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

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

- Acacia nilotica - pioneer for dry lands

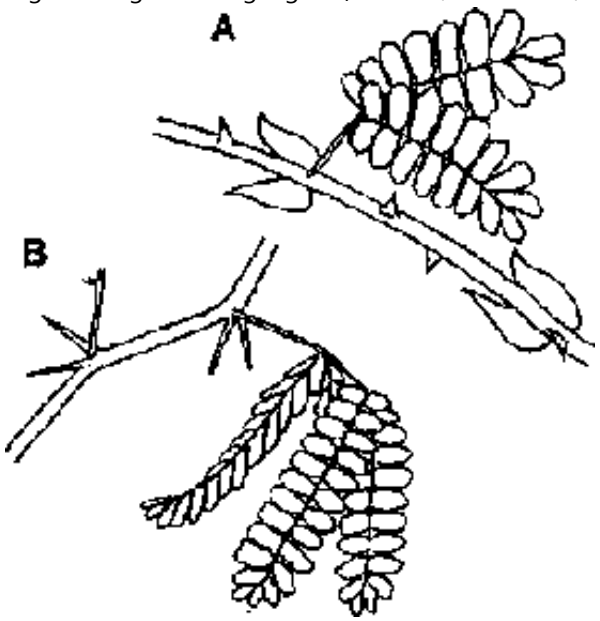
Prosopis cineraria: a multipurpose tree for arid areas

Prosopis cineraria is a versatile species, providing fodder, fuel food, timber, and shade, as well as affecting soil improvement and sand dune stabilization. It is commonly used in dryland agroforestry in India and Pakistan. The tree is known locally as jandi or khejri (India), jand (Pakistan), and ghaf (Arabic). Its synonym is P. spicigera.

BOTANY.

Prosopis cineraria (L.) Druce (family Leguminosae, subfamily Mimosoideae) is one of 44 species of leguminous trees and shrubs in the genus. It is a small, thorny, irregularly branched tree, 5-10 m high. Evergreen or nearly so, it forms an open crown and has thick, rough gray bark with deep fissures.

Leaves are alternate, bipinnately compound with 1-3 pairs of pinnae. Each pinna has 7-14 pairs of leaflets, 15 mm long and 2-4 mm broad. The thorns are straight with a conical base and distributed sparsely along the length of the stem. They first become visible when the seedlings are 6-8 weeks old. In this respect, P. cineraria differs from the thorny New World species of Prosopis (e.g., P. juliflora) which have thorns in pairs at the nodes but thornless internodes.



Young branches of (A) Prosopis cineraria and (B) P. juliflora, showing the differing position of thorns.

The 0.6 cm yellow-green flowers are borne on 5-23 cm spike-like racemes. Up to 25 dull brown seeds, 03-0.8 cm long, are contained in each of the light yellow pods, which are long (8-19 cm), narrow (0.4-0.7 cm), and cylindrical. As with other Prosopis, rooting can be very deep; the tap root of P. cineraria may penetrate vertically up to 20 m or more (Mahoney 1990).

ECOLOGY.

P. cineraria occurs naturally in the dry and arid regions of India, Pakistan, Afghanistan, Iran, and Arabia. It is one of the principal species on higher and older alluvium in the Indus river valley. It is extremely drought tolerant, growing in areas with as little as 75 mm annual rainfall generally 150400 mm (FFN 1991), with dry seasons of eight months or more (NAS 1980).

Slightly frost hardy and tolerant of temperatures up to 50°C, it grows at altitudes from sea level to 600 m. The tree is found in alluvial and coarse, sandy, often alkaline soils where the pH may reach 9.8. In vitro studies have confirmed the nodulation of P. cineraria with Rhizobium.

In areas such as the Wahiba Sands in Oman there exist isolated, ancient P. cineraria trees. It also grows gregariously on sand. Under less extreme conditions, P. cineraria, often in association with Acacia tortilis, may form open dry, woodlands, which are important communities within the desert ecosystem. There is considerable phenotypic variation between individuals in crown shape, growth rate, and branching. Ecotypes growing in highly saline coastal areas have also been identified.

USES.

Wood:

P. cineraria provides excellent firewood (calorific value, cat 5,000 kcal/kg) and charcoal Its wood is favored for cooking and domestic heating (Mahoney 1990). Hard and reasonably durable, the wood has a variety of uses for house building, posts, tool handles, and boat frames, although poor tree form limits its usefulness as timber.

Fodder:

The leaves are an available, excellent, and nutritious fodder, readily eaten by many animals including camels, goats, and donkeys. The tree produces leaves during the extremely dry summer months when most other trees are leafless. Leaves contain

13.8% crude protein, 20% crude fiber, and 18% calcium (FFN 1991). The pods also provide a good fodder, containing a dry, sweet pulp.

Food:

Pods are eaten as a vegetable in the human diet in some areas. In Rajasthan, green pods called sangri are boiled and dried (FFN 1991). The flowers are valuable for honey production. The bark can be used in leather tanning and yields an edible gum. Bark and flowers are used medicinally (NAS 1980). In times of famine, the powdered bark has been mixed with flour and made into cakes (Bhandari 1978).

Land use:

P. cineraria effectively stabilizes sand dunes and can withstand periodic burial (Gates and Brown 1988). Because of a deep taproot, trees are not believed to compete for moisture or nutrients with crops grown dose to the trunk. During the growing season it casts only light shade and is therefore suitable as an agroforestry species. Farmers in arid and semi-arid regions of India and Pakistan have long believed it to increase soil fertility in crop fields. Yields of sorghum or millet increased when grown under P. cineraria, as a result of higher organic matter content, total nitrogen, available phosphorus, soluble calcium, and lower pH (Mann and Shankarnarayan 1980). Other crops traditionally grown amid scattered khejri are maize, wheat, and mustard.

SILVICULTURE.

Seeds (25,000/kg) remain viable for decades in dry storage and establish well with 80-90% germination (Mahoney 1990). Soaking seeds in tepid water for 24 h

is recommended as a pre-germination treatment. The round end of the seed may also be scarified by scratching or nicking with a file or knife.

P. cineraria is difficult to propagate by cuttings, although treatment with rooting hormones has proved successful in India. Propagation by root suckers and by air layering has been reported. Recent attention has also been given to micropropagation of this species, but it appears that in vitro propagation is more difficult with P. cineraria than with many other Prosopis species. The tree is also considered slower growing than other Prosopis.

Seedlings are raised in a nursery and transplanted when 2-3 months old at the onset of the rainy season. Trees can be planted in close lines as a hedge with 1 m spacing between trees (Mahoney 1990), but tree densities of 50-100/ha are recommended for both agroforestry and silvopastoral systems. One or two weedings are necessary during the first year owing to slow initial growth rate. Early pruning to encourage straight growth is recommended (NAS 1980). The tree responds well to irrigation, tolerating up to 50% sea water.

The tree coppices readily (NAS 1980). Maximum yields of fodder are obtained when the trees are pollarded on a threeyear-rotation. Villagers traditionally lop their trees in winter and store the sun-dried leaves for dry season fodder.

YIELD.

The trees reach 3-5 m high in 5-6 years with an average diameter of 6 cm. Annual firewood yields of up to 2.9 m^3/ha have been reported (NAS 1980). A moderate sized tree may yield 45 kg of dry leaf fodder per year.

RESEARCH.

Although P. cineraria plays a vital role as an agroforestry species in some parts of its natural range, little success has been achieved in planting it elsewhere. Further work is needed to establish the range of conditions under which it might prove useful. P. cineraria displays considerable genetic variation, particularly in populations close to the edge of its natural range, which are often threatened by overgrazing. Genetic conservation of this valuable resource is considered a priority.

LIMITATIONS.

Desert locusts (Shistocarica gregaria) and Melolonthidae beetles attack the foliage, and bruchid beetles feed on the mature dried seeds. Termites (Odontoteomen obesus), white grubs (Halorachia spp.), and the gallfly (Goccidomulid gall)) arc also important pests. There is little information on diseases of P. cineraria. This NFT is not suitable for planting in riverine areas or subhumid environments where it can become an aggressive colonizer and spread rapidly.

PRINCIPAL REFERENCES:

Bhandari, MM. 1978. Flora of the Indian Desert. Scientific Publishers, Jodhpur, India.

Burkart, A. 1976. A monograph of the genus Prosopis (Leguminosae, subfam. Mimosoideae). J. Am. Arb. 57(3/4): 219-249; 450-525.

FFN. 1991. Spotlight on species: Prosopis cineraria. Farm Forestry News Vol. 4, No. 3.

Gates, P.J. and K Brown. 1988. Acacia tortilis and Prosopis cineraria: Leguminous trees for arid areas. Outlook on Agriculture 17:61 64.

Leakey, R.R.B. and F.T. T. Last. 1980. Biology and potential of Prosopis species in arid environments with particular reference to P. cineraria. 1. Arid Environments 3:9-24.

Mahoney, D. 1990. Trees of Somalia - A field guide for development workers. Oxfam/HDRA, Oxford. p. 133-136.

Mann, H.S. and K.A. Shankarnarayan. 1980. The role of Prosopis cineraria in an agropastoral system in Western Rajasthan. In Browse in Africa, edited by H.N LeHouerou, International Livestock Centre for Africa, Addis Ababa, Ethiopia. p. 437442.

NAS (National Academy of Sciences). 1980. Firewood Crops. Vol. 1. National Academy Press, Washington, D.C. p. 150

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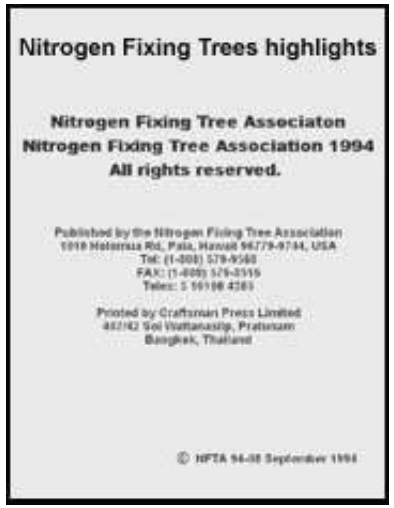

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Juliflorae acacias: new food source for the sahel

Julifloræ acacias: new food source for the sahel

The seeds of certain Acacia species were an important traditional food resource for Australia's desert Aborigines (Crawford, 1982: O'Connell et al., 1983; Latz, 1984; Brand and Cherikoff, 1985; Orr and Hiddens. 1987). According to a recent review (Thomson, 1992), 44 of the 125 Acacia species found in the deserts of subtropical Australia have some potential as sources of human food, including the A. holosericea/cowleana group, A. tumida and A. adsurgens from the large section Juliflorae. These species have a colonizing habit and are characterized by:

- **Precociousness, producing seed within 18 to 24 months of planting**
- **High self fertility**
- **High fecundity, setting heavy seed crops two to three years after planting**
- **A short life span of only 5 to 10 years.**

They have exhibited very good or outstanding growth and adaptation to other tropical dry zones, notably the Sahelian zone of West Africa (Cossalter, 1987). They have a major, but scarcely tapped, potential to provide a protein-rich food source, particularly as famine reserve food. for the people living in semi-arid regions of sub-Saharan Africa.

Taxonomy and genetic resources

Acacia holosericea/cowleana group.

Recent laboratory and field research has revealed that the widely planted A.

holosericea consists of at least four distinct entities of differing ploidy levels (Moran et al., in press: Maslin and Thomson, in preparation). The diploid (2n = 26) species, A. neurocarpa, occurs in moist niches in northwestern Australia and Northern Territory. Key morphological traits are:

- **Large, broad phyllodes, especially pronounced in young plants**
- **Stout, flattened branchlets**
- **Long (2 mm) linear bracteoles.**

The tetraploid (2n = 104) species, A. holosericea, occurs in riverine and woodland habitats in subhumid parts of northern Australia. The pods of both A. neurocarpa and A. holosericea are tightly and irregularly coiled.

