



Moringa oleifera Lam.

Protologue

Encycl. 1(2): 398 (1785).

Family

Moringaceae

Chromosome number

$n = 11$, $2n = 28$

Synonyms

Moringa pterygosperma Gaertn. (1791).

Vernacular names

Drumstick tree, ben oil tree, horseradish tree (En). Mouroungue, ben ailée, moringa ailée, pois quénique, néverdié (Fr). Moringa, moringueiro (Po). Mzunze, mronge, mlonge (Sw).

Origin and geographic distribution

Moringa oleifera is indigenous in northern India and Pakistan. It has been introduced throughout the tropics and subtropics and has become naturalized in many African countries.

Uses

Whereas in Asia the fruits are the most important part of *Moringa oleifera*, the leaves are preferred in Africa. The leaves are eaten as a salad, cooked, and in soups and sauces. In the Mascarene Islands it is known as 'brède mouroungue' or 'brède médaille'. Flowers are sometimes eaten as a vegetable, added to sauces or used to make tea. In Sudan the flowers are made into a paste by crushing and then fried. The young fruits are eaten as a vegetable ('drumsticks' or 'bâtons mouroungue'), older fruits are added to sauces. In West Africa some health projects fight malnutrition quite successfully by promoting a number of measures including the use of *Moringa oleifera* leaf powder in the diet of children and pregnant and lactating women. The tuberous root cores can be a substitute for horseradish (*Armoracia rusticana* Gaertn., B.Mey. & Scherb.).

The whole or pounded seeds have long been used to purify water in Sudan, and this practice is promoted elsewhere in Africa. The seed cake, a residue from oil extraction, can also be used for water purification.

The fried seeds are eaten in Nigeria and are said to taste like groundnuts. The seeds are added locally to sauces for their bitter taste. The seed oil, known as 'Ben oil' or 'Behen oil', can be used for cooking, in hair-dressing, as a lubricant and in the perfume industry as a base for fragrant volatile compounds in perfumes. 'Moringa acid oil', consisting of fatty acids from the



planted



1, leaf; 2, inflorescence; 3, fruit.

Source: PROSEA

seed oil, is used as a lubricant and to make soap.

Almost all parts have traditional medicinal applications.

Especially the uses as an anodyne, anthelmintic, antispasmodic and disinfectant (bactericidal, fungicidal) are widespread. The bark exudes a white to reddish gum ('Ben gum' or 'Moringa gum') with the properties of tragacanth (*Astragalus*) oil, which is used for tanning, in calico printing and is sometimes added to sauces to make them thicker.

Moringa oleifera is used for living fences, in alley cropping and as a source of nectar for bees. The leaves are eaten by livestock, especially goats, camels and donkeys. The seed cake is considered unsuitable as animal feed because of the high content of alkaloids and saponins and is mainly used as fertilizer. The soft wood burns smoke-free and yields a blue dye. In India its pulp has been used to make paper.

Production and international trade

In Africa local trade is mainly restricted to the leaves. In Kenya, some 2000 mostly small-scale farmers produce *Moringa oleifera* green fruits for the Asian community. In Tanzania an enterprise has started with the aim of producing oil and a flocculating agent. There is considerable international trade, mostly from India, in canned and fresh fruits, oil, seeds and leaf powder, but statistics on the volumes and value are not available.

Properties

The leafy tips of *Moringa oleifera* contain per 100 g edible portion: water 78.7 g, energy 268 kJ (64 kcal), protein 9.4 g, fat 1.4 g, carbohydrate 8.3 g, total dietary fibre 2.0 g, Ca 185 mg, Mg 147 mg, P 112 mg, Fe 4.0 mg, Zn 0.6 mg, vitamin A 7564 IU, thiamin 0.3 mg, riboflavin 0.7 mg, niacin 2.2 mg, folate 40 µg, ascorbic acid 51.7 mg. The raw fruits contain per 100 g edible portion: water 88.2 g, energy 155 kJ (37 kcal), protein 2.1 g, fat 0.2 g, carbohydrate 8.5 g, total dietary fibre 3.2 g, Ca 30 mg, Mg 45 mg, P 50 mg, Fe 0.4 mg, Zn 0.4 mg, vitamin A 74 IU, thiamin 0.05 mg, riboflavin 0.07 mg, niacin 0.6 mg, folate 44 µg, ascorbic acid 141.0 mg (USDA, 2003). The dry seeds contain on average: protein 29%, fibre 7.5% and oil 36–42%; of the total fatty acid content oleic acid 65–75%, behenic acid 9%, palmitic acid 9%, stearic acid 7% and small amounts of lignoceric acid and myristic acid. The oil is clear and odourless and does not become rancid quickly. Seeds of *Moringa oleifera* contain a glucosinolate that on hydrolysis yields 4-(α -L-rhamnosyloxy)-benzyl isothiocyanate, an active bactericide and fungicide. The seeds of *Moringa oleifera* yield a lower amount (4–5% of dry weight) of glucosinolate than those of *Moringa stenopetala* (8–10% of dry weight) and should therefore be used at a higher dosage. This isothiocyanate gives the crushed seeds the pungent horseradish smell. Glucosinolