



Moringa oleifera
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Moringa oleifera LAM., 1785

syn.: *Guilandina moringa* LAM.; *Hyperanthera moringa* WILLD.;
Moringa nux-ben PERR.; *Moringa pterygosperma* GAERTN., 1791

Meerrettichbaum, Pferderettichbaum Familie: Moringaceae

Arabic: rawag

Assamese: saijna, sohjna

Bengali: sajina

Burmese: daintha, dandalonbin

Chinese: la ken

English: drumstick tree,
horseradish tree, ben tree

French: moringe à graine ailée,
morungue

Gujarati: midhosaragavo, saragavo

Hindi: mungna, saijna, shajna

Kannada: nugge

Konkani: maissang, moring,
moxing

Malayalam: murinna, sigru

Marathi: achajhada, shevgi

Nepali: shobhanjan, sohijan

Oriya: sajina

Portuguese: moringa, moringueiro

Punjabi: sainjna, soanjna

Sanskrit: shobhanjana, sigru

Sinhalese: murunga

Spanish: ángela, ben, moringa

Swahili: mrongo, mzunze

Tamil: moringa, murungai

Telegu: mulaga, munaga,
tellamunaga

Urdu: sahajna



Fig. 1: Flower detail (front and side view)





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Drumstick tree, also known as horseradish tree and ben tree in English, is a small to medium-sized, evergreen or deciduous tree native to northern India, Pakistan and Nepal. It is cultivated and has become naturalized well beyond its native range, including throughout South Asia, and in many countries of Southeast Asia, the Arabian Peninsula, tropical Africa, Central America, the Caribbean and tropical South America. The tree usually grows to 10 or 12 m in height, with a spreading, open crown of drooping, brittle branches, feathery foliage of tripinnate leaves, and thick, corky, deeply fissured whitish bark. It is valued mainly for its edible fruits, leaves, flowers, roots, and seed oil, and is used extensively in traditional medicine throughout its native and introduced ranges.

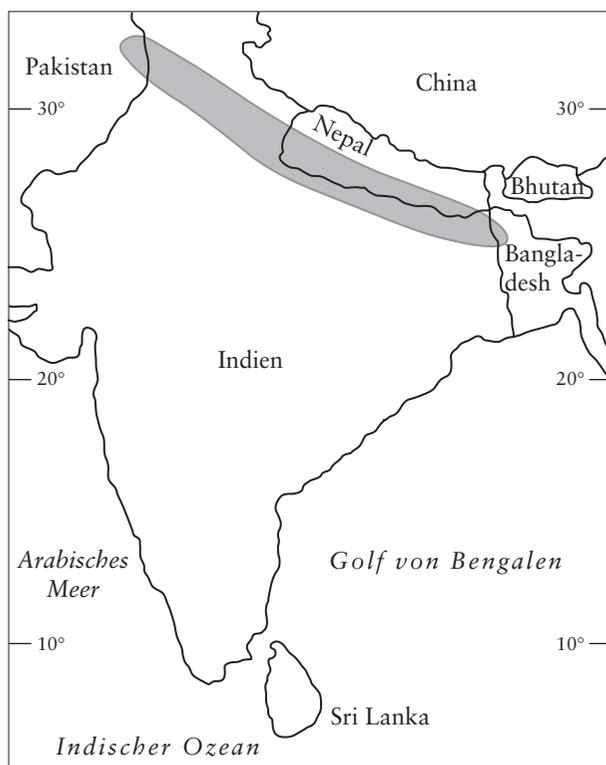


Fig. 2: Native range

Distribution

Drumstick tree is indigenous to the Himalayan foothills of South Asia from northeastern Pakistan (33°N, 73°E) to northern West Bengal State in India and northeastern Bangladesh where it is commonly found from sea level to 1,400 m on recent alluvial land or near riverbeds and streams [40, 47, 51, 60].

It is cultivated and has become naturalized in other parts of Pakistan, India, and Nepal, as well as in Afghanistan, Bangladesh, Sri Lanka, Southeast Asia, West Asia, the Arabian peninsula, East and West Africa, throughout the West Indies and southern Florida, in Central and South America from Mexico to Peru, as well as in Brazil and Paraguay [17, 21, 29, 30, 51, 65].

Morphology

Moringa oleifera tree is a small, fast-growing evergreen or deciduous tree that usually grows up to 10 or 12 m in height. It has a spreading, open crown of drooping, fragile branches, feathery foliage of tripinnate leaves, and thick, corky, whitish bark.

Leaves and young shoots

The leaves are bipinnate or more commonly tripinnate, up to 45 cm long, and are alternate and spirally arranged on the twigs. Pinnae and pinnules are opposite; leaflets are 1.2 to 2.0 cm long and 0.6 to 1.0 cm wide, the lateral leaflets elliptic, the terminal ones obovate; petioles of lateral leaflets are 1.5 to 2.5 mm long, those of terminal ones 3 to 6 mm long. The leaflets are finely hairy, green and almost hairless on the upper surface, paler and hairless beneath, with red-tinged midveins, with entire (not toothed) margins, and are rounded or blunt-pointed at the apex and short-pointed at the base. The twigs are finely hairy and green, becoming brown.

Flowers, fruits and seeds

The fragrant, bisexual, yellowish white flowers are borne on slender, hairy stalks in spreading or drooping axillary clusters (panicles) 10–25 cm long. Individual flowers, set in a basal cup (hypanthium) *ca.* 3 mm long, are approximately 0.7 to 1 cm long and 2 cm broad, with five unequal yellowish-white, thinly veined, spatulate petals, five stamens with five smaller sterile stamens (staminodes), and a pistil composed of a 1-celled ovary and slender style [27, 30, 51]. The fruits are pendulous, linear, three-sided pods with nine longitudinal ridges, usually 20 to 50 cm long, but occasionally up to 1 m or longer, and 2.0 to 2.5 cm broad. The pods, each usually containing up to 26 seeds, are dark green during their development, and take approximately 3 months to mature after flowering [45]. They turn brown on maturity, and split open longitudinally along the three angles, releasing the dark brown, trigonous seeds. Seeds measure about 1 cm in diameter, with three whitish papery wings on the angles. Seed weights differ among varieties, ranging from 3,000 to 9,000 seeds per kilogram [43].





Fig. 3: Compound leaf; paler lower surfaces of leaflets shown at left

Taxonomy and genetic differentiation

Moringa, derived from the vernacular south Indian (Tamil) name, is the sole genus in the family *Moringaceae*, with 12 deciduous tree species native to semi-arid habitats from North Africa to Southeast Asia [32]. In addition to *M. oleifera*, which is a diploid species with 28 chromosomes, several other species of *Moringa* have proven to be useful sources of food, fiber, medicinals, and other products. These include *M. concanensis* NIMMO, *M. drouhardii* JUMELLE, *M. longituba* ENGL., *M. ovalifolia* DINTER et A. BERGER, *M. peregrina* (FORSK.) FIORI, and *M. stenopetala* CUFORD [21, 37].



Fig. 4: Flower panicle

Bark and wood

The bark is whitish-gray, thick, soft, fissured and warty or corky, becoming rough. When wounded, the bark exudes a gum which is initially white in color but changes to reddish brown or brownish black on exposure. The wood is soft and light, with a density of 0.5 to 0.7 g/cm³ [66].

Rooting habit

Seedlings develop a swollen, tuberous, white taproot which has a characteristic pungent odor, and very sparse lateral roots. Trees grown from seeds develop a deep, stout taproot with a wide-spreading system of thick, tuberous lateral roots. Taproots do not develop on trees propagated from cuttings [29].



Fig. 5: Bark of mature tree



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Drumstick tree exhibits considerable phenotypic variation within its range [51, 57]. While wild trees usually bear small fruits, cultivated varieties grown in south India, known as „Jaffna“ and „Chavakacheri murunga,“ bear fruits ranging in length from 60 to 90 cm and 90 to 120 cm, respectively. A variety with red-tipped fruits, „Chemmurunga,“ is said to flower year-round and have high fruit yields. Other well-known varieties cultivated in the south Indian State of Tamilnadu include „Palmurungai,“ which has a thick pulp and bitter taste, „Punamurungai,“ and „Kodaikalmurungai,“ which produces very short fruits (15 to 23 cm in length). In the West Indies, several varieties are cultivated; some produce an abundance of fruit while others rarely flower and are principally grown for their foliage [51].

Growth, development and yield

M. oleifera grows rapidly on favorable sites, with height increments of 1 to 2 m per year during the first 3 to 4 years. It is not known how long trees normally live. In an experiment conducted under rainfed conditions in Tanzania, nursery grown seedlings attained an average height of 4.1 m during the first year [38]. While trees rarely grow taller than 10 to 12 m, they occasionally attain heights of up to 16 m with stem diameters of up to 75 cm [46]. Fruit production begins as early as 6 to 8 months after planting in the case of trees raised from stem and branch cuttings [51]. Fruit yields are generally low during the first 2 years, but from the third year onward, a single tree can yield between 600 and 1,600 fruits each year [6, 37, 51].