The hexaploid species, A. colei ms, is widespread in the semiarid zone of northern Australia. It appears to have evolved as a result of past hybridization between A. neurocarpa and A. cowleana (a tetraploid species). Fruiting plants of A. colei ms are readily distinguished from A. neurocarpa and A. holosericea by their strongly and openly curved pods. A fourth undescribed entity, A. aff. colei, bears a close resemblance to A. colei ms. but is distinguished by its curly pods.

All four species have been subject to field trials in West Africa. They have proven to be fast growing, adapted to most soil types including sands and skeletal soils, and not prone to termite attack or browsing by livestock. Acacia colei ms has shown excellent adaptability to the Sahelian belt of West Africa since its introduction in the early 1970s under the name "A. holosericea" (Mandora provenance) by the Centre technique forestier tropical (Cossalter, 1987).

Acacia colei ms holds great promise for human food production in dry regions of tropical Africa. It tolerates prolonged dry periods and bears heavy seed crops that are easy to collect and clean. The seeds are readily released by fully mature pods, without resorting to pounding that may release an irritating dust. Plants are highly self-fertile, with little apparent within-species variation.

Acacia cowleana is another fast-growing large shrub or small tree with a wide distribution in the semi-arid, subtropical areas of northern Australia. Isozyme studies found only limited intraspecific variation, mainly between populations (Moran et al., 1992). This species performed well in several trials in West Africa. It proved especially promising for sandy soils in southern Niger. However, field trials near Ouagadougou, Burkina Faso, revealed substantial differences in the growth and survival rates of different provenances (IRBET/CTFT, 1989).

Acacia cowleana appears to be directly involved in the evolution of two other species with potential as human foodA. oligophleba and A. aff.cowleana. Acacia oligophleba is a multistemmed large shrub or small tree from warm to hot, subtropical to semi-arid, zones of northwestern Queensland and Northern Territory. Its general appearance suggests a vigorous form of A. cowleana. Pedley (1978) gives a botanical description. One seedlot (CSIRO S13774), under the name "A. cowleana", was included in the FAO/CSIRO series of international provenance trials for A. aneura. At Bandia, Senegal, A. oligophleba grew quickly at first, but plants started to die out after about five years. In ACIAR/QDF trials in southeast Queensland, A. oligophleba an average height of 3.3 to 4.0 m after 3.5 years Bryan and Bell, 1989). Plants flower precociously-at 15 months in southeastern Queensland-and produce heavy seed crops following good summer rains.

Acacia aff. cowleana is a spreading shrub that grows on rocky sites in semi-arid areas of northern Australia. It appears to have arisen through hybridization between A. cowleana and A. gonoclada and closely resembles A. cowleana. Until recently, the two species were confused. New shoots of A. aff. cowleana are covered with reddish-brown resin and this provides a useful distinguishing feature. This species has a unique capacity to produce moderately heavy seed crops from difficult, rocky sites, including those with a lateritic hardpan.

Acacia humida.

A fast-growing, multistemmed shrub or small tree from the semi-arid to subhumid zones of northwestern Australia. A. tumida has performed well in field trials in Niger, Burkina Faso and Senegal. This species is well adapted to infertile soils, including podzols, laterites and loose. drifting sands. Populations vary considerably in many characters. including plant habit, coppicing ability and seed size. Acacia tumida hybridizes with A. difficilis, A. eriopoda and, less frequently. with A. trachycarpa (Thomson, 1992). Turnbull (1986) provides a full description.

Acacia adsurgens.

A moderately fast-growing, multistemmed shrub from semi-arid regions of northern and central Australia' A. adsurgens is well adapted to sandy soils. The species is fully described by Thomson and Hall (1989). It has been observed to produce heavy seed crops on infertile sands in southern Niger.

Yield potential

Flowering and seed set in these species depend on the amount and distribution of

rainfall in the previous rainy season and on any subsequent, out-of-season rains. In northern Australia, Juliflorae acacias set heavy seed when cumulative rainfall is at least 300 to 400 mm, especially when rain is concentrated towards the end of, or even after, the main rainy season. Clearly, these acacias are capable of producing a useful seed crop in years that are unfavorable to short-duration rainy-season crops such as maize, millet or sorghum.

In native stands. typical yields are 250 to 500 g tree^{-1}, but mature specimens can yield up 1 to 2 kg of clean seed. There is little information on seed production in plantations. Yields are affected by many factors-such as moisture regime, insect predation and management-but seed production in managed plantations at wide spacings (for instance 5 x 5 m) will normally exceed 100 kg ha^{-1}.

In northern Australia. predation by various insect pests, such as chalcid wasps, may cause considerable seed destruction. Appropriate quarantine measures are crucial to prevent the accidental entry of Australian insect pests into other regions where these trees are introduced. Fortunately, the Bruchid beetles that cause extensive damage to seed crops in African acacias do not appear to be a serious problem for the Australian Juliflorae species (Doran et al., 1983).

Utilization

Until recently, knowledge of the use of Australian acacia seeds as human food came exclusively from the desertdwelling Australian Aborigines. Once the pods have turned brown and begun to split, the seed can be harvested quickly by beating the pods onto a large sheet or tarpaulin spread underneath the tree. A particularly efficient technique is to cut the small pod-bearing branches and beat

them directly onto a sheet. The seeds of these species, especially A. colei ms and A. tumida, may be cleaned with minimal threshing or winnowing. If rubbed in water, the empty seeds and arils float off.

The dry seeds may be lightly roasted and ground with a little water into a paste: the flavor has been likened to peanut butter (Latz, 1984). The roasted or unroasted seeds may be ground into flour with a stone or wooden mortar and pestle or with a mechanical mill such as used for grinding millet. Acacia seed flour can be mixed with water and cooked as unleavened bread or mixed with wheat flour and baked into bread (20% acacia flour according to Thor burn et al., 1987) or biscuits (50% acacia flour according to Maggiore, 1985).

The large seeds of A. tumida can also be consumed green (Crawford. 1982). Green pods are readily harvested, but nearmature seeds are only available for three to four weeks. The green pods should be lightly roasted to force them open and to dry up any bitter juices. The flavor of green acacia seeds has been likened to peas. but in the case of A. tumida there is a somewhat unpleasant aftertaste.

Recent experience Niger southern that A. that colei is readily integrated into traditional agriculture and enjoys a high level of acceptance as a food source (T. Rinaudo. SIM International. personal communication). No aspect of seed preparation requires new technologies or special skills. The question of acceptability of acacia seed food products is still unanswered in other parts of Africa. Important aspects are texture, taste, appearance and ease of preparation.

With their hard coats, the seeds may be stored at ambient tropical temperatures without deterioration for more than 10 years. If wetted, they neither germinate

nor rot easily, making them an ideal food reserve for times of famine.

Food value.

The seeds of the Juliflorae acacias are rich in nutrients, with high protein, energy and fat contents. The high protein content is noteworthy as the diet in dry sub-Saharan Africa is often lacking in protein, especially for children. Of total dry seed weight, A. adsurgens is 26% protein (Maggiore and Latz, unpublished), A. "holosericea" is 21% (Peterson, 1978), and A. cowleana is 22 to 24% protein (Maggiore and Latz, unpublished). Acacia seed proteins include globulins, and to a lesser extent, albumins that provide a well-balanced source of essential amino acids.

Toxicity.

The seeds of most pods contain some potentially toxic proteins, but these are denatured by cooking. Proteinase inhibitors, affecting trypsin and chymotrypsin, have been found in seeds of A. cowleana and other species. but only at levels similar to those found in peas or beans-much lower than levels in soybeans or winged beans (Kortt, 1984). The seeds of these species are reported to be free of the serious neurotoxins present in the seeds of African acacias (Murray, 1984). Further research is required on possible toxic or antinutritional components, but these are unlikely to constitute a hazard in species widely eaten by Australian Aborigines.

Silviculture

Establishment.

The Juliflorae acacias are easily propagated from seed and readily established in the field, either from container-grown seedlings or by direct seeding. Germination is enhanced by immersing the seeds in rapidly boiling water for 60 seconds. The recommendation is to maintain seedlings in a nursery for 10 to 14 weeks. In hot weather, germination usually occurs within seven days and seedlings grow quickly. Inoculation with an effective strain of a Bradyrhizobium root symbiont may promote uniform seedling growth, but is not essential. Turnbull (1986) gives more information on establishment practices for particular species.

Direct seeding is a promising technique for establishing broad-scale plantings. Pretreated seeds should be sown either just before or at the beginning of the rainy season. This approach has proven successful in trials in northern Nigeria and Senegal. However, direct seeding with A. colei ms failed at Tanout, Niger, where annual rainfall was only 170 to 200 mm (P. Beckman, Eden Foundation, personal communication). Successful establishment by direct seeding probably requires rainfall levels of 350 to 400 mm.

Planting systems.

In many parts of the Sahel, low bushy windbreaks of Juliflorae acacias could help crop establishment by reducing wind speed and sand blasting. However, competition for soil moisture will probably limit the intercropping potential of these trees in the harsh Sahelian environment. Single or staggered double-row windbreaks. positioned perpendicular to damaging winds at intervals of 40 to 50 m, may provide an effective compromise between conventional windbreaks and alley-cropping systems.

These trees can grow on difficult sites that are unsuitable for traditional crops. Acacia tumida has great potential for stabilizing moving sands, while A. cowleana and A. colei can tolerate hardpan near the soil surface. Low planting densities, of about 400 trees ha~, are suitable for non-arable sites where the objective is to maximize seed production.

Farmers in West Africa are increasingly planting Juliflorae acacias in and around their villages for shade and ornamental purposes. There is considerable opportunity to expand these plantings for combined food and fuelwood production. There is also scope for interplanting fast-maturing Juliflorae acacias with slower-developing, but valuable local trees such as Faidherbia albida (for fodder) or Securidaca longipedunculata (for medicine). When planted in suitable arrangements, the Juliflorae acacias can help protect these trees and provide early yields of food and fuelwood.

Pruning regimes.

Most of the Juliflorae acacias that hold promise for food production have poor coppicing ability. The exception is certain populations of A. tumida that can regrow from basal coppice and root suckers. Most species respond well to light pruning and pollarding, and these practices, when properly applied, may increase plant longevity by several years.

The extent and vigor of regrowth depend on season of cutting, cutting height and retention of phyllode-bearing branches. In Niger, A. colei ms regrew best after cutting in June, while in Senegal the best regrowth was after cutting between May and July. The recommended cutting height is I m, retaining at least one phyllode-

holding branch. Plants have been observed to set moderately heavy seed crops within a year of heavy pruning.

Research needs

Wider use of the Juliflorae acacias as human food requires further investigation in several areas. These include yield potential. management and possible toxic effects associated with long-term high rates of ingestion. The Australian Tree Seed Center (CSIRO Division of Forestry) is currently identifying priority areas for future research and plans to coordinate such activities. Pilot evaluations are urgently needed in different areas of sub-Saharan Africa.

Seed source

Seed of A. colei. A. cowleana. A. aff. cowleana and A. oligophleba is available from Future Forests. They can be contacted by FAX at (613) 306-6094.

Further reading

Brand. J.C. and Cherikoff, V. 1985. The nutritional composition of Australian Aboriginal food plants of the desert regions. In G.E. Wickens, J.R. Goodin and J.V. Field, eds. Plants for arid lands. London: Allen and Unwin. pp. 53-68.

