Leucaena leucocephala (Lam.) de Wit   Leucaena, tantan

Leguminosae (Mimosoideae)   Legume family

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Leucaena leucocephala (Lam.) de Wit, commonly known as leucaena, tantan, guaje (Mexico), huaxin (Central America), zarcilla (Puerto Rico), and by many other names, is one of the most extensively cultivated leguminous trees in the world. Adapted to a wide range of lowland sites in the tropics and subtropics, this semideciduous tree has been planted in many countries outside its native southern North American and Central American range. Depending on the variety, it is either a tall, slender tree with an irregular, spreading crown (fig. 1) or a many-branched shrub *(34, 51)*. Leucaena is used for a variety of purposes including, timber, fuelwood, forage, and organic fertilizer.

HABITAT

Native and Introduced Ranges

Leucaena originally grew in the midlands of Guatemala, Honduras, El Salvador, and southern Mexico, a range extending from latitudes 12° to 20° N. Several varieties were spread by pre-Columbian civilizations throughout the coastal lowlands of Central America, from northern Mexico to Nicaragua *(51, 75)* (fig. 2). Today leucaena is cultivated or has become naturalized worldwide between latitudes 25° N. and 25° S.

During the period of Spanish colonial trade from 1565 to 1825, a shrubby variety of leucaena (now called the "common" or "Hawaiian" type) from Acapulco, Mexico, was introduced and became naturalized in the New World from southern Florida and Texas through the West Indies and in South America as far south as Brazil and Chile, and in the Philippines, Guam, and other Spanish island possessions. The usefulness of the species as a shade tree in plantations of coffee, cacao, cinchona, pepper, vanilla, and other crops led to its introduction to Indonesia, Papua New Guinea, Malaysia, other countries in Southeast Asia, Hawaii, Fiji, northern Australia, India, and parts of east and west Africa *(51, 75)*. In Puerto Rico and elsewhere in the West Indies, from the Bahamas and Cuba to Trinidad and Tobago, leucaena is naturalized on roadsides, abandoned pastures, and early secondary forests in dry coastal regions *(17, 34)*. Leucaena is sometimes regarded as a weed due to its rapid colonizing ability and tendency to form dense thickets on disturbed sites *(34)*.

Since the 1960's, seeds of a number of the much taller "giant" or "Salvador type" varieties have been collected from sites in Central America. These varieties have been studied extensively in plantation culture in Hawaii and have been planted throughout the Tropics in plantation and agroforestry systems *(6, 75)*.

Climate

Although leucaena can survive in areas receiving an average annual rainfall less than 300 mm *(75)* or greater than 4000 mm *(14)*, it grows well only where annual rainfall is between 600 and 2000 mm, with a dry season of 2 to 6 months *(6, 39, 50, 51, 78)*. Optimal growth occurs in areas receiving an annual rainfall of about 1500 mm, with a dry season lasting 4 months *(75)*. In Central America, leucaena is commonly planted where annual rainfall averages between 900 and 2900 mm *(7)*. Leucaena is drought-tolerant, although long dry seasons greatly reduce productivity *(51)*.

Figure 1.—*Leucaena* (Leucaena leucocephala) *"giant" type K8 in Puerto Rico.*

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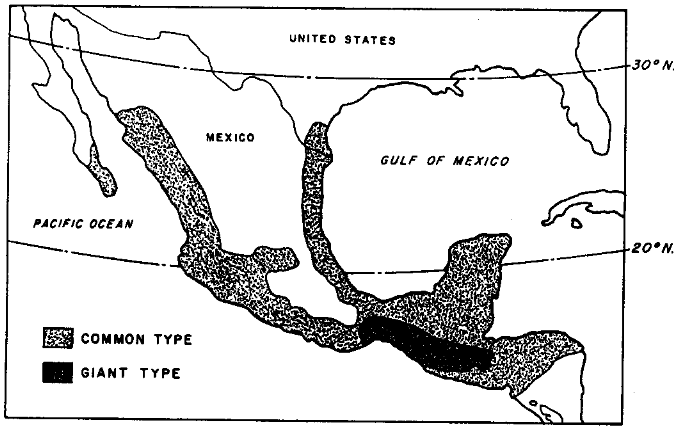

Figure 2.—*Native range of leucaena* (Leucaena leucocephala) *(adapted from* 51*).*

Leucaena tolerates a fairly broad range of temperature regimes. It grows well in areas where mean annual temperatures range from 20 to 30 °C, with mean minimum temperatures of 16 to 24 °C and mean maximum temperatures of 24 to 32 °C during the coldest and warmest months, respectively *(8, 75, 78)*. Best growth occurs in areas with a mean annual temperature between 25 and 30 °C *(75)*. Although leucaena can survive mild frosts of short duration, growth is severely restricted at low temperatures *(75)*.