Reproduction and regeneration, propagation, cultivation

Flowering phenology varies widely among varieties and with location. In its seasonally cool north Indian range, trees may flower only once between the months of April and June, while in southern India, flowering typically occurs two times each year. In locales with more constant seasonal temperatures and rainfall regimes such as the Caribbean islands, flowering may occur more or less continuously throughout the year [30, 51]. Flowering generally begins at an early age, usually within the first year and often within 6 months after planting. Trees generally produce good seed crops for about 12 years [66]. Pollination is usually by bees and other insects, as well as by birds [24, 37, 66]. The mature, dehiscent capsules, mature about 3 months after flowering, and remain on the tree for several months, releasing the seeds that are dispersed mainly by wind and water, but probably also by seed-eating animals. The natural regeneration of drumstick tree is fair on disturbed sites such as roadsides and field borders, where competition for light and soil moisture is not severe.



Fig. 6: Fruits (app. ½ nat. size)





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Seeds should be sown without pretreatment, as scarification does not facilitate germination [52]. The optimal sowing depth is 1 to 2 cm [52, 63]. Germination is commonly between 60 and 90 % for fresh seeds, and occurs between 7 and 30 days after sowing [21, 42, 46, 52]. Seeds do not retain their viability in storage at ambient temperatures for longer than 2 months [52, 63]; germination percentages of 60, 48 and 7.5 % were reported for seeds after 1, 2, and 3 months, respectively, in India [37]. In test conducted in Brazil, however, seeds retained their viability for several years in cold storage, or inside hermetically sealed containers stored at ambient temperatures [59]. Both germination and early seedling growth are favored by partially shaded conditions [21].

Seedling growth is rapid. In tests conducted in Puerto Rico, container-grown seedlings were 20–30 cm in height 6 weeks after sowing, and seedlings reached plantable size (30–50 cm) 2–3 months after sowing [46]. Seedlings occasionally grow much quicker, attaining heights of 1.8–3.6 m after sowing [37].

M. oleifera is easily propagated by cuttings, but is difficult to propagate by air layering [52]. Propagation by cuttings is often preferred to plants raised from seeds, which are reportedly slower to flower and fruit and produce fruit of inferior quality [51]. Large branch or stem cuttings 1.0–1.5 m long and 4–5 cm in diameter are typically planted during the summer rainy season in southern India [51]. Large branch or stem cuttings, planted in moist soil to a depth of about 50 cm, root readily and grow to sizeable trees within a few months [42, 51]. Some studies suggest that trees grown from seeds produce longer roots than those from cuttings and may be preferable for planting in semiarid and arid regions where water table depth is a potential growth-limiting factor [21]. In northern India, rooting success of branch cuttings was better during the spring months than either the summer rainy season or the cooler winter months [52]. Higher rooting percentages have been obtained by treating cuttings with the plant growth regulator indol-butyric acid (IBA) at concentrations of 50 ppm for 24 hours prior to planting [52].

The tree resprouts vigorously after cutting, producing four to eight shoots per stump [42]. Trees grown for fruit and fodder production are commonly pollarded to restrict crown spread and to promote new branch growth [51].

Ecology

In the South Asian native range of drumstick tree, annual temperature fluctuations tend to be large, with minimum and maximum shade temperatures ranging from –1 to 3 °C and 38 to 48 °C during the coldest and warmest months, respectively [60]. In this region, annual rainfall ranges from 750 to 2200 mm [42, 60]. Within its native and introduced ranges, mean annual temperatures range from 12.6 °C to 40 °C, with annual rainfall of at least 500 mm [66].

Drumstick tree is highly drought tolerant, and is cultivated in semiarid and arid regions of India, Pakistan, Afghanistan, Saudi Arabia, and East Africa receiving an annual rainfall as low as 300 mm [6, 51], although such sites are probably irrigated or have a high water table within reach of the roots. It grows at elevations from sea level to 1400 m along the larger rivers of its native range on sandy or gravelly alluvium [6, 60]; these soils are generally well drained and often very low in organic matter. While surface soils may be very dry for several months of the year, the water table is usually located within the maximum rooting depth of trees [8]. In its introduced range, the tree grows at elevations up to 1200 m [21] in most light- to medium-textured soils, but best growth occurs on sandy loams [51]. Poor growth was reported on semiarid Alfisols at an elevation of 1,560 m in Kenya [22].