Cossalter, C. 1987. Introducing Australian acacias in dry tropical Africa. In J.W. Turnbull, ed. Australian acacias in developing countries. Proceedings 16. Canberra: ACIAR. pp. 118-22.

Crawford, I.M. 1982. Traditional Aboriginal plant resources in the Kalumburu area:

aspects in ethno-economics. Records of the Western Australian Museum. Suppl. 15.

Doran, J.C., Turnbull, J.W., Boland, D.J. and Gunn, B.V. 1983. Handbook on seeds of dry-zone Acacias. Rome: FAO.

IRBET/CTFT (Institut de recherche en biologic et ecologic tropicale/Centre technique forestier tropical). 1989. Rapport annuel d'activits. Ouagadougou: IRBET/CTFT.

Kortt. A.A. 1985. Characteristics of the proteinase inhibitors of Acacia seeds. In G.P. Jones, ed. The food potential of seeds from Australian native plants. Victoria (Australia): Deakin University Press, pp. 121-45.

Latz. P.K. 1984. Bushfires and bushtucker: Aborigines and plants in central Australia. M.A. thesis. Armidale (Australia): University of New England.

Maggiore, P.M.A. 1985. Utilization of some Australian seeds in edible food products. In G.P. Jones, ed. The food potential of seeds from Australian native plants. Victoria (Australia): Deakin University Press, pp. 59-73.

Maslin, B.R. and Thomson, L.A.J. In preparation. Reappraisal of the taxonomy of Acacia holosericea A. Cunn. ex Don, including the description of a new species, A. colei, and the reinstatement of A. neurocarpa A. Cunn. ex Hook.

Moran, G.F., Thomson, L.A.J., Grant, J.E. and Bell, J.C. In press. Genetic diversity in Acacia holosericea. In A.P.N. House and C.E. Harwood, eds. Australian dry-zone acacias for human food. Canberra: Australian Tree Seed Centre, CSIRO Division of

Forestry.

Murray, D.R. 1984. The food value of Acacia seeds. Australian Plants. 13(101):25 - 26. J.F., Latz, P.K. and Barnett. P. 1983. Traditional. modern plant use among the Alyawara of central. Australia. Economic Botany. 37(1):80-109.

Orr, T.M. and Hiddens, L.J. 1987. Contribution of Australian acacias to human nutrition. In J.W. Turnbull, ed. Australian acacias in developing countries. Proceedings 16. Canberra: ACIAR, pp. 112-15.

Pedley. L. 1978. A revision of Acacia Mill. in Queensland. Austrobaileya. 1(2):75-234.

Peterson, N. 1978. Traditional patterns of subsistence in 1975. In B.S. Hetzel and H.J. Frith. eds. The nutrition of Aborigines in relation to the ecosystem of Central Australia Melbourne: CSIRO.

Ryan. P.A. and Bell, R.E. 1989. Growth. coppicing and flowering of Australian tree species in trials in southeastern Queensland. Australia. In D.J. Boland, ed. Trees for the tropics: growing Australian multipurpose trees and shrubs in developing countries. Monograph 10. Canberra: ACIAR. pp. 49-68.

Thomson. L.A.J. 1992. Australia's sub-tropical dry-zone Acacia species with human food potential. In A.P.N. House and C.E. Harwood. eds. Australian dry-zone acacias for human food. Canberra: Australian Tree Seed Center, CSIRO Division of Forestry, pp. 3-36.

Thorburn. A.W.. Brand, J.C., Cherikoff, V. and Truswell, A.S. 1987. Lower

postprandial plasma glucose and insulin after addition of Acacia coriacea flour to wheat bread. Australia and New Zealand Journal of Medicine. 17:24-26.

Turnbull. J.W. 1986. Multipurpose Australian trees and shrubs: lesser-known species for fuelwood and agroforestry. Monograph 1. Canberra: ACIAR.

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Sesbania grandiflora: NFT for beauty, food, fodder and soil improvement

Sesbania grandiflora is a tree that grows rapidly, provides light shade, and is often grown as an ornamental. This softwooded tree's leaves are used as fodder and its flowers as food. Grandiflora is planted in gardens for its intercropping compatibility and soil-improving properties.

Botany

Sesbania grandiflora (L.) Poir. is a tree that grows to 8-10 m in height The pink-red or white flowers of this papilionaceous (pea-like flowered) legume are unusually large (5-10 cm in length and about 3 cm wide before opening); this novelty may be the principal reason for grandiflora having been distributed by man throughout the tropics and subtropics. Within its genus, S. grandiflora is a member of the subgenus Agati, and it is thus more closely related to the unusual

littoral sesbanias of Pacific islands than to the more typical sesbanias of subgenus Sesbania, such as the perennial S. sesban and the annual sesbanias grown for green manure (such as S. cannabina).

Grandiflora's pinnate leaves may be 30 cm long, with 12-20 pairs of oblong, rounded leaflets averaging 3-4 cm long and about 1 cm wide. The leaves are borne at the terminals of branches, and the canopy is open, with a thin crown which produces light shade. Its racemes bear 2-3 flowers. The pods are usually 30-50 cm long by about 8 mm wide. The seeds are tan to red-brown, 6-8 x 3-5 mm, 14-20 weighing 1 g. The trunk may reach 25 cm diameter at breast height Grandiflora may live 20 years or more.

grandiflora is very closely related to the endemic Australian species, S. formosa. This relationship supports the supposition that grandiflora may have originated in Indonesia. S. formosa bears white flowers and is often indistinguishable from grandiflora to the casual observer. The two species appear to have similar growth habits and adaptivity, and it is possible that S. formosa also can be used for the purposes described here for grandiflora.

Distribution

Grandiflora is found in cultivation throughout the tropics and subtropics.

Ecology

Because wild populations of grandiflora are unknown, its natural habitat is uncertain. grandiflora is grown most successfully in the lowland tropics (below 1000 m elevation) and warm, frost-free subtropics. It can be grown in regions

with as little as 800 mm rainfall or as much as 2000-4000 mm. It seems to prefer a birnodal rainfall distribution, growing rapidly during wet seasons but capable of withstanding prolonged dry seasons of up to nine months.

Sesbania grandiflora, from Sachet, M.-H. 1987. The littoral species of *Sesbania* (Leguminosae) in the South Pacific islands and its relatives. Bulletin du Museum National d'Histoire Naturelle, section B, 4th series, Adansonia 9:3-27. (Focuses on subgenus Agati.)

Sesbania grandiflora

Grandiflora is tolerant of soil salinity and waterlogging, and withstands occasional short periods of flooding. It is well adapted to heavy clay soils.

Uses

Fodder, food, and soil improvement are the principal uses for grandiflora

Fodder.

Grandiflora is valued as a fodder in many regions. In south-central Lombok, Indonesia, grandiflora grown around rice paddy bunds provides up to 70 percent of the diets of cattle and goats during the annual eight-month dry season (Mudahan Hazdi, personal communication). The leaves contain as much as 25-30 percent crude protein.

Although ruminants readily consume grandiflora fodder, and its digestibility is high, some feeding studies have indicate that antinutritional factors are present. Until further research provides clear guidelines, caution should be used in feeding S. grandiflora to ruminants and other animals, and restricting feeding to less than 30 percent of dry matter intake is suggested. grandiflora leaf is toxic to chickens and should not be fed to them or other monogastric animals.

Soil improvement.

Grandiflora is often maintained in gardens and around crop fields for its contribution of nitrogen. The light shade cast by its canopy does not block much light, allowing the growth of companion plants. Falling leaflets and flowers recycle nutrients to the ground. Seedlings grow rapidly enough that they have been used similarly to annual green manure crops. For example, grown around paddy bunds for incorporation before planting the subsequent rice crop.

Wood.

The wood is rather light and not ideal for firewood or pulping; the bark is thick and corky and is a further detriment to either of these uses. The trunks may be used as poles for temporary shelters and sheds, but they may not last very long due to rots and insect infestation.

Food.

Leaves, seed pods, and flowers of grandiflora are sources of food. The young, tender pods are cooked similarly as the green beans. In South Asia the young leaves are chopped and sauteed, perhaps with spices, onion, or coconut milk In the Philippines, unopened white flowers are a common vegetable, steamed or cooked in soups and stews after the stamen and calyx have been removed. Selection of white-flowered varieties that flower profusely has resulted from this use in the Philippines.

Other uses.

grandiflora has been used to shade nurseries and some crops, such as turmeric, as support for climbing crops such as pepper and betel vine, and as an element of windbreaks. The leaves of the tree have various uses in the herbal medical lore of certain regions.

Culture and Management.

Grandiflora is grown from seed, which may be planted without scarification. Stored seeds lose viability within a year or two. Seeds may be direct-sown or

transplanted from nurseries; bare-rooted transplants are usually successful.

Seedling growth of grandiflora may be very rapid. Under harsh conditions or neglect, however, seedling survival may be poor. The leaf canopy is open and casts only light shade, hence its popularity in gardens.

Grandiflora cannot be coppiced or pollarded. Harvesting leaves for fodder must be done selectively, to avoid complete defoliation, and cannot be done more than a few times per year. More intensive harvesting, such as managing as a hedgerow, reduces the life of the tree. For example, cutting at 1 m high five times a year can result in tree mortality. Because grandiflora establishes so rapidly, frequent replanting is a management option if heavy harvesting results in tree decline.

Where flowers and pods are harvested for consumption as vegetables, the structure of the tree is shaped by pruning so that the canopy remains low, within reach for convenient harvesting.

Symbiosis

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

Limitations

Grandiflora's soft wood is susceptible to damage by insects. Fodder cuttings cannot be severe. Seed recovery may be limited by pod pests. Seed viability

declines after one year.

References

Evans, Dale O. 1990. What is Sesbania? Botany, taxonomy, plant geography, and natural history of the perennial members of the genus. In: B. Macklin and D.O. Evans (eds), Perennial Sesbania species in agroforestry systems. Nitrogen Fixing Tree Association. p. 5-19.

Evans, D.O., and Macklin, B. (eds). 1990. Perennial Sesbania production and use. Nitrogen Fixing Tree Association. 41 p.

Evans, D.O., and Rotar, P.P. 1987. Sesbania in agriculture. Westview Press, Boulder, Colorado, U.S.A.

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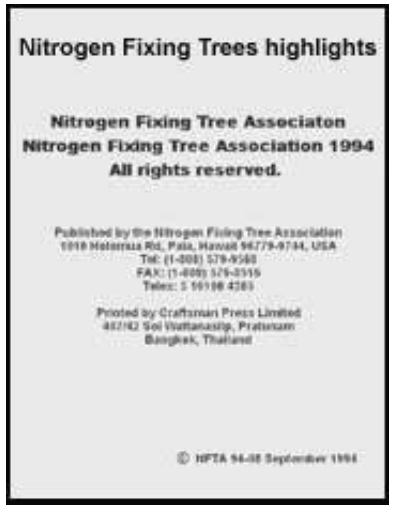

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Albizia saman: pasture improvement, shade, timber and more

Albizia saman (Jacq.) F. Muell. (Leguminosae, Subfamily Mimosoideae) is a fast growing tree which obtains a large size. It is most common as a pasture, shade or ornamental tree, but has numerous uses. This New World tree is so widely cultivated and used in Southeast and South Asia it is often mistaken as native to that area. It was formerly classified as Samanea saman, Pithecellobium saman and Enterolobium saman. Common names include saman, monkey pod, raintree, cow tamarind, algarrabo and guango.