Soils and Topography

Leucaena tolerates a wide array of soil conditions, from skeletal and stony soils to heavy clays *(50)*. In Mexico, natural stands occur in areas with volcanic soils *(43)*. Best growth occurs in well-drained soils that are moderately alkaline (pH 7.5) to slightly acidic (pH 6.0). The species tolerates moderate salinity, up to 20 mmhos/cm *(72)*.

Leucaena grows poorly in compacted soils, sites with impeded drainage, or on acidic, calcium-poor Oxisols with a pH less than 5.0 and high levels of exchangeable aluminum *(14, 34, 39, 51, 72)*. Adequate available soil phosphorus appears to be essential for vigorous root development; reduced phosphorus availability at low soil pH may limit growth on acidic soils *(6)*. In India, very poor growth was reported on saline-alkaline soils characterized by high exchangeable Na and K *(10)*.

Leucaena is primarily a lowland species that generally does not grow well above 500 m between 10° and 25° latitudes, nor above 1000 m within 10° of the equator *(75)*. However, it does occur in natural stands in western Mexico at elevations above 1500 m *(43)* and is cultivated to about 1500 m in parts of Southeast Asia *(2, 14, 51, 75, 78)*. In Puerto Rico, it commonly grows on hillsides and embankments at lower and middle elevations.

Associated Forest Cover

In its native Mexican and Central American range, leucaena is an important component of secondary semi-deciduous and deciduous forests *(59)*. In western Mexico, it grows in dry deciduous forests in association with *Lysiloma* spp., *Bursera* spp., and arborescent *Ipomoea* spp. *(43)*.

In 42- to 56-year-old secondary forest stands established on abandoned agricultural and urban sites in Puerto Rico's Guanica Biosphere Reserve (subtropical dry forest, *sensu* Holdridge; *23*), leucaena is associated with *Colubrina aborescens* (Miller) Sarg., *Croton lucidus* L., *Exostema caribaeum* (Jacq.) Schult. in L., *Pisonia albida* (Heimerl) Britton ex Standl., *Pithecellobium unguis-cati* (L.) Mart., *Prosopis pallida* (H. & B. ex Willd.) HBK., *Tamarindus indica* L., and *Thouinia striata* var. *portoricensis* (Radlk.) Votava & Alain.[1] In Barbados, leucaena grows in sandy coastal forests in association with *Coccoloba uvifera* (L.) L., *Hippomane mancinella* L., *Thespesia populnea* (L.) Soland. ex Correa, *Terminalia catappa* L., *Cordia sebestena* L., and *C. obliqua* Willd.; in xerophytic shrub formations on rocky hillsides with *Psidium guajava* L., *Ziziphus mauritiana* Lam., *Tecoma stans* (L.) HBK., *Pisonia aculeata* L., and *Acacia farnesiana* (L.) Willd.; and in calcareous, sandy coastal secondary forests with *Clerodendrum aculeatum* (L.) Schlecht., *Pithecellobium unguis-cati*, *Eupatorium odoratum* L., and *Z. mauritiana (17)*.

LIFE HISTORY

Reproduction and Early Growth

Flowering and Fruiting.—Flowering phenology varies widely among varieties and with location. The varieties of the common type flower year-round *(35, 75)*, often beginning as early as when they are 4 to 6 months old. The giant varieties flower seasonally, usually twice a year *(51, 75)*. The spherical, whitish flower heads are 2.0 to 2.5 cm in diameter and are borne on stalks 2 to 3 cm long at the ends or sides of twigs (fig. 3).

The fruits, generally produced in abundance from the first year onward, are flat, thin pods, dark brown when ripe, 10 to 15 cm long and 1.5 to 2.0 cm wide *(34)*. A pod contains 15 to 20 seeds *(8)*.