Drumstick tree is a strongly light-demanding species, and is commonly planted at spacings of 3 by 3 m to 5 by 5 m in block plantations, or at 5-m spacing in line plantings [42, 51]. „Living fences“ or hedges of drumstick tree are typically established at spacings of 1 m or less and managed for foliage production through frequent cuttings [37]. Seedlings are susceptible to drought and to competition with grasses. Once established, however, saplings and pole-size trees are very hardy and can survive both drought and root competition. The tree is highly susceptible to wind damage. In its native range, drumstick tree grows in secondary dry tropical deciduous forests in association with such species as *Albizia procera* (ROXB.) BENTH., *Bombax malabaricum* DC., *Dalbergia sissoo* ROXB., *Ficus glomerata* ROXB., *Gmelina arborea* L., *Kydia calycina* ROXB., and *Lagerstroemia parviflora* ROXB. [1, 8].

Pathology

In its native Indian range, *M. oleifera* is susceptible to several insect pests. These include the bark-eating caterpillar, *Indarbela quadrinotata* WLK.; the hairy caterpillar, *Eupterote molifera* WLK.; the green leaf caterpillar, *Noorda blitealis* WLK.; and the budworm, *N. moringae* TAMS, which can cause serious defoliation; the larvae of *Tetragonia siva*, *Metanastia byrtaca*, *Heliothis armigera*, and *Helopeltis antonii* SIGN. (Lepidoptera); an aphid, *Aphis caraccivora*; the scale insects *Ceroplastodes cajani* and *Diaspidotus* sp.; the stem borers *Indarbela tetraonis* (MOORE) and *Diaxenopsis apomecynoides*; and a fruitfly, *Gitonia* sp. [7, 25, 37, 49, 51, 62]. Several other insect pests causing minor or only occasionally serious damage have also been reported. In Puerto Rico, the tree is reportedly very susceptible to attack by termites [36], and seed predation by an unidentified insect is often very heavy [46].



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The species is not affected by any serious diseases in its native or introduced ranges, although several diseases causing minor damage to trees growing in southern India have been reported, including a root rot caused by *Diplodia* sp. [51] and fruit rot caused by *Cochliobolus hawaiiensis* [28]. Drumstick tree is the collateral host of *Leveillula taurica*, a powdery mildew that causes serious damage in papaya (*Carica papaya* L.) nurseries in south India [61].

Uses

The wood of *M. oleifera* is little used outside of its native range except as a fuelwood and occasionally for light construction [16, 30]. In India, it is used to a limited extent in the textile industry for shuttles and picking-sticks and is suitable for pulp production for newsprint [19, 53], cellophane, and textiles [34, 42]. The corky bark yields a coarse fiber, which is utilized in making mats, paper, and cordage. The stem exudes a mucilaginous gum that is used in leather tanning and calico printing [4, 42, 51]. In many parts of its range, the leaves and twigs are used as fodder for cattle, sheep, goats, and camels [33, 43]. The flowers are a good source of pollen for honeybees [6, 30, 50].

The tree is mainly valued for its edible, tender pods, which have a taste very similar to asparagus. These are eaten as a nutritious vegetable, either cooked or pickled. The tender leaves taste like watercress and, along with the flowers, are eaten cooked or raw. They are rich in protein, minerals, beta-carotene, thiamin, riboflavin, and other vitamins, particularly vitamins A and C [11, 16, 20, 41, 42, 48, 51, 54, 55, 64]. The ascorbic acid (vitamin C) content of the green pods ranges from 92 to 126 mg per 100 g of pulp [14]. The young fruits, flowers, and leaves contain 5 to 10 percent protein. The immature seeds, which taste like peanuts after frying, are also consumed raw or cooked [51, 58]. The roots, which have the pungent taste of horseradish (*Armoracia rusticana* GAERTN.: Brassicaceae), are used as a condiment or garnish after peeling, drying, and mixing with vinegar [36]. The root bark must be completely removed as it is rich in alkaloids, notably moringine, a toxic compound allied to ephedrine [37].