Source: Little and Wadsworth, 1989

Albizia saman

Botany

Albizias are related to and often mistaken for Acacias-in the Philippines acacia is a common name for A. saman. Albizia saman can obtain a height of 3045 m and diameter breast height (DBH) of 150-250 cm. Open-grown specimens have short stems and stout wide-spreading nearly horizontal branches. The umbrella-shaped crown may be wider than the height of the tree. The brown gray bark is rough and furrowed into ridges and plates (Little and Wadsworth 1989). Limb bark is lighter in color. Twigs are stout and green. The bipinnately compound leaves are 2540 cm long dark green above and light green below. The stalkless leaflets are arranged in pairs numbering from 12 to 32 (Little and Wadsworth 1989). Leaflets are wider towards the apex. Both leaves and leaflets are progressively larger towards their terminal ends.

The showy flower heads, composed of many narrow pink flowers, are found near the end of twigs and appear from March to September (Hensleigh and Holaway 1988). The dark-brown to black pods are hard and thick with a raised seam. They are 8-20 cm long and about 2 cm wide. The pods do not readily open and remain on trees for long periods. Seeds are red-brown oblong and squarish. There are 5000-8000 seed/kg.

Ecology

Albizia saman is found in the tropics from sea-level to 1000 meters where the temperature is 20-35° Celsius. It is a common component of dry forests and grass savannas. Annual rainfall in these areas is 600-3000 mm/year. Albizia saman easily survives dry seasons of 24 months. While more common on drier sites, this

species grows best in moist, well-drained fertile soils (Hensleigh and Holaway 1988). It tolerates heavy clays and infertile or waterlogged soils. Although normally found in neutral to moderately acid soils, it will grow in soil with pH as low as 4.6 (Franco et al. 1995).

Distribution

This species is native from Southern Mexico and Guatemala south to Peru, Bolivia and Brazil. It is naturalized throughout the tropics and has been introduced to sub-tropical areas.

Uses

Shade and ornamental.

Albizia saman is planted along roads throughout the tropics. In parks and commons, its high arching branches provide welcome protection from the heat of the tropical sun. Having crowns of great diameter, trees furnish ample shade. Trees serve as windbreaks and are cultivated for their beautiful pink flowers.

Wood.

The wood of Albizia saman is highly valued for the manufacture of furniture, cabinets, decorative veneers, bowls and other handicrafts. The chocolate heartwood and yellow sapwood form a beautiful contrast. The light-weight wood (specific gravity 0.48) is strong, durable, works easily and takes a good finish (Chudnoff 1984). It shrinks so little that products made from green wood dry without warping (NAS 1979). Albizia saman is a good quality fuel and charcoal,

producing 5200-5600 kcal/kg (F/FRED 1994). Other uses of the wood include fencing, construction timbers, plywood and the manufacture of crates, wheels and boats.

Pasture and fodder.

Albizia saman is a valuable component of pasture systems. Its shade protects livestock from the hot tropical sun. Its nutritious pods contain 12-18% crude protein and are 40% digestible (F/FRED 1994). Relished by livestock, pods are an important dry-season fodder. Tree leaves are also nutritious, but are not an important fodder. The shade and nitrogen-rich leaf-litter of A. saman improve the nutritional value of understory grass (Allen and Allen 1981). During the dryseason, grass beneath trees remains green and succulent while exposed grass becomes dry and unpalatable. Leaves fold inward at night which may increase the amount of moisture, rain and dew, reaching the understory. In the morning leaves unfold giving full shade and conserving soil moisture.

Agroforestry.

This species is used as shade for tea, coffee, cacao, nutmeg and vanilla. Performance has been fair in alley-and hedgerow-cropping studies. Initial growth is slower than other woody perennials, but A. saman coppices well and yields nitrogen-rich green manure. However, shallow roots and large branch size compete heavily with companion crops, especially in dry areas. In these systems, A. saman must be heavily pruned. In most areas, other species will be more appropriate for alley-and hedgerow-cropping studies. Albizia saman is appropriate in home gardens where it provides a service role and multiple products

simultaneously.

Other uses.

Children eat the pods which contain a sticky sweetflavored pulp. A fruit drink is also made from the pulp. Honey is produced from the flowers. The bark yields gums and resins. In Thailand, A. saman is an important host plant for lac production (Subansenee 1994).

Silviculture

Propagation.

Seeds of A. saman have hard, impermeable seedcoats. Two methods of seed scarification are recommended. For small quantities of seed, cut through the seedcoat opposite the micropyle, or pointed-end of the seed, taking care not to damage the seed embryo. For large quantities of seed, pour boiled water over the seeds, soak and stir for two minutes. Drain off the hot water. The hot water should equal five times the volume of seeds. With either method of scarification, the seed should be soaked in cool water overnight before sowing (NFTA 1989). Seed should be sown at a depth equal to its width in large nursery bags, 10cm x 20cm. The recommended nursery mixture is 3 parts soil: 1 part sand: 1 part compost. Seedlings should receive partial shade for 2-4 weeks and then be exposed to full sunlight. After 3-5 months seedlings will be 20-30 cm tall and ready for field planting. Direct sowing is possible, but success depends on rigorous weed control. Albizia saman can be propagated by cutting or stump cutting.

Management.

Open-grown A. saman have short trunks and spreading limbs which are considered poor form for timber production. Close spacing, 1.5-2 meters, does produce straighter trees with less branching, but boles retain a spiral form. For this reason, A. saman is not commonly planted in single-purpose timber plantations. In pastures, home gardens or other multiplepurpose plantings, tree spacing will depend on companion plants and management strategy.

A light-demanding species, A. saman grows fast and is tolerant of heavy weed competition. However, survival and growth can be improved through vigorous weed control until trees achieve dominance over competing vegetation. Wood production varies by site and management system. A good site can produce 10-25 m^3/hectare/year under a 10-15 year rotation (F/FRED 1994).

Symbiosis

Albizia saman forms nitrogen fixing symbiosis with many strains of Rhizobium. In the field it readily forms root nodules.

Limitations

Heterophylla cabana, Psylla acacia-baileyanae and other defoliators are common pests (Braze 1990) but do not cause serious stress problems. Wide spreading branches and shallow roots make A. saman susceptible to damage during intense storms. The destruction of natural forests threatens the genetic diversity of this species. In response to this threat, the Oxford Forestry Institute has included A. saman in its gene conservation program (Hughes 1989).

References

Allen, O.N. and E.K. Allen. 1981. The Leguminosae: a source book of characteristics, uses and nodulation. Wisconsin Press. Madison, Wisconsin, USA. pp. 590-92.

Braza, R.D. 1990. Psyllids on nitrogen fixing trees in the Philippines. NFTRR 8:62-63.

Chudnoff, M. 1984. Tropical timbers of the world. Agriculture Handbook 607. USDA Forest Service. Washington, DC.p. 134.

F/FRED. 1994. Growing Multipurpose Trees on Small Farms (2nd ed.). Module 9. Species fact heets. Bangkok, Thailand. Winrock International, pp. 22-23.

Franco, A., E.F.C. Campello, LE. Dias and S.M. de Faria. 1995. Revegetation of acidic residues from bauxite mining using nodulated and mycorrhizal legume trees. In: D. Evans and L. Szott (eds.), Nitrogen fixing trees for acid soils. Nitrogen Fixing Tree Research Reports (Special Issue). Morrilton, Arkansas, USA. In press.

Hensleigh, T.E. and B.K. Holaway. 1988. Agroforestry species for the Philippines. US Peace Corps. Washington, DC. pp. 281-84.

Hughes, C.E. 1989. Intensive study of multipurpose tree genetic resources. Oxford Forestry Institute, University of Oxford, UK. pp. 66-79.

Little, E.L. and F.H. Wadsworth. 1989. Common trees of Puerto Rico and the Virgin Islands. Agriculture Handbook No. 249.USDA Forest Service. Washington, DC. pp. 164-66.

NAS. 1979. Tropical legumes: Resources for the future. National Academy of Sciences, National Research Council. Washington, DC. pp. 202-03.

Macklin, B., N. Glover, J. Chamberlain and M. Treacy. 1989. NFTA cooperative planting program establishment guide. Nitrogen Fixing Tree Association. Morrilton, Arkansas, USA. 36 p.

Subansenee, W. 1994. Economic value of Albizia saman. In: JB Raintree and HA Francisco (eds.). Marketing of Multipurpose Tree Products in Asia Bangkok, Thailand. Winrock International, pp. 229-35.

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Acacia aneura - a desert fodder tree

Acacia aneura is known as mulga in its native Australia where it is one of the best known species in the genus. Mulga is the Aboriginal word for a long narrow shield made of acacia wood. It is probably the most important woody forage plant in Australia because it is palatable, abundant and widespread in regions of low rainfall. Its use as an exotic. however, has been restricted by its relatively slow growth rate and its limited capacity to regenerate after fire or severe branch lopping.

Acacia aneura repented with permission, M. Simmons, 1981. Inset map shows natural distribution of mulga in Australia (Turnbull et al. 1986).

BOTANY:

Acacia aneura F. Muell. ex Benth. is one of many thornless acacias endemic to Australia. It occurs as a 10-15 m tall, often single stemmed tree in higher rainfall areas but is a 2-3 m high shrub in dry situations or on very shallow soils. Its form and phyllode morphology are exceptionally variable (Midgley and Gunn 1985). The phyllodes range from short and needle-like to long (20 cm), broad (1 cm) and net. Very fine hairs give the foliage an attractive silverygrey appearance.

Small yellow flowers form spikes 1.5-2.0 cm long Thin. flat membranous pods. 2-5 cm long, usually with an obvious narrow wing along their edge, contain dark

brown seeds. each with a small pale aril at the base.

Flowering depends on favorable weather conditions and only late summer flowering followed by winter rain leads to seed set (Davies 1976).

ECOLOGY:

Mulga is the one of the dominant species in Australian shrub woodlands. Natural populations extend over an area of 1.5 million km² chiefly in the arid climates where the annual rainfall is 200-250 mm. Mulga ranges in elevation from sea level to 300 m elevation. In many of the drier parts of its distribution mulga occurs as the only species in groves up to 50 m wide and 400 m long with intergrove areas acting as water catchments to provide substantial run-on water.

In the eastern part of its range in northern New South Wales and Queensland mulga is found in semiarid conditions with a mean annual rainfall of 300-500 mm. It experiences hot summers and cool winters with light frosts. Soils supporting mulga are usually acidic sands or sandy loams, which permit easy filtration of water into the upper horizons, but are usually very low in nitrogen and available phosphorus (Turnbull 1986). Acacia aneura can live for more than 50 years, it is drought-tolerant, but very fire sensitive (Kube 1987).

PROVENANCE TRIALS:

The wide variability in soils and climate together with a high degree of polymorphism suggests that major provenance differences will occur in growth rates and drought and frost tolerance. International provenance trials were initiated in 1984 by FAO and CSIRO Division of Forestry and Forest Products.

Canberra (Midgley and Gunn 1985) and trials were established in South Asia the Middle East, Africa and South America.

WOOD USE:

The heartwood of mulga is dark brown with contrasting markings of golden yellow; the sapwood is white. The wood is very hard, heavy (850-1100 kg/m³) and durable in the ground: it turns well and takes a high polish (Boland et al. 1984). Mulga also makes an excellent firewood and charcoal. In Australia the wood has been used extensively for fence posts but a log size rarely exceeding 2 m x 25 cm usually restricts the use of the wood to small turnery items.

FODDER:

In many parts of Australia mulga forms a significant part of a sheep's diet at all times of the year but without supplementary high quality feed it supplies protein and energy barely sufficient for maintenance of dry-range sheep (Goodchild and McMeniman 1987). Phyllodes have a high crude protein level (11-16%), low phosphorus content (0.05-0.12%) and good palatability (Turnbull et al. 1986, Vercoe in Boland, 1987). Excessive grazing may result in the death of mulga.