Seed Production and Dissemination.—Leucaena seeds are small, flat, teardrop-shaped (8 mm long), shiny, and dark brown with a thin but fairly durable seedcoat *(34)*. There are about 17,000 to 21,000 seeds per kilogram *(8, 14, 76)*. Seeds are generally released from dehiscent pods while still on the tree, although unopened or partially opened pods may be carried long distances by wind. The seed pods are commonly eaten by and pass through livestock, which appear to be important dispersal agents in pastures.

Seed pods may be collected from branches when ripe, before dehiscience. Pods should be sun-dried and then threshed to release seeds; threshing is commonly done by beating the dried pods in cloth bags *(75)*.

Seedling Development.—Germination in leucaena is epigeal. Leucaena seeds germinate on or near the soil surface and should not be planted deeper than 2 cm *(51)*. Although seeds may be sown without scarification, mechanical scarification (abrasion with sandpaper or clipping the seedcoat) or either of the following treatments are used to

[1]Molina, Sandra. 1992. Personal communication. Located at U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Río Piedras, PR 00928-2500.

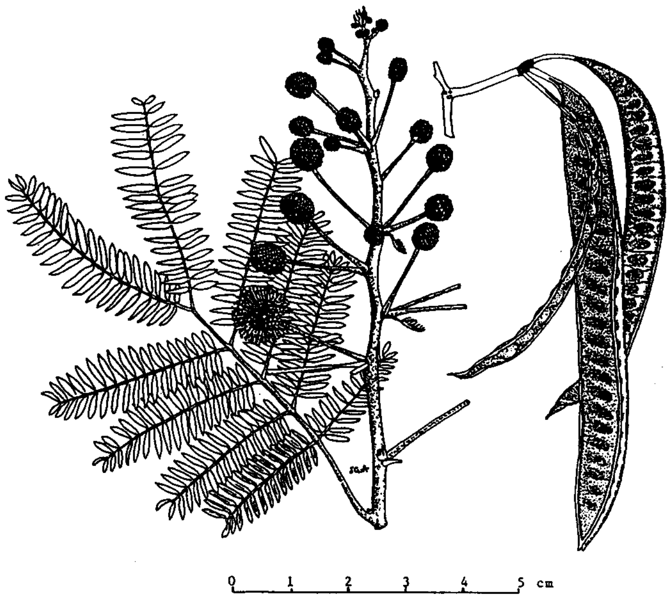

Figure 3.—*Foliage and fruit of leucaena* (Leucaena leucocephala) (35).

ensure more rapid and uniform germination: (a) immersion in hot water (80 °C) for 3 to 4 minutes followed by soaking in water at room temperature for up to 12 hours *(11, 13, 51, 76)* or (b) soaking in concentrated sulfuric acid for 15 to 30 minutes *(11, 51)*. Scarification may be followed by inoculation with nitrogen-fixing *Rhizobium* bacteria (mixed with finely ground peat) after coating the scarified seed with a gum arabic or concentrated sugar solution. Presowing inoculation facilitates good field establishment in soils devoid of leucaena rhizobia *(51)*.

Seed germination is commonly 50 to 98 percent for fresh seeds *(11, 76)*. Scarified seeds germinate 6 to 10 days after sowing *(8, 14, 76)*; unscarified seeds germinate 6 to 60 days after sowing *(14, 76)*. Dried, scarified seeds retain their viability for 6 to 12 months *(75)*. Unscarified seeds will remain viable for more than 1 year when stored under dry conditions at ambient temperature and up to 5 years stored at 2 to 6 °C *(11, 75)*.

In the nursery, seeds may be sown directly into seedling containers or in open beds and transplanted to containers when seedlings are 7 to 10 cm in height *(8)*. Nursery media should be well drained, have good nutrient and water holding capacity, and have a pH between 5.5 and 7.5 *(75)*. Scarified seeds should be sown directly on the soil surface and covered with a 3- to 5-mm thick layer of coarse sand or fine gravel *(31, 75)*. Alternatively, seeds may be germinated on damp towels and potted when the radicle emerges *(75)*. Dibble tube seedling containers may be preferable to polyethylene bags to prevent root spiraling and to facilitate seedling transport and planting *(75)*.

