de Educatin. San Salvador, El Salvador. p. 248-249.

Vallejo, M.A., and F.J. Oveido. 1994. Caracteristicas botanical, usos y distribucin de los principales arboles y arbustos con potencial forrajero de America Central. In: Arboles y arbustos forrajeros en America Central. Volumen 2. Serie Tcnica. Informe Tchnico N° 236. Centro Agronmico Tropical de Investigacin y Ensenanza (CATIE). Turrialba, Costa Rica p. 676-677.

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Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

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Faidherbia albida - inverted phenology supports dryzone agroforestry

The African winterthorn is famous for its unusual phenology It sheds its leaves with the rains and is green during the dry season, favoring crop production beneath its canopy and reducing the need for a fallow period on poorer soils.

Botany

Faidherbia albida (Del.) A. Chev. (syn. Acacia albida Del.) is a monotypic genus in the legume subfamily Mimosoidae. Normally a deciduous tree to 15 m it can reach 25 m or more in southern Africa. with a large rounded crown and spreading branches. and trunk diameters of 1 m or more. It is distinguished by its phenology, whitish twigs and paired thorns. blue green bipinnate leaves lacking a petiolar gland, but with glands between nearly all its 2-12 pinnate pairs. The inverted phenology, does not occur in seedlings until their tap roots are well into the water table.

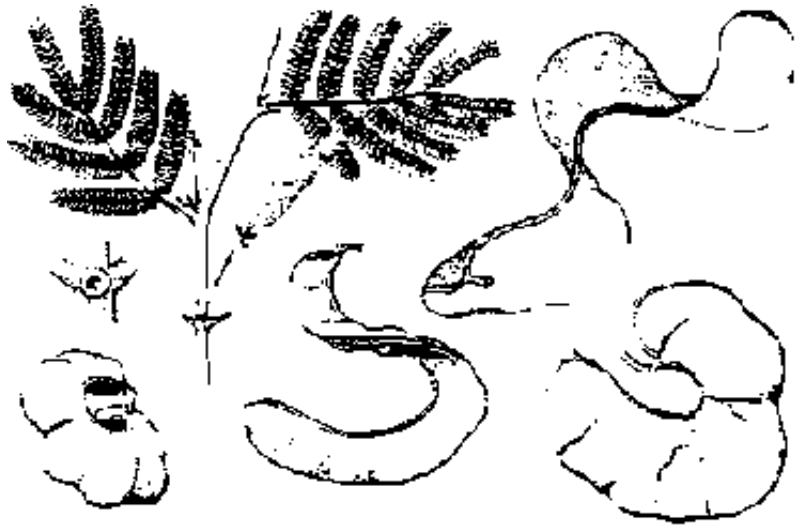
Flower buds appear soon after leaves on current season's growth. About 100 creamy white flowers occur on spikes up to 16 cm long, but most abort and normally 5 or less mature into pods 3-4 months later (Zen-Nlo & Joly in Van Den

Beldt 1992). Pods (11-30 cm long x 1.4-6.7 cm wide) are orange to reddish brown, often coiled or twisted, and contain up to 30 seeds. Seeds are dispersed by herbivores eating the indehiscent pods or by the pods floating down rivers. Populations in Cameroon show levels of outcrossing from 50-100%, with variation in a population throughout the flowering season. It is a diploid species (2n = 26) over most of its range; a polyploid (2n = 52) has been recorded from Israel (Halevy 1971).

Distribution and Ecology

Its natural range extends throughout dry tropical Africa into the Middle East and Arabia, from 270 m below sea level in Palestine up to 2500 m in Sudan (Wickens 1969). It has been introduced into India, Pakistan, Nepal, Peru, Cyprus, Cape Verde and the Ascension Islands. It grows in a wide range of climates and habitats, either scattered or gregarious. in closed canopy woodland or open savanna and in cultivated lands. It is usually a pioneer on alluvial flats but can form part of a fire climax vegetation in the west African savannas, where optimal conditions are between 500-800 mm annual rainfall. In east Africa it grows well with 1800 to 8 mm or less, provided it taps underground water. It is susceptible to frost damage.

The species develops into large populations on deep sands and alluvia in the Sahelian belt heavy vertisols in the Ethiopian highlands, and around many of the rift valley lakes or riverine and valley bottoms in east and southern Africa. It withstands flooding for a number of months along the Zambesi and Nile rivers and in paddy fields.



Pods vary considerably between trees in one population.

Faidherbia albida

Uses

Agroforestry.

The mulch created by falling leaf litter and the canopy shade at planting time creates as improved microclimate (better rainfall infiltration, reduced evapotranspiration and temperature extremes) resulting in increased crop yields (Charreau & Vidal 1965 and Poschen 1986 in CTFT 1988). Geiger et al. (in Vandenbelt 1992) argue that the fertility effect may in part be due to the tree developing on more fertile microsites rather than creating them. Animal dung and urine commonly accumulate under these shade trees.

In Zimbabwe, average leaf fall was calculated at 0.73 t/ha/yr at 11 trees/ha (Dunham 1989) compared with 0.580.97 t/ha/yr at 10 trees/ha in Senegal. Small leaflets rapidly decompose and increase the soil organic matter. In sandy

Senegalese soils. mineralized carbon increased by 73%, and total N and available P almost doubled under the canopy compared with open fields (Charreau & Vidal 1965 in CTFT 1988). The species is well suited to subsistence farming when the crop is a cereal (millet. sorghum and maize). Groundnuts yields can be depressed under the canopy from increased vegetative growth due to excess N in relation to P & K. Trees also integrate well in the rice paddy fields and are used as shade for coffee. Analysis of economic returns from cereal cropping under F. albida in the eastern highlands of Ethiopia showed an income gain of 82% was possible where cropping was under 65 trees/ha compared to treeless fields (Poschen 1986 in CTFT 1988).