OTHER USES:

Mulga can be used in arid areas to provide shelter and shade, its attractive silvery grey foliage makes it a popular choice for amenity plantings. The Australian Aborigines ground the mulga seed for flour. The seeds have a protein content comparable to dried split peas or peanuts (Caffin et al. 1980). Aborigines also used the resinous phyllodes of desert mulga form as an adhesive resin (Turnbull et

al. 1986).

ESTABLISHMENT:

For good germination. seed (50,000110,000/kg) should be scarified by mechanical abrasion or immersed in undiluted sulfuric acid (95% 36N) for 30 minutes and then thoroughly washed in water. Alternatively, immersion in hot water (90°C) for 1 minute will usually break dormancy (Doran and Gunn 1987). Seeds sown in a germination tray are ready for separating into containers within 10 days. The potting mix needs to drain freely but have good moisture holding capacity (Kube 1987).

Nursery growth is slow with seedlings often taking 6-8 months to reach 20 cm tall. When transplanted to the field the seedlings usually require several months without severe moisture stress to survive and in arid areas may need supplementary irrigation. Established seedlings have the ability to survive severe drought. They develop a long tap root and an extensive lateral root system in the top 30 cm of the soil. Acacia aneura needs to be protected from browsing animals while young.

GROWTH:

Growth rate is generally slow but is related to moisture conditions. In central Australia planted specimens receiving an average of 370 mm of rainfall a year grew in ten years into multi-stemmed shrubs 3 m tall and 2-4 cm dbh with a crown diameter of 2 m (Kube 1987). Cultivated specimens receiving regular irrigation have reached 10 m tall and 10 cm dbh in 10 years. In trials where

rainfall is relatively high, the Charleville, Queensland provenance a broad phyllode form, has grown more rapidly than provenances from central Australia (Ryan and Bell 1989). Trees with different phyllode forms have been observed to have different growth rates (Fox 1980).

SYMBIOSIS:

A. aneura forms nodules with Rhizobium with which it exhibits a degree of specificity (Roughley 1987). Ectomycorrhizal associations have been observed and there is almost certainly VA mycorrhizal symbiosis (Reddell and Warren 1987).

PESTS AND DISEASES:

In its natural habitat A. aneura is subject to partial defoliation by a range of insects and root damage by termites. Termite damage was light (4% mortality) to moderate (30% mortality) to two provenances aged 18 months in a trial in Zimbabwe (Mitchell 1989).

WEEDINESS:

With its relatively slow growth rate and irregular seeding habits A. aneura is unlikely to become a serious weed.

PRINCIPAL REFERENCES:

Boland, D.J., M.H. Brooker, G.M. Chippendale, N. Hall, B.P.M. Hyland, R.D. Johnston, D A. Kleinig and J.D. Turner. 1984. Forest trees of Australia. 4th Ed. Nelson-CSIRO, Melbourne.

**Boland, D.J. (ed). 1987. Trees for the tropics: Growing Australian multipurpose trees and shrubs in
developing countries. ACIAR Monograph No. 10. ACIAR. Canberra, Australia.**

Caffin. N.,R. Bell. G. Nitchie, S. Weston and N. Ho. 1980. Protein and mineral content of several species of Acacia seeds. Mulga Research Centre Annual Rep. No. 3, 1979. W. Australian Inst. of Tech., Bentley, Australia. p. 43-44.

Davies, S.J.J.F. 1976. Studies of the flowering season and fruit production of some arid zone shrubs and l trees in western Australia. J. of Ecology 64:665-687.

Fox, J.E.D. 1980. Stability in mulga stands in times of drought. in Mulga Research Centre Annual Report No. 3, 1979. W. Australian Inst. of Tech., Bentley, Australia.

Midgley, S.J. and B.V. Gunn. 1985. Acacia uneura seed collections for international provenance trials. Forest Genetic Resources Information 13:21-29.

Simmons. M. 1981. Acacias of Australia. Thomas Nelson. Melbourne.

Turnbull. J.W. (ed). 1986. Multipurpose Australian trees and shrubs. ACIAR Monograph No. 1. ACIAR. Canberra, Australia.

**Turnbull. J.W. (ed). 1987. Australian acacias in developing, countries. ACIAR Proceedings No. 16.
ACIAR. Canberra Australia.**

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Casuarina junghuhniana: a highly adaptable tropical casuarina

Casuarina junghuhniana Miq. occurs naturally in Indonesia where its common names are jemara or cemara (Java), and adjaob and kasuari (Timor). It is an environmentally important nitrogen-fxing tree, hosting the actinorhiza Frankia. C. junghuhniana is a tall forest tree 15-25 m tall and 30-50 cm diameter, that can grow up to 35 m in height and 1 m in diameter. A putative hybrid with C. equisetifolia is commercially cultivated in Thailand (Chittachumnonk 1983). C. junghuhniana is locally important in Indonesia for fuelwood, poles and soil conservation. With domestication its utility could be enhanced.

BOTANY:

The crown of jemara is reasonably open and consists of numerous long deciduous branchlets bearing reduced scale leaves. It is dioecious; individual trees are carry either male or female flowers. Male flowers are borne on the tips of deciduous branchlets and female "cones " in the axils of scale "leaves " on permanent shoots. This species grows rapidly with a strong apical dominance. It has the capacity to produce vigorous root suckers and female trees seed abundantly.

DISTRIBUTION:

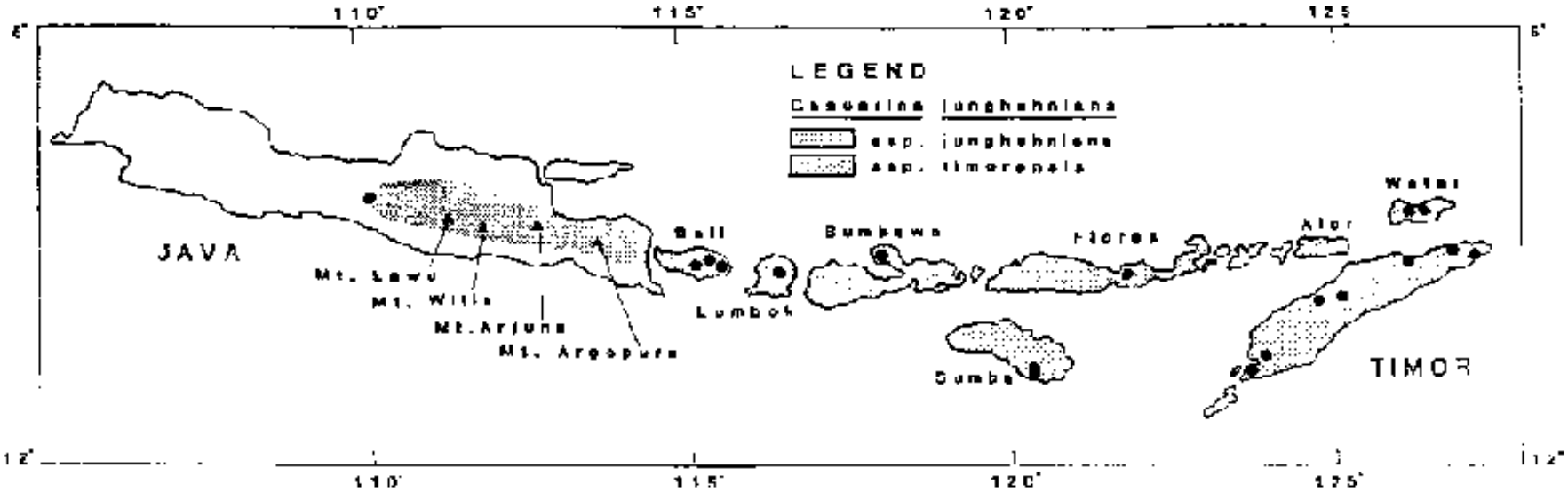
The taxonomy of C junghuhniana is very confused and requires revision. Currently the species is considered to consist of two subspecies. Subspecies junghuhniana is

found on the islands of Java, Bali, Lombok, Sumbawa and Flores. A subspecies tentatively called timorensis occurs on Timor, Wetar, Sumba and perhaps Sumbawa, Indonesia. Variation within each subspecies funkier complicates the subgroupings. The subspecies junghuhniana consists of discrete populations having coarse, fine, and intermediate textured deciduous branchlets but the patterns of variation are currently unresolved. The coarse forms may be related to tree growth on exposed sites. The coarse form is notable for its rugged, deeply furrowed, corky bark which is unusual for a casuarina. Subspecies timorensis on Timor is also thought to consist of two forms which the locals term "white" and "black" casuarinas. The hillside form has long, robust deciduous branchlets which in the riverine form are short and thin. Provenance trials of this casuarina have not been conducted. Environmental variation in natural habitat, however, suggests that considerable genetic variation is present.

ECOLOGY:

Casuarina junghuhniana is wholely tropical in distribution, and is a native of highlands in Indonesia where it pioneers deforested lands such as screes (rocky slopes) and grasslands, and in disturbed areas it replaces mixed mountain forest plant communities (NAS 1984). Subspecies junghuhniana typically grows in extensive pure stands on volcanic slopes between altitudes of 1500 to 3100 m but can also occur below 100 m. Subspecies timorensis is normally found at lower altitudes, especially in Timor where it grows from near sea level to 300 m. Rainfall in its natural habitat is monsoonal with a well-defined summer maximum and a range of 700-1500 mm (NAS 1984). C jungilahniana often forms pure stands in dry and periodically burnedover areas. It is also found along gravelly stream beds in Timor. Once trees reach a few meters in height they are fire resistant and have

good sprouting ability if fire damaged. C junghuhniana grows in a wide range of soils from volcanic, sandy to compact clay soil and including very acidic sites, pH 2.8 (Chittachumnonk 1983). It also appears well-adapted to growing on alkaline soils in Timor (Turnbull 1989 pers. comm.). It can tolerate waterlogging up to 104 days (Verhoef 1943). It is considered moderate (NAS 1984) to very (Djogo 1989) drought resistant and is especially good as a pioneer on landslide-prone soils (Djogo 1989). In Timor it commonly grows on limestonederived soils.



The generalized range of the natural distribution of Casuarina junghuhniana in Indonesia. The map was constructed using herbarium records and the locations of the original collections are indicated by the black dots and triangles.

USES:

As with other casuarinas, wood of C junghuhniana is highly suitable for fuelwood and charcoal production. Its calorific value in charcoal form is 7180 kcal/kg, among the highest for a firewood species. Its wood is very heavy having an air-

dry density of 900, kg/m³ (Chomcharn et al. 1986).

C junghuhniana is especially suitable for wind breaks and for ornamental plantings. It is not used as fodder. In Timor C. junghuhniana is used for soil improvement, live fencing, building material and firewood, and branches and foliage are burnt and the ashes spread in village gardens (Djogo 1989). It has been used in revegetation and land rehabilitation projects in Java for nearly a century. In Thailand its straight-stemmed character makes it a popular underground pile for construction work as well as for fishtrap stakes. It is grown on farm boundaries for pole production in Kenya and Tanzania.

SILVICULTURE:

Seed from C. junghuhniana is small with approximately 1-1.6 million seeds per kg. No special pretreatment is needed to germinate seed. Like most casuarinas, seed probably loses viability quickly unless kept in dry, cold storage.