Light shade is recommended during the first few weeks of seedling development *(8, 75)*. Taproot development is rapid in young seedlings. Seedlings generally begin to reach plantable size (20-cm height) at 10 weeks *(75, 79)*.

Plantations may be established by direct seeding; by planting container-grown seedlings, bare-root seedlings, stem cuttings (2 to 5 cm diameter); or by stumps *(31, 75)*. For bare-root seedlings, seeds should be sown in open beds that are flooded to facilitate uprooting when seedlings are 2 to 3 months old or at least 50 cm tall *(75)*. For stump plantings, seedlings should be grown in raised beds for 4 to 5 months or until seedling basal diameters average 1 cm and heights exceed 1 m. Before transplanting, seedlings are uprooted and the stem cut to 10 to 20 cm above the root collar and the taproot to 15 to 20 cm below *(31, 75)*.

Leucaena seedlings grow slowly during the first months after planting. This is often due, at least in part, to root spiraling or taproot damage during planting *(75)*. Average seedling heights generally range from 0.5 to 1.5 m at 6 months after outplanting *(8, 19, 58)*. During the first 3 to 6 months after planting, seedlings are susceptible to suppression by competing vegetation and should be weeded during this early phase *(8, 75)*. In some areas young plantations may also require protection against termites, leaf-cutting ants (*Atta* spp.), and rodents during the first year after establishment *(8, 51)*.

Natural regeneration of leucaena is good in both natural stands and plantations (*9;* author, personal observation). Abundant seed production and rapid germination and establishment make leucaena an aggressive colonizer of disturbed habitats. Its capacity to outcompete and suppress grasses has led to its use in reclamation of degraded hillslopes in Indonesia *(14)*.

Vegetative Reproduction.—Leucaena is readily propagated from cuttings *(2, 8, 35)*. When cut, it coppices vigorously, producing various numbers of shoots depending on stump diameter and cutting height, technique, and season. Coppice yields typically exceed those of first rotation crops *(8, 75)*. Stem cuttings root easily in mist chambers, particularly when treated with the plant growth regulators indole-butyric acid (IBA), naphthalene acetic acid (NAA), and indoleacetic acid (IAA) *(60)*.

Sapling and Pole Stage to Maturity

Growth and Yield.—Leucaena grows rapidly on favorable sites. As noted previously, there is much genotypic variation in size and form of trees at maturity, ranging from very branchy shrubs less than 5 m in height to medium-sized trees 8 to 20 m in height, with diameters at breast height (d.b.h.s) of up to 50 cm and spreading crowns with smooth gray or grayish-brown bark.

In adaptability trials conducted at more than 150 sites in subtropical and tropical dry, moist, and wet forest life zones (sensu Holdridge; *23*) in Guatemala, Costa Rica, Nicaragua, El Salvador, and Panama, growth varied greatly *(7, 64)*. Most of these trials were small-scale, plantation plots established at densities ranging from 2,500 to 10,000 trees per hectare on sites with neutral to slightly acid soils. Average tree heights in these trials generally ranged from 1.0 to 5.5 m at 12 months, 2.0 to 9.0 m at 24 months, 3.5 to 11.0 m at 36 months, and 5.0 to 13 m at 48 months. Average stem d.b.h. generally ranged from 1.5 to 4.5 cm at 12 months, 2.0 to 7.5 cm at 24 months, 2.5 to 10.0 cm at 36 months, and 3.5 to 10.5 cm at 48 months. Total aboveground biomass (ovendry mass) ranged from 10 to 40 t/ha in 2-year old plantations and from 48 to 90 t/ha in 5-year old plantations. No consistent growth rate differences were apparent among the many provenances tested nor across the wide range of life zones where these trials were conducted, although most of the highest growth rates recorded were on sites in the tropical moist forest life zone.

In Costa Rica, mean annual height and d.b.h. growth for 26 plantation sites averaged 2.0 m and 1.5 cm, respectively, for plantations 4 years old or older. At 5.3 years, tree height, d.b.h., and basal area averaged 12.9 m, 12.6 cm, and 11.6 m^2/ha, respectively *(63)*. In these trials, conducted at elevations ranging from 50 to 1160 m above sea level and with annual rainfall between 1600 and 3100 mm, the best growth was observed on well-drained, light-textured soils in locales with a well-defined dry season.