Fodder.

The nutritional value of leaves and fruit is well documented. Pods fall towards the end of the dry season when fodder is scarce; leaves and branchlets are lopped around this time. Fruit production is highly variable between trees and between years. Average pod production ranges from 6 to 135 kg/tree/yr in the Sudanian zone. In Zimbabwe (Mane pools) 2 trees averaged 161 kg/tree/yr (Dunham 1990). and a single tree varied from 40-339 kg/yr. Average pod production in the Mana woodland was 590 kg/ha/yr at 11 tree/ha. The pods fall over a period of months. In west Africa pods are sometimes shaken down, collected, and fed to animals or sold in markets or at roadsides.

Trees are lopped in a number of countries for leaves and fuelwood, but this in turn affects the pod production and can extend foliage retention into the rainy season. Leaves, pods and seeds contain 200, 150 and 260 g total protein/kg of dry matter; total protein digestibility can reach 73%. Tannins limit digestibility, but

incorporating pods into low quality fodder enhances ingestion without reducing digestibility. Milling the pods increases digestion of seeds.

Other uses.

While the wood is used for fuel. it is lighter (specific gravity 0.6-0.7) and less suitable than many African acacias. Because of its size, the wood is locally used for dugout canoes, mortars, doors and some light carpentry but it is susceptible to borers. Cooked seeds are eaten as a human famine food both in Ghana. Nambia. Zambia and Zimbabwe. Flowering later than most plants, it is a useful source of pollen and nectar for honey bees. and log beehives are made from its bark. Widely used for local medicines. Ovambo Namibians use its bark for toothbrushes and is reputed to contain Fluorine. Thorny branches are used for fencing.

Establishment and Growth

Hard coated seeds store well under dry conditions, and are often extracted by pounding the pods in a mortar. Pretreatment is needed for rapid uniform germination. Mechanical scarification works best for small lots. Dipping seed for 5-15 minutes in cone. sulphuric acid or covering the seed with boiling water then allowing to cool for 24 hours are also effective. There are 7,000-20,000 seeds/kg, the seeds are smaller in west Africa than those from the east and south. Seeds can be sown directly or nursery planted, ideally using long poly tubes (30x8 cm), with regular watering and freqent mechanical root or air root pruning (CTFT 1988). Seedlings can be transplanted 3-6 months later. Spacing at 10x10 m is common, but varies with moisture availability and local farming traditions. Establishment in farmers' fields affords protection and weeding as the species is vulnerable to

competition. Tractor ploughing between mature trees can promote coppicing from damaged roots.

Extremely variable growth rates have been recorded because of genetic and site variation. Isozyme studies at OFI & CIRAD-Fret indicate a large genetic diversity within the species, distributed into 3 major areas, west, southern and northeastern Africa with the latter being a key area of diversity. Larger seeded east and southern African provenances initially grow faster than the west African provenances and have a higher shoot/root ratio, but can collapse after a couple of years in the more arid west Africa where water tables are deep. On average 1-1.5 m annual height growth has been recorded on favourable sites in Africa. Clonal propagation from shoot and root cuttings and from callus has been developed although elite stock needs to be identified. Seed from a broad range of provenances is available from members of the African Acacia trials network (OFI, CIRAD-Fret, DFSC, FAO).

Symbiosis

Faidherbia albida nodulates with Bradvrhizobium bacteria common in tropical soils, and has VA mycorrhizal associations. It develops both surface and deep tap roots and in sandy Sahelian soils the highest densities of Bradyrhizobium were found at the water table 30-35 m below the surface. In moister sites abundant nodules can be found near the surface (Dupuy & Dreyfus in Van Den Beldt 1992).

Limitations

Apart from damage from foraging animals and rodents, the principal pests and

diseases are insects and nematodes. Bruchid beetles can destroy up to 50% of the seeds. Seedlings are attacked by sap sucking insects or cochineal bugs, and nematodes (Meloidogyne javanica, M. icognita) favored by the moist nursery conditions. Caterpillars of the moth Crypsotindia conifera can defoliate adult trees by up to 50% in Nigeria and Zimbabwe. For control methods see CTFT (1988). Insect galls (leaf and flower) and parasitic plants occur sporadically in its native range. It is less susceptible to fungal diseases due to its inverted phenology, but leaf blight (Rhizoctonia solani) has been recorded on nursery plants in India Felled timber is susceptible to a variety of wood borers. It is vulnerable to competition in establishment. The thorns can be a deterrent to farmers not used to them.

References

Centre Technique Forestier Tropical (1988) Faidherbia albida A. Chev. (syn. Acacia albida Del.) Monographie. CTFT/CIRAD. Nogent-sur-Marne, France. 72pp. (English version 1989).

Dunham, K. M. (1989) Litterfall, nutrient-fall and production in an Acacia albida woodland in Zimbabwe. Jour. of Trop. Ecol. 5, 227-238

Dunham, K. M. (1990) Fruit production by Acacia albida trees in Zambezi riverine woodlands. Jour. of Trop. Ecol. 6, 445-457

Halevy, G. (1971) A study of Acacia albida in Israel. LaYaaran 21 (3/3) 97-89, 52-63

Van Den Beldt, R.J. (Ed.) (1992) Faidherbia albida in the West African Semi-arid

Tropics Proceedings of a Workshop, 22-26 April 1991, Niamey, Niger. ICRISAT & ICRAF, Patancheru, A.P. 502324, India 206pp.

Wickens G.E. (1969). A study of Acacia albida Del. (Mimosoidae). Kew Bulletin, 23 (2): 181-202.

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