In Indonesia, Kenya and Tanzania all C. junghuhniana are raised from seed. In Thailand and India planting stock is raised by vegetative propagation because only male trees were originally introduced. Airlayering has been tried but with little success. The most successful method for production on a large scale was developed in Thailand. Stem cuttings of young shoots are placed in small pots filled with soil and river sand. Several pots are enclosed in polyethylene bags with tops supported by a stake. Rooting hormone (IBA) is necessary to promote rooting. The rooting process takes 3-4 weeks under 70% shade. Mahmood and Possuswam (1980) also report successful root cuttings of shoots and root suckers of this casuarina in India.

YIELD:

C junghuhniana has the potential to grow very quickly. In irrigated plantations in Thailand it can attain 21 m height and 15 cm diameter at 5 years. Growth is normally slower without irrigation. In Markhanam, Madras, India trees reach 5 m tall at 20 months after planting (Thirawat 1953). Well-maintained plantations can produce 30-35 m^3/ha/y (Boontawee and Wasuwanich 1980).

PESTS AND DISEASES:

There appear to be no serious insect pests of C junghuhniana. In East lava forests of C junghuhniana have been attacked by caterpillars but the trees recovered even after repeated defoliations. Defoliation of C junghuhniana plantations by a locust Aulaches miliaris) during rainy season has also been reported in Thailand. Young trees died but older trees suffered only a temporary setback. Also reported from Thailand was minor damage to young shoots by an insect identified as Aristobia approxirmator in plantations Chittachumnonk 1983). In dry areas subterranean termites can destroy young plants by attacking their roots.

PRINCIPAL REFERENCES:

Boontawee, B. and Wasuwanich P. 1980. Casuarina junghuhniana. Forestry review, Silvicultural Research Subdivision, Royal Forest Department, Thailand.

Chittachumnonk, P. 1983. Silviculture of Casuarina junghuhniana in Thailand. In S.J. Midgley, J.W. Turnbull and R.D. Johnston (eds), Casuarina ecology, management and utilization. CSIRO, Canberra. p. 102-106.

Chomcharn, A., S. Visuthideppakul and P. Hortrakul. 1986. Wood property and potential uses of 14 fast-growing tree species. Report, Division of Forest Products Research, Royal Forest Department, Thailand.

Djogo, A.P.Y. 1989. The possibilities of using local drought resistant and multipurpose tree species as alternatives to lamtoro (Leucaena leucocephala) for agroforestry and social forestry in West Timor. Working paper, Env. and Policy Inst., East West Center, Hawaii. (in press)

Mahmood, AM. and P.K Possuswam. 1980. Propagation of Casuarina junghuhniana by planting shoots and root suckers. Indian Forester 106(4):298-299.

NAS (National Academy of Science). 1984. Casuarinas: Nitrogen fixing trees for adverse sites. National Academy Press, Washington, D.C.

Thirawat, S. 1953. Note on Casuarina junghuhniana with special reference to its experimental introduction into India. Indian Forester 79(12):636442.

Verhoef, L. 1943. Root studies in the tropics. VI. Further data about the oxygen requirements of the root system. Korte Meded. B.P.S. 81:1-65.

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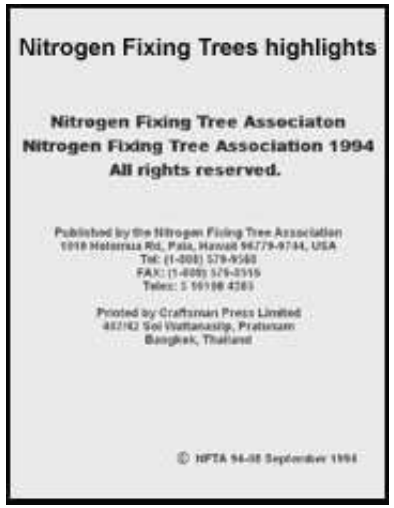
Nitrogen Fixing Trees Highlights (Winrock, 1990-1997, 100



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- ***(introduction...)***
- **Acacia koa - Hawaii's most valued native tree**
- **Acacia leucophloea - shade and fodder for livestock in arid environments**
- **Alnus acuminata: valuable timber tree for tropical highlands**
- **Albizia saman: pasture improvement, shade, timber and more**
- **Casuarina junghuhniana: a highly adaptable tropical casuarina**
- **Enterolobium cyclocarpum: the ear pod tree for fasture, fodder and wood**
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Enterolobium cyclocarpum: the ear pod tree for fasture, fodder and wood

Enterolobium cyclocarpum the ear pod tree for fastare, fodder and wood

Enterolobium cycloca, pum (Jacq.) Griseb. is one of the largest trees in the dry forest formation of Mexico and Central America, reaching up to 3 m diameter and 40 m in height with a huge spreading crown. It is a conspicuous and well-known tree in its native range. Large crowned trees scattered in pastures are a common sight and a distinctive feature of the landscape in many parts of Central America. Such is its fame that Enterolobium has been adopted as the national tree of Costa Rica. The province of Guanacaste in Costa Rica is named after Enterolobium which occurs abundantly in that area.

Enterolobiant cyclocarpum is also well-known for its distinctive, thickened, contorted, indehiscent pods which resemble an ear in form. Most of the common names for Enterolobium refer to this resemblance, including ear fruit, ear pod, orejon (from Spanish oreja an ear) and guanacaste (conacaste, a NahuatI derivation signifying ear tree).

BOTANY:

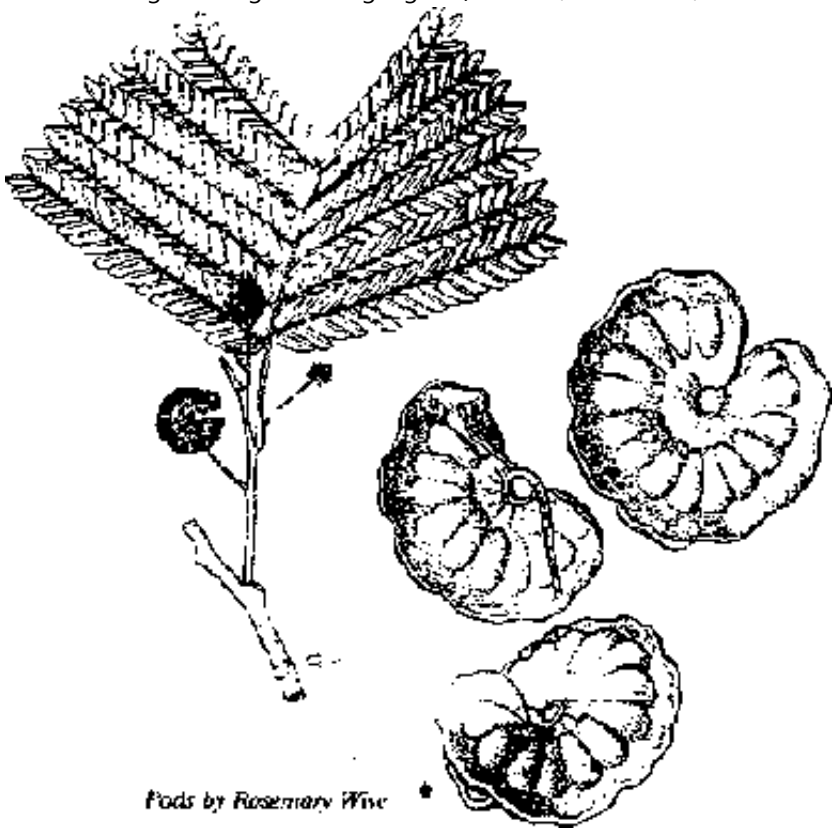
The nitrogen ftxing tree Enterolobium cvclocarpum belongs to the subfamily Mimosoideae of the Leguminosae and is placed in the tribe lngeae. The genus Enterolobium is closely related to Albizia and Samanea and is probably only maintained as a separate genus due to its widespread cultivation. Enterolobium contains only five species, all from Central and South America, and only E. cyclocarpum is widely cullivated. Closely related species, such as E. schomburgkii Benth., remain untested to date.

Enterolobium leaves are bipinnately compound with opposite leaflets. Small white

flowers occur in compact round heads. In Central America E. cyclocarpum is sometimes confused with Albizia niopoides (Guanacaste blanco) due to similarity in tree form but may be readily distinguished by the different bark which is pale golden yellow in A. niopoides.

ECOLOGY:

Enterolobium cyclocarpum occurs from latitude 23°N in central Mexico, south through Central America, to TN in northern South America. It has been widely introduced throughout the tropics where it is cultivated mainly as a roadside or garden tree. In its native range, Enterolobium occurs in a wide range of different forest types from tropical, dry deciduous forest to tropical moist forest. It becomes a climax tree only in the dry forest, being restricted to disturbed areas in wetter forest types. Enterolobium cyclocarpum is a lowland species occurring from sea level to 1200 m elevation and has only very limited tolerance of frost.



Enterolobium cyclocarpum

Annual rainfall varies between 750-2500 mm through most of its native range with a dry season that lasts 1-7 months. Trees are generally deciduous, losing their leaves during the dry season and flushing out again about two months before the onset of the rainy season. Flowering starts while the trees are leafless (March-April in Central America), and the pods take a year to mature, ripening in April-May.

USES:

The wide spreading canopy of a mature Enterolobium makes it an ideal shade tree,

whether for livestock in pasture lands, for perennial crops such as coffee, or in roadside and urban plantings. Its value to livestock is further enhanced by production of large quantities of highly palatable and nutritious pods containing a sugary dry pulp. Pods are generally shed at the end of the dry season in Central America when livestock feed is particularly short. Pods fall from the trees gradually over a period of two months thus spreading the availability of pods for livestock. Data from Puerto Rico suggests that pod production may be delayed as much as 25 years after planting. The foliage is also palatable, though to a lesser extent than the pods, which results in high mortality of natural regeneration in pasture lands and may explain why the tree occurs naturally only as scattered individuals.

Enterolobium heartwood is reddish-brown, coarse-textured and moderately durable, with a straight interlocking grain and an appearance somewhat similar to walnut. Specific gravity is variable, ranging from 0.40.6. The wood is resistant to attack by dry-wood termites and Lyctus, and can be used in house construction as well as for nonstructural interior elements including panelling. The white sapwood, by contrast, is highly susceptible to insect attack. Enterolobium wood may also be used for boat-building because of its durability in water; it has been used in the past for water-troughs and dug-out canoes. The dust from sawmilling can produce allergic reactions in workers.

Other uses include food (the immature pods as a cooked vegetable, or the seeds toasted and ground), soapmaking (using tannins from the pods and bark), and medicinal use of bark extracts against colds and bronchitis. The ability of Enterolobium to fix nitrogen, and to resprout vigorously when coppiced, suggest it could also have a role in alley-cropping systems as a hedgerow species, though

this is an area requiring further research.

SILVICULTURE:

Enterolobium is a light-demanding species at all stages in its development. It is susceptible to weed competition during early, growth. Enterolobium resprouts vigorously after coppicing or lopping; indeed, it is difficult to kill Enterolobium by girdling because of its tendency to resprout below the girdle line. Little information is available, however, on its response to repeated cutting. With no silvicultural intervention it usually occurs as a single, large, open-grown tree, though pruning can improve the length and form of the bole.

Enterolobium can tolerate a wide range of soil types, from alkaline and calcareous to somewhat acidic (pH as low as 5), provided that aluminum saturation is not a problem. Best growth is on deep, medium-textured soils but sandy and clay soils also allow good development provided drainage is unimpeded. The trees will not thrive on sites prone to waterlogging.

PROPAGATION:

The combination of large nutritious pods and seeds with hard coats is ideal for seed dispersal of Enterolobium by animals. Seeds are most easily collected by waiting for pods to fall. An adult tree produces an average of 2000 pods, each with 10-16 seeds (9001200/kg). Trees produce seed crops in most years in Central America. Seed extraction from the indehiscent pods is usually carried out by manual threshing, milling or maceration of the pods followed by winnowing and screening.