The results from these Central American trials are typical of the range of growth rates and yields obtained elsewhere for young plantations. In experimental plantations less than 5 years old established in Puerto Rico (*58*; author, unpublished data), India *(9, 33, 44, 52)*, Nepal *(65)*, the Philippines *(39)*, and Tanzania *(40)*, stem diameter growth ranged from 2.0 to 3.5 cm/yr, and height growth ranged between 2.6 and 4.0 m/yr. In more mature plantation stands (5 years or older), mean annual height and diameter growth is usually much lower, less than 2.0 m and 2.0 cm, respectively[2] *(36, 61)*.

Total aboveground biomass production estimates for Puerto Rico *(36)*, Hawaii *(5)*, and India *(9, 21, 49)* are within the range of 5 to 55 dry t/ha/yr reported in the Central American trials cited above. Several studies, however, do report both lower and, more often, higher production in India *(9, 33, 44, 46, 47, 52)*, Pakistan *(81)*, and Tanzania *(40)*. On good sites in the Philippines, average annual yields range from 13 to 32 t/ha *(75)*.

Average annual volume growth in well-managed experimental plantations on good sites is generally between 30 and 55 m^3 /ha *(9, 26, 39)*. In commercial-scale plantations in the Philippines, however, average annual volume yields were usually lower, between 8 and 30 m^3/ha *(39)*.

Differences in genotype (even among the giant or Salvador types), local soil and climatic conditions, management intensity, and plantation age all appear to greatly influence growth and yield, often making comparisons among studies difficult. Site-index curves, volume tables, and biomass regressions have been published in recent years for leucaena *(18, 20, 29)*.

Rooting Habit.—Leucaena forms a deep, strongly developed taproot and, generally, a wide-spreading, although sparse, lateral root system *(2)*. In fertile, well-drained soils, lateral roots sometimes grow downward at a sharp angle *(14)*. Fine roots are often concentrated in the surface horizons close to the stem base *(58)*. A dense mat of small, feeding roots 5 to 10 cm deep was consistently noted for 1.5-year old trees harvested from plantation plots on a sandy coastal site in Puerto Rico (author, personal observation). Root biomass comprised 9 to 48 percent of total tree biomass in these young Puerto Rican plantations, and 15 to 24 percent of total tree biomass in 3-year-old plantations in India *(44, 49)*.

The small, horizontal, lateral roots in the aerated surface soil layers readily form a symbiotic association with nitrogen-fixing bacteria of the *Rhizobiaceae*. In Hawaii, leucaena was found to be nodulated by *Rhizobium* spp. strains from *Demanthus virgatus, Mimosa pudica* L., *Prosopis juliflora* (Sw.) DC., and two *Sesbania* species *(2)*. Annual nitrogen fixation rates by leucaena have been estimated to be as high as 110 kg/ha under field conditions *(22)*. Nodulation appears to be greatly influenced by soil reaction and is poor at pH levels below 5.5 *(3)*.

In addition to *Rhizobium* spp., the fine roots and root hairs are also commonly infected with vehiscular-arbuscular mycorrhizae (VAM), which improve the phosphorus nutrition and water relations in leucaena *(27, 28, 80)*. In phosphorus-deficient tropical soils, dual inoculation with *Rhizobium* spp. and VAM greatly enhances seedling growth *(41, 67)*. Infection by VAM appears to be necessary for nodulation to occur in some soils *(62)*.

Reaction to Competition.—Leucaena is a strongly light-demanding species, growing best in full sun or under very light shade. Under heavily shaded conditions, such as in the understory of dense stands, growth is suppressed. Suppressed individuals may persist in the understory, however, and respond quickly when new clearings are created *(51)*.

Young plantation stands respond well to weeding. In trials at three sites in Costa Rica, no consistent trends for diameter or height growth were reported during the first 5 years of growth at stand densities ranging from 400 to 2,500 trees per hectare *(64)*. At higher plantation densities, individual tree growth rates decline, branching tends to be suppressed, and self-pruning of lateral branches is common *(44, 75)*.