The seeds contain 19 to 47 percent oil [2, 26, 58]. Known commercially as „ben oil“, it is similar to olive oil and is rich in palmitic, stearic, behmic, and oleic acids [42, 64], and is used for human consumption, and in cosmetics and soaps [13, 51, 58]. The oil is highly valued by perfumers for its power of absorbing and retaining odors, and by watchmakers as a lubricant [51]. The oilcake is used as a fertilizer [12]. The dried, powdered, seeds have been used, both in crude form and following extraction of their active principle in petroleum ether through a hot percolation process [23], as an effective and low-cost coagulant

for removing turbidity and reducing bacterial and viral contamination from drinking water in rural communities in the Sudan, Malawi, India, Myanmar, and Indonesia [21, 35, 44, 56]. Leaf extracts have been found to increase *Rhizobium* root nodulation, nodule weight, and nitrogenase activity in mung bean (*Vigna mungo* (L.) HEPPER) when applied to seeds or as a root dressing [3].

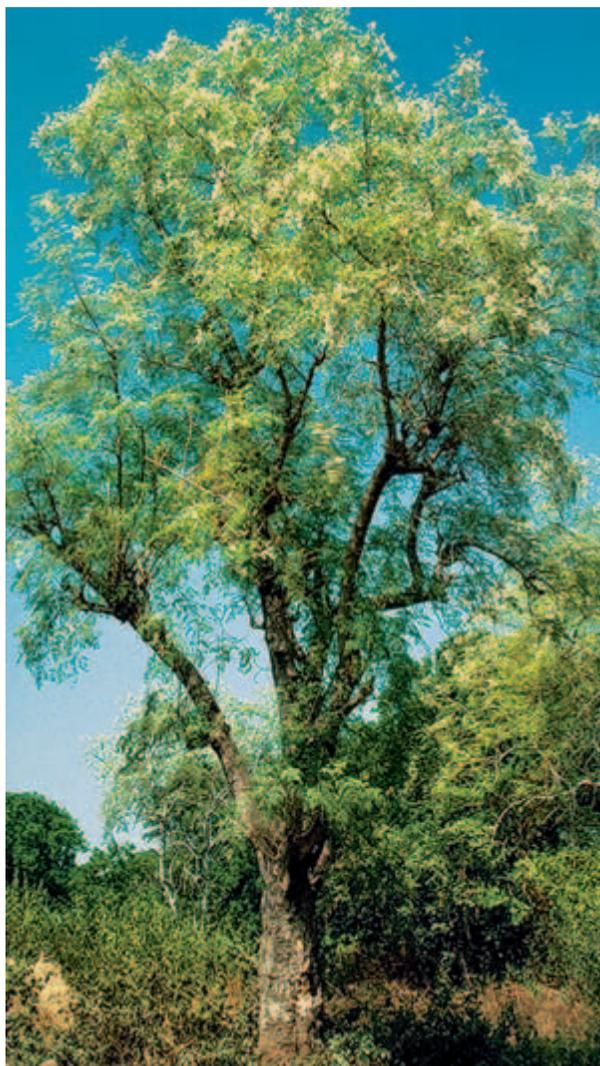


Fig. 7: Full grown *Moringa oleifera* in Jabalpur, Madhya Pradesh/India

Drumstick tree has numerous traditional medicinal uses in many parts of its native and introduced ranges [6, 27, 39, 47, 51, 66], and the tree continues to have an important role, in traditional Asian and West African medicine [5, 6, 9, 37, 58]. In traditional Indian medicine various parts of the tree are used therapeutically, including for treatment





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of ascites, rheumatism, venomous bites, and as cardiac and circulatory stimulants. The roots, leaves and seeds are of particular importance in Ayurveda, and the uses of the roots, root bark, stem bark, stem exudates, leaves, flowers, and seeds treating a wide range of ailments have been discussed in ancient Sanskrit texts on medicine [51]. The root of young trees and also the root bark are considered rubefacient, vesicant carminative, stomachic, and abortifacient; among other uses, they are commonly applied externally to cure inflammatory swellings. The flowers and roots contain pterogosperrin, an antibiotic that is highly effective in the treatment of cholera [31]. The flowers are also used as a tonic, diuretic and cholagogue. The leaves, rich in vitamin A and C, are considered useful in scurvy and respiratory ailments; they are also used as an emetic. The juice extracted from the leaves has strong antibacterial and antimalarial properties [9, 12, 15, 18]; a paste of the leaves is used as an external application to promote healing of wounds. The seed oil is applied externally to treat rheumatism and gout [10, 47]. Several compounds of proven medicinal value have been isolated from the roots, root bark, stem bark, and seeds [6].

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The author:

DR. JOHN A. PARROTTA
USDA Forest Service, Research & Development
1601 North Kent Street, Arlington, VA 22209 (USA)

edited by:
DR. BERND STIMM