Enterolobium seed is naturally scarified by passage through the gut of large herbivores. It is likely that the original consumers of Enterolobium pods are now extinct and their role as seed dispersal agents has been assumed by horses and cattle. Collected seed requires pretreatment before sowing to allow water to penetrate the seed coat. Manual scarification is effective, as is treatment with hot water or concentrated sulfuric acid. A suitable hot water treatment is a brief (30 second) soak in water close to boiling point, followed by 24 hours in water at room temperature. Enterolobium seeds remain viable for several years under cool, dry conditions and can be easily stored under normal conditions.

Seed supplies are currently dependent on collections from natural populations in Latin America and scattered cultivated trees in areas where Enterolobium has been introduced. Most early introductions of E. cyclocarpum were undocumented, casual and collected from a narrow genetic base. A broader range of representative germplasm should be tested to evaluate the potential of the species. Seed is available from OFI and NFTA for the establishment of field trials.

The seed should be sown 1-2 cm deep with the micropyle pointing downwards; the emerging root is not strongly geotropic and may come up out of the soil if the seed is planted upside down. Early seedling growth is rapid and vigorous. This early advantage over smaller-seeded species can continue several months after outplanting, but thereafter growth rate, though still vigorous, is no longer exceptional relative to other fast growing species.

PESTS AND DISEASES:

Enterolobium has no serious or widespread disease and insect problems, although

attack by a Fusarium fungus, with associated damage by wood-boring insects, can cause affected limbs to fall from mature trees. Branches may also be broken off by storm damage. Both factors reduce the desirability of Enterolobium for urban and roadside planting. Although no bruchid seed predators are found on E. cyclocarpum, the green pods are often preyed upon by parrots and fruiting may be further disrupted by the gall forming moth Asphondylia enterolobii.

PRINCIPAL REFERENCES:

Echenique-Manrique, R. and R.A. Plumptre. 199.0. A guide to the use of Mexican and Belizean timbers. Tropical Forestry Paper 20. Oxford Forestry Institute, UK. 175 p.

Francis, J.K. 1988. Enterolobium cyclocarpum (Jacq.) Griseb. Guanacaste, Earpod-tree. Leguminosae. Legume Family. USDA Forest Service. Southern Forest Experiment Starion. SO-ITF-SM-15.

Janzen, D.H. 1983. Enterolobium cyclocarpurn. In D.H. Janzen (ed), Costa Rican Natural History. Univ. Chicago Press. Chicago, IL. 816 p.

Little, E.L., R.O. Woodbury, and F.H. Wadsworth. 1974. Trees of Puerto Rico and the Virgin Islands, Vol. 2. USDA Agric. Handbook No. 449. p. 258-259.

Standley, P.C. and J.A. Steyermark. 1946. Enterolobium.. In Flora of Guatemala. Fieldiana: Botany 24(V):32-34.

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

Erythrina variegata: more than a pretty tree

Erythrina variegata is a showy, spreading tree legume with brilliant red blossoms. Commonly known as the 'Indian coral tree' in Asia or 'tropical coral' in the Pacific, this highly valued ornamental has been described as one of the gems of the floral world. It has also proven valuable for fodder production and as a sturdy component of windbreaks. It is a useful species for soil enrichment because it nodulates readily and prolifically in both acid and alkaline soils. Farmers in India appreciate E. variegata as fodder, light timber and, more recently. pulp for the paper industry.

Botany

Erythrina variegata is a medium to large tree, commonly reaching 15 to 20 m in height in 20 to 25 years. It has an erect, spreading form, typically with several vertically oriented branches emerging from the lower stem. On favorable sites, the stem can reach a diameter at breast height (dbh) of 50 to 60 cm in just 15 to 20 years.

Erythrina variegata L. From Little and Skolmen (1989), p.143.

The smooth bark is streaked with vertical lines of green, buff, grey and white. Small black prickles cover the stem and branches. These become longer if the tree suffers moisture stress. They typically drop off as the girth of the stem expands (Hegde, 1993). The leaves are trifoliate. The leaflets are commonly variegated, medium to light green, heart shaped. 7 to 12 cm wide and 12 to 18 cm long. The trees are deciduous. typically losing their leaves before flowering except under very humid conditions.

Brilliant orange-red flowers emerge in dense, conical inflorescences 5 to 7 cm long and 2 to 3 cm wide, usually after the leaves have dropped. Flowering is normally followed by a lavish production of seed. The pods are thick and black-1.5 to 2 cm wide and 15 to 20 cm long. Each contains 5 to 10 egg-shaped seeds. These are

glossy brown, red or purple and are 6 to 10 mm in diameter and 12 to 17 mm long.

A column-shaped cultivar, 'Tropic Coral' or 'Tall Erythrina', is used extensively in windbreaks and as an ornamental in parks and gardens. Through cultivation, it has spread from New Caledonia to Australia, Hawaii and southern Florida. Unlike other cultivars. the leaves of 'Tropic Canal' remain on the tree through flowering.

Ecology

Erythrina variegata is well adapted to the humid and semiarid tropics and subtropics, occurring in zones with annual rainfall of 800 to 1500 mm distributed over a five- to six-month rainy season. The species is most commonly found in warm coastal areas up to an elevation of 1500 m. The trees prefer a deep. well-drained, sandy loam, but they tolerate a wide range of soil conditions-from sands to clays of pH 4.5 to 8.0. They can withstand waterlogging for up to two weeks and are fairly tolerant of fire. Erythrina variegata is bird-pollinated, outcrossed and sometimes genetically incompatible.

Distribution

Erythrina variegata is native to the coast of India and Malaysia. It has been widely introduced in coastal areas of the Old World tropics, extending from East Africa and Madagascar through India, Indochina, Malaysia, northern Australia and Polynesia. The seeds can float on salt water for months, facilitating the spread of the species. Introduced to the Americas, it was so well established by 1825 that Candolle described two new species based on trees considered to be native to the New World (McClintock, 1982). It is now a very popular hedge species in southern

Florida.

Uses

Support for vine crops.

Farmers in India use E. variegata to support climbing plants such as betel (Piper belle), black pepper (Piper nigrum), vanilla (Vanilla planifolia) and yam (Dioscorea spp.) (Hegde, 1993). Trees established to support vines are usually planted at a spacing of 2 x 2 to 2 x 3 m. Vines are planted three to four months after establishment of the tree seedlings or during the following rainy season. During the hottest months. foliage from the closely spaced trees shades the vines and keeps them moist. When the days become cooler, the leaves fall and the vines receive more direct sunlight, which matches their requirements at this time.

Shade.

Coffee and cacao growers establish E. variegata shade trees from large cuttings (2 to 3 m long and 2 to 5 cm in diameter) at a spacing of 8 x 10 m. The trees are pollarded once a year to a height of 2 to 3 m to produce a spreading crown. The pruned leaves are usually spread in the plantation as mulch. The branches may be used as fuelwood.

Windbreaks.

Erythrina variegata, particularly the columnar variety, is widely used as a windbreak for soil and water conservation. The trees have a strong, vertical root system that does not seem to compete too severely with adjacent crops (Rotar et

al., 1986). Windbreaks are normally established from large cuttings planted in lines at a spacing of about 2 m.

Live fenceposts.

Erythrina variegata makes excellent live fenceposts. Farmers commonly establish fenceposts from three-yearold upright branches about 15 cm in diameter and 2.5 m long. These are normally stacked in the shade in an upright position and left to cure for one week before planting.

Fodder.

The foliage of E. variegata makes an excellent feed for most livestock. Leaves normally contain 16 to 18% crude protein and have an in-vitro dry-matter digestibility of 50% A tree of average size, pruned three or four times a year, produces from 15 to 50 kg of green fodder annually depending on growing conditions. Trees maintained in coffee plantations benefit from associated cultivation practices-they can produce up to 100 kg of fodder from one annual harvest. The leaves have no known toxicity to cattle.

Wood.

The wood of E variegata is light and sott. with a specific gravity of 0.2 to 0.3. Each shade tree in a coffee plantation can yield from 25 to 40 kg of wood from annual pollarding. The wood is used to construct floats, packing boxes, picture frames and toys, and, in India, it is increasingly used for pulp production. The timber requires careful seasoning, preferably kiln drying. It does not split on nailing, but holds nails poorly.

Medicinal.

Erythrina variegata has a reputation for medicinal properties in India, China and Southeast Asia. The bark and leaves are used in many traditional medicines, including paribhadra, an Indian preparation said to destroy pathogenic parasites and relieve joint pain. Juice from the leaves is mixed with honey and ingested to kill tapeworm, roundworm and threadworm (Hegde, 1993). Women take this juice to stimulate lactation and menstruation. It is also commonly mixed with castor oil to cure dysentery. A warm poultice of the leaves is applied externally to relieve rheumatic joints. The bark is used as a laxative, diuretic and expectorant.

Other uses.

With their rapid growth and prolific nodulation, all erythrinas are a good source of organic matter for green manure. The nitrogen-rich litterfall decomposes rapidly, making nutrients available for plant uptake. The dry foliage of E. variegata normally contains from 1 to 3% nitrogen.

Aqueous leaf extracts of E. variegata have also proven highly toxic to certain nematodes (Mohanty and Das, 1988).

Silviculture

Establishment.

Erythrina variegata is successfully propagated from seed or large stem cuttings. Seed should be scarified by soaking in hot water (80°C) for 10 minutes and then in tepid water overnight. Treated seeds normally germinate within 8 to 10 days.

Well-watered seedlings are normally ready for planting at 10 weeks.

Woody cuttings establish best under dry conditions. They should always be held for at least 24 hours before planting to prevent attack by soil fungi. Cuttings establish quickly, producing axillary shoots in three to four weeks and then rooting. To produce tall trees with straight stems, it is important to retain the terminal bud of branch cuttings. The columnshaped form, 'Tropic Coral', may not reproduce true to form from seed and should thus be propagated from cuttings.

Management.

Erythrina variegata generally requires little maintenance. Once established, seedlings grow rapidly, usually to 3 m in one year. Cuttings typically produce more and larger side branches than seedlings; they should be pruned when young if upward growth and a clear bole are desired.

Limitations

This species is a host to the fruit-piercing moth Othreis fullonia, a destructive insect pest in the Pacific region. The larvae feed on the tree and the adults 'pierce' important commercial fruits such as oranges, guava, papaya. banana and grapes. causmg serious economic losses (Muniappan, 1993). The light wood. with 60 to 65% moisture content, is not useful as a fuel. Even when dry, it produces smoke when burned.

Further Reading

Hegde, N. 1993. Cultivation and uses of Erythrina variegata in Western India. In

S.B. Westley and M.H. Powell, eds. Erythrina in the New and Old Worlds. Paia, HI (USA): NFTA, pp. 77-84.

Little, E.L. and Skolmen, R.G. 1989. Common forest trees of Hawaii (native and introduced). Agricultural Handbook 679. Washington, DC: USDA Forest Service, pp. 142-44.

McClintock, E. 1982. Erythrinas cultivated in California. Erythrina Symposium IV. Allertonia. 3 (1): 139-54.

Mohanty, K.C. and Das, S.N. 1988. Nematicidal properties of Erythrina indica against Meloidogyne incognita and Tylenchorhynchus rnashhoodi. Indian Journal of NernatolOgy.18(1):138.

Muniappan, R. 1993. Status of Erythrina species and the fruitpiercing moth in the Pacific. In S.B. Westley and M.H. Powell, eds. Erythrina in the New and Old Worlds. Paia, HI (USA): NFTA, pp.340-44.

Raven, P.H. 1974. Erythrina (Fabaceae): achievements and opportunities. LLOYDIA (Journal of Natural Pruducts). 37:321-31.