Leucaena is well suited to management at close spacing for fuelwood and fodder production. Mean annual wood biomass increments in young (2- to 3-year-old) plantations generally increase with plantation density up to about 50,000 trees per hectare and culminate between 1 and 3 years *(7, 8, 33, 75)*. Except on dry sites, fuelwood production is commonly greatest at a 1- by 1-m spacing *(33)*. Leucaena is commonly planted in energy and pulpwood tree farms at spacings of 1 by 0.5 m or 1 by 1 m, and at densities of up to 75,000 trees per hectare when grown as a forage crop *(39)*. For production of poles and fuelwood, spacings of 1 by 2 m to 2.5 by 2.5 m, with a rotation age of 3 to 5 years, are recommended *(44, 63, 75)*. For large-diameter wood products (pulpwood or sawtimber), initial stocking of 5,000 to 10,000 trees per hectare is recommended, with a thinning to about 2,500 trees per hectare at 2 to 3 years and a final rotation length of 6 or more years *(75)*. As a shade tree in coffee plantations, a 5- by 5-m spacing is considered optimal *(63)*.

Leucaena grows well in mixed-species plantations. In Puerto Rico, leucaena planted in a 1:1 mixture with either *Casuarina equisetifolia* L. or *Eucalyptus robusta* Sm. showed greater height and stem diameter growth than did leucaena in pure plantations during the first 2 years of development (author, unpublished data). The associated species also grew faster than in monocultures at the same stand density on the same site.

Damaging Agents.—Since 1982, severe defoliation by the sap-sucking leucaena psyllid, *Heteropsylla cubana* Crawford (Homoptera: Psyllidae), has been reported in plantations in Asia and the Pacific. Native to the Caribbean, Mexico, and Central and South America, the leucaena psyllid was first noted in Hawaii in 1984; elsewhere in the Pacific, Southeast Asia, and Australia in 1985 and 1986 *(45)*; in Sri Lanka in 1986; and in India, Burma, and China

[2]U.S. Forest Service. Unpublished data on growth in *Leucaena leucocephala* plantation at Cambalache, Puerto Rico. Located at: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Río Piedras, PR 00928-2500.

in 1988 *(54)*. Psyllid-resistance seems to vary among *Leucaena* genotypes; in Hawaii, the varieties K527, K538, K584, K591, K636, K656, and K658 are psyllid-tolerant *(68)*. Some success in increasing leucaena resistence to the pest has been achieved through hybridization with other *Leucaena* species, specifically with *L. collinsii* Britton & Rose, *L. diversifolia* (Schlecht) Benth., *L. esculenta* (Moc. & Sessé) Benth., and *L. pallida* Britton & Rose *(68)*. A number of the psyllid's natural enemies, both parasitic and predatory, have been identified in the Caribbean and Hawaii as possible biological control agents *(48)*.

In Puerto Rico, leucaena is the host of several homopteran, isopteran, lepidopteran, and thysanopteran insect species, although none is reported to cause serious damage *(42)*. The larvae of *Heliothis zea* (Lepidoptera: Pieredae) partially defoliated young leucaena plantations on the northern coast of Puerto Rico (author, personal observation). In Indonesia, *Pseudococcus citri* Risso, which occurs at elevations above 600 m, and the mealy bug *Ferrisia virgata* Ckll. feed on leucaena pods *(14)*. The twig girdler, *Oncideres rhodosticta* attacks leucaena in southern Texas *(16)*. Several insect pests affecting seedlings and mature trees have been reported in the Philippines *(4)*.

Leucaena is susceptible to a number of leaf and root pathogens *(69, 74)*. Leaf spot, caused by *Exosporium leucaenae* F.L. Stevens & Dalby, has been reported in Puerto Rico *(74)*, and leaf pustules, caused by the fungus *Camptomeris leucaenae* (F.L. Stevens & Dalby) Syd., have been reported in Puerto Rico, the Dominican Republic, and Venezuela *(69)*. In Hawaii, *Botryosphaeria ribis* var. *chromogena* Shear, Stevens & Wilcox and *Physalospora obtusa* (Schw.) Cke. cause dieback of branches *(69, 74)*. A severe pod rot caused by *Colletotrichium gloeosporioides* (Penzig) Penzig & Sacc., has been observed in Mauritius *(38)*. Causes of root rot include *Fomes lamaoensis* (Murr.) Sacc. & Trott. (in the East Indies), *F. lignosus* (Klotzsch) Bres. in the Pacific and equatorial Africa (Congo), *Helicobasidium compactum* Boed. in the East Indies, *Rhizoctonia choussii* Crandall & Arillaga in El Salvador, *Rosellinia arcuata* Petch and *R. bunodes* (Berk. & Br.) Sacc. in Java and Sumatra, and *Ustulina deusta* (Fr.) Petr. in Sumatra *(14, 69)*. "Pink disease," caused by *Corticium salmonicolor* Berk. & Br., has been reported in the East Indies; heartrot, caused by *Ganoderma lucidum* (Fr.) Karst. has been reported in the Philippines and *G. pseudoferreum* Walkef. in the Pacific; and the wilt *Verticillium albo-atrum* Reinke. & Berth. has been reported in Congo *(69)*. Gummosis and canker disease, caused by *Fusarium semitecum*, have been reported in India *(9, 66)*. Damping-off, caused by the fungal pathogens of the genera *Pythium* or *Rhizochtonia*, is sometimes a problem in the nursery *(75)*.

Leucaena is highly susceptible to fire damage when young, although affected trees usually recover rapidly by coppicing *(75)*. The species suffers only minor, small-branch damage in moderate winds. When subjected to hurricane-force winds, newly planted seedlings in Puerto Rico were defoliated and suffered die-back to the root collar; however, 94 percent of these seedlings resprouted and grew rapidly thereafter *(57)*.

SPECIAL USES

Leucaena wood has a specific gravity between 0.50 and 0.59 g/cm^3 and when air-dried (15-percent moisture content, wet-weight basis) has a caloric value of 19.4 kJ/g. These characteristics favor its use for firewood and charcoal *(34, 39, 71)*. In the Philippines, where leucaena has long been used for these purposes, large-scale plantations have been established to provide fuel for electric power generators, factories, and agricultural processing facilities *(15, 50)*.

The sapwood is pale yellow and the heartwood light reddish. Leucaena wood machines easily, takes water-soluble preservatives readily, dries without splitting or checking, and is of low- to medium-durability *(75)*. Compression strength and longitudinal modulus of elasticity range from 297 to 340 kg/cm^2 and 86,000 to 104,000 kg/cm^2, respectively *(71)*.

Leucaena lumber is used for light construction and boxes, and roundwood is used for fenceposts as well as construction and transmission poles *(50)*. The wood is also suitable for furniture stock and particleboard *(71)*. This species is considered a promising source of short-fiber pulp for paper production. Recent trials in Taiwan, Japan, the Philippines, and India indicate that leucaena is suitable for pulp production by the unbleached kraft, soda-AQ, neutral sulphite semi-chemical (NSSC), and dissolving pulp processing methods *(25, 55)*

Leucaena is used in many parts of the tropics as a shade tree or companion crop in plantations of cacao, coffee, tea, vanilla and other vine crops, coconut, rubber, teak, and cinchona *(12, 31, 51, 53, 75)*. It is cultivated in many areas in dense hedgerows and is intercropped with maize and other food crops. In these "alley cropping" systems, leucaena hedges are often cut two or more times per year, and the harvested foliage is used as a green manure or livestock fodder *(8, 32, 37, 40, 75)*.

Leucaena is also cultivated for soil improvement. Its foliage is used as an organic fertilizer, its nitrogen-fixing capabilities increasing the supply of nitrogen to upper soil horizons *(14, 36, 73, 77)*. Its aggressive, deep-rooting habit is reported to increase soil infiltration capacity and decrease surface runoff on sites with heavy soils and those with impervious subsoil layers *(50)*. Leucaena's ability to thrive on steep slopes, in marginal soils, and in areas with extended dry seasons make it useful for reforesting denuded watersheds, hillslopes, and grasslands *(2, 12, 50)*.

Leucaena is also used as a roadside ornamental, for shade around homes, and in hedges, windbreaks, and firebreaks *(14, 51, 75)*. Studies of plantations grown in industrial areas of India with high levels of atmospheric pollutants, specifically chlorine and hydrochloric acid, have suggested that leucaena is intermediate in its ability to withstand severe air pollution compared with several other commonly planted species *(1)*.