Rotar, P.P., Joy, R.J. and Weissich, P.R. 1986. 'Tropic Coral': tall erythrina (Erythrina variegate L.). Research Extension 072. Honolulu, HI (USA): University of Hawaii.

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- **Olneya tesota - a potential food crop for hot arid zones**
- **Honey mesquite: a multipurpose tree for arid lands**

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

Inga is a large genus of leguminous trees native to the American humid tropics. Inga edulis, the best known of the Inga species, is popular with agroforesters for its rapid growth, tolerance of acid soils and high production of leafy biomass to control weeds and erosion.

Botany

Inga edulis Mart. is one of about 250 species of Inga of the Mimosoideae subfamily of the Leguminosae. It reaches a height of 30 m and a stem diameter (dbh) of 60 cm. and usually branches from below 3 m. The branches form a broad, flat, moderately dense canopy. The bark is pale grey and smooth, with pale elongated lenticels. The young twigs are angular in cross-section and covered in fine short brown hair.

The leaves are once pinnate, up to 24 cm long, with 4 to 6 pairs of opposite leaflets. The terminal pair of leaflets is larger than the basal pair and can be up to 18 cm long and 11 cm wide. Between each leaflet there is a nectary gland on the leaf rhachis; in 1. edulis these are large (2 to 3 mm) and squashed transversely,

an important character for identifying the species. The leaflets and rhachis are covered in dense, short, rough brown hair. The seedlings have a characteristic grayish sheen on the upper leaf surface.

The inflorescences are dense axillary spikes of flowers, each consisting of a calyx tube with 5 lobes (4 to 9 mm long), a corolla tube with 5 lobes (13 to 25 mm long), and a large number of white stamens up to 4.5 cm long, united in a tube in the lower half. In humid climates 1. edulis may flower throughout the year, but in regions with a short dry season it is most likely to flower at the beginning of the wet season. The inflorescences may not have many flowers open at the same time, but they are usually conspicuous.

The fruits are ribbed, cylindrical pods, straight or often spirally twisted, up to I m long (occasionally even longer), and 3 to 5 cm in diameter. They contain fleshy green seeds (3 cm long) in a sweet, white, cottony pulp. They are produced during the wet season, and monkeys and birds eat the sweet pulp and scatter the soft seeds (Castro and King, 1950). These are recalcitrant and sometimes begin to germinate in the pod, often within a few days of reaching the ground where they need humidity to survive.

Distribution and ecology

The native range of Inga edulis is in Amazonian Brazil, Bolivia, Peru, Ecuador and Colombia. The species has also been introduced across most of tropical South America, Panama and Costa Rica. It grows in hot, humid climates between 26°S and 10°N, and up to 1600 m elevation. It is most widespread in areas without a dry season (Andean South America. western Brazil) or with a dry season of three

to four months and minimum annual rainfall of around 1200 mm. It can tolerate short droughts, although in its natural range some rain falls every month.

Inga edulis is particularly tolerant of acid soils (Smythe, 1993; M. Hands, Department of Geography, Cambridge University, personal communication; Salazar and Palm, 1991), outgrowing many other leguminous trees in trials under such conditions. It is a forest gap regenerator: although seedlings often establish themselves in the shade of other trees, it needs light to grow and flower. In the forest it becomes a canopy tree. but it is also common in secondary forest.

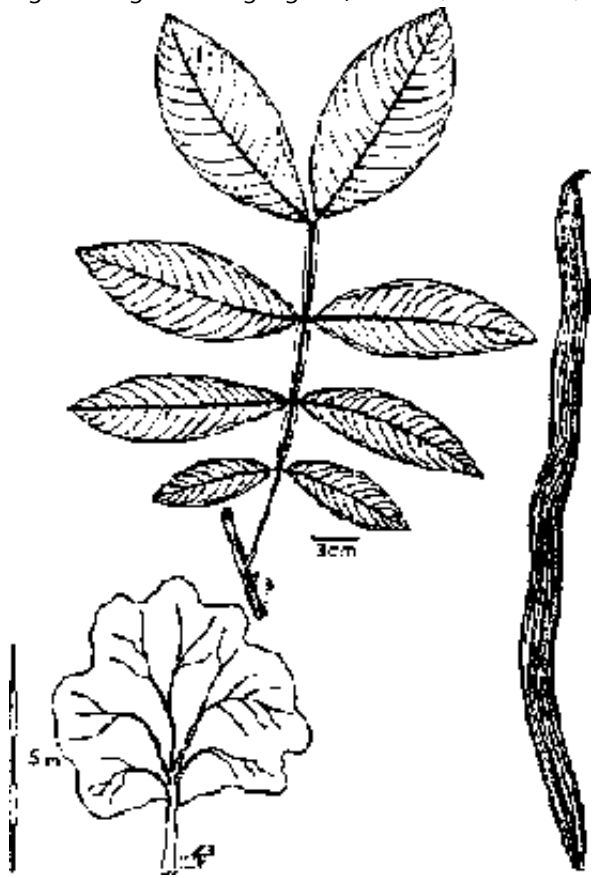
Uses

Shade and litter.

Inga edulis has been used as a shade tree for perennial crops-mainly coffee and cacao-since the beginning of the nineteenth century. Many farmers value it as much for soil protection as for shade. The leaf litter protects the soil surface and roots of other plants, helps retain nutrients in the topsoil, and (most importantly for farmers in the humid tropics) controls weeds.

Improved fallow.

In Amazonian Peru, Szott and Melndez (1991) grew crops on land cleared and burnt after seven different fallow treatments. Land where Inga edulis had been planted gave the highest crop yields-34% higher than crops following natural forest fallow.



Inga edulis, from C.H. Dodson, A.H. Gentry and F.M. Valverde. 1985. La flora de Jauneche. Banco Central del Ecuador.

Alley cropping.

In species trials in Costa Rica, Peru and Brazil, 1. edulis was outstanding in terms of growth. Coppice regrowth was also good after pruning. In four out of five trials, crop yields were higher under alley cropping with 1. edulis than in control plots (Smythe, 1993; Fernandes et al., 1991; Salazar et al., 1991; Salazar and Palm, 1991; M. Hands, personal communication). In two of these trials, crops performed better with 1. edulis than with other species (Salazar and Palm, 1991; M. Hands,

personal communication).

The litter is high in nitrogen, lignins and polyphenols. It is slow to decompose, but provides a long-term build up of organic nitrogen (Palm and Sanchez, 1990) and effective weed control. Weed biomass decreased considerably in all agroforestry trials with 1. edulis, much more than with other leguminous species (Salazar and Palm, 1991). On cultivated slopes, 1. edulis mulch reduced soil erosion to levels almost equal to those under secondary forest (Alegre and Fernandes, 1991). Existing trials are still too new to ascertain whether 1. edulis can maintain or improve soil fertility on acid sites in the long term, but results so far are promising.

Other uses.

The large fruit is popular throughout the region where 1. edulis is distributed. Fruits are sold in local markets in Bolivia, Peru, Ecuador, Brazil and Costa Rica. The branches are a popular source of fuelwood, with a high calorific content and little smoke, but the trees are not cultivated specifically for fuelwood.

Silviculture

Propagation.

Inga edulis seed can only be stored up to two weeks. Best results have been achieved by removing the pulp and storing the seed in impermeable bags. Normally. only one seed should be sown in a plastic bag. no more than 2 cm below the soil surface. Semi-shade should be provided if possible. The seeds germinate readily (95 to 100% germination rate) within 2 to 3 days. Seedlings are normally

kept for two months in the nursery. They should be watered regularly and the shade should be removed one month before transplanting.

Establishment.

Farmers sometimes sow 1. edulis seed directly in the field. This must be done during a season of regular rainfall to avoid seed desiccation. Direct seeding has not yet proven to be a reliable method for establishing a trial. Bare-rooted seedlings can be transplanted successfully from the nursery (Fernandes et al., 1991). Inga edulis has not been reproduced by cuttings.

Management and symbiosis.

An area of I m diameter should be kept clear around the trees during the first six months as they become established. Inga edulis grows back well after pruning, but not if cut too low (below 0.75 m). It responds better if pruning height is varied and a few branches are left uncut (Salazar et al., 1991). The cut should be made carefully, at least 3 cm above a node from which the shoots can grow again (M. Hands, personal communication).

Fernandes and others (1991) observed Rhizobium nodules on the roots of 1. edulis, both in the field and in the nursery. They also showed that vesicular-arbuscular (VA) mycorrhizal infection occurs in acid tropical soils and that nodulation rates increase when mycorrhizae have infected the root. In their trial, plant biomass correlated positively with length of root infection by VA mycorrhizae.

Limitations.

Inga edulis pods are heavy and bulky to transport. This, combined with short seed viability, means that I. edulis seed must normally be collected near the planting site.

Decomposing slowly, the leaves do not provide fast-cycling green manure. In Ecuador, Inga edulis is particularly susceptible to infestation with mistletoe.

Related species

In Central America, 1. edulis is replaced by the closely related 1. oerstediana Benth., a popular species for coffee shade from sea level to elevations of 2000 m. The flowers are smaller than those of 1. edulis and the fruits are much shorter. In ongoing trials in Honduras and Costa Rica, 1. oerstediana has shown fast growth and abundant production of leafy biomass. Another promising species from the same section of the genus is the Amazonian 1. ingoides (Rich.) Willd., which has grown well for four years on a periodically flooded site in lowland Bolivia.

Research needs

Inga edulis has been introduced throughout the neotropics, but seed is usually collected from a few trees already estabfished in plantations and transported over very short distances. Population studies in the species's native range could help identify diversity in growth rate, fruit size, soil tolerance and litter-decomposition rates. Methods to prolong seed viability would also improve the usefulness of this species.

References

Alegre, J.C. and Fernandes, E.C.M. 1991. Runoff and erosion losses under forest low-input and alley-cropping on slopes: Y-433B. In TropSoils technical report 1988-89. Raleigh, NC (USA): North Carolina State University, pp. 227-28.

Castro, Y.G.P. and Krug, P. 1950. Experiments on germination and storage of seeds of Inga edulis. a species used in shading coffee trees. [In Portuguese.] Sao Paulo (Brazil): Office of the Secretary of State for Agriculture, Forestry Service.

Fernandes, E.C.M., Davey, C.B. and Sanchez, J.A. 199]. Alleycropping on an Ultisol in the Peruvian Amazon: mulch, fertilizer and hedgerow root-pruning effects: Y-433A. In TropSoils technical report 1988-89. Raleigh, NC (USA): North Carolina State University, pp. 223-26.

Palm, C.A. and Sanchez, P.A. 1990. Decomposition and nutrient release patterns of the leaves of three tropical legumes. Biotropica. 22(4):330-38.

Salazar, A.A. and Palm, C.A. 1991. Alley-cropping on Ultisols: Y-425. In TropSoils technical report 1988-89. Raleigh, NC (USA): North Carolina State University, pp. 221-22.

Salazar, A.A., Palm, C.A. and Szott, L.T. 1991. Alleycropping on alluvial soils: Y-417. In TropSoils technical report 1988-89. Raleigh, NC (USA): North Carolina State University, pp. 218-20.

Smythe, S. 1993. The role of trees in tropical agroforestry. Ph.D. thesis. Cambridge (UK): Cambridge University, Department of Plant Sciences, 215 pp.

Szott, L.T. and Melndez, G. 1991. Crop yields, soil nitrogen mineralization, and soil

chemical properties following 4.5 years of managed leguminous fallows. In TropSoils technical report 1988-89. Raleigh. NC (USA): North Carolina State University, pp. 234-36.

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