The leaves and seed pods are widely used as fodder for cattle, water buffalo, and goats. The protein content of dry forage (leaves and small branches) ranges from 14.0 to 16.2 percent *(56)*. Depending on variety, the foliage contains 19 to 47 percent mimosine *(6)*, an amino acid that may be toxic to livestock. Mimosine causes weight loss and ill health in monogastric animals such as pigs, horses, rabbits, and poultry when leucaena fodder comprises more than about 5 to 10 percent (by weight) of the diet *(39)*. However, ruminants (cattle, buffalo, and goats) in most parts of the world (with the exception of Australia, Papua New Guinea, and parts of Africa and the Pacific), have stomach microorganisms that render mimosine harmless *(51)*.

In some rural areas of Central America and Southeast Asia, people eat both the young seed pods and leaves as a cooked vegetable, and the seeds reportedly can be prepared as a coffee substitute *(14, 35)*. However, the potential for mimosine toxicity makes human consumption risky *(51)*. The bark and roots are used in home remedies *(34)*. The roots reportedly have emmenagogic and abortive properties *(70)*. The seeds yield 8.8 percent oil consisting of palmitic, stearic, behenic, lignoceric, oleic, and linoleic acids *(2)*. Leucaena is considered a good forage plant for honeybees *(34)*.

In Mexico red, brown, and black dyes are extracted from the pods, leaves, and bark. Throughout the Pacific Basin, leucaena seeds are used as beads for decorative purposes *(51)*. The seeds contain selenium and are used in Sri Lanka to prepare a fish poison and worm repellant *(12)*.

GENETICS

Leucaena is a genus consisting of about 50 species of shrubs and trees occurring in tropical and subtropical regions of North and South America, Africa, and the South Pacific *(2, 6)*. About 13 species are endemic to Mexico *(2)*. In addition to *L. leucocephala*, several other species are worthy of further study as possible sources of good-quality wood, fuel, and fodder. These include *L. collinsii* Britton & Rose, *L. diversifolia* (Schlecht) Benth., *L. esculenta* (Moc. & Sessé) Benth., *L. lanceolata* Watson, *L. macrophylla* Benth., *L. pulverulenta* (Schlecht) Benth., *L. retusa* Benth., *L. shannoni* Donn. Smith, and *L. trichodes* Benth. *(2, 6)*.

Field studies and chromosomal analyses suggest that *L. leucocephala*, a polyploid species with 104 chromosomes, originated as an allotetraploid hybrid of *L. diversifolia* and *L. collinsii*. The common and giant varieties of leucaena may be viewed as the northern and southern strains of this species *(6)*.

There are more than 800 known varieties of leucaena *(6, 30)*, broadly classified into three types. The common type includes short, bushy varieties that grow to 5 m in height. Originally from coastal areas of Mexico, this type has spread widely throughout the Tropics, becoming an aggressive colonizer in many areas. The giant type includes tall varieties growing to 20 m in height, with larger leaves, pods, and seeds, and larger, less-branching trunks. Originally from the inland forests of Central America and Mexico, they have been studied only since the early 1960's. A number of extremely high-yielding Salvador-type cultivars, known as "Hawaiian giants" and designated K8, K28, K67, K636, etc., are being planted for timber, wood products, and fuel worldwide. The "Peru" type includes medium-sized tree varieties growing up to 10 m in height. These varieties branch extensively, often low on the trunk, and produce high forage yields when pruned at frequent intervals *(51)*. The genus *Leucaena* is an interbreeding complex; breeding efforts have concentrated on producing interspecific hybrids, of which more than 50 are currently under study in Hawaii, Australia, Taiwan, and Indonesia *(55)*.

Leucaena leucocephala (Lam.) de Wit has been known by several botanical synonyms, including *Leucaena glauca* (L.) Benth., *L. blancii* Goyena, *L. glabrata* Rose, *L. greggii* Watson, *L. latisiliqua* (L.) W.T. Gillis, and *L. salvadorensis* Standley *(6, 51)*, *Acacia biceps* DC., *A. caringa* Ham., *A. frondosa* Willd., *A. glauca* DC., *A. leucocephala* DC. *(24)*, and *Mimosa glauca* L. *(12)*.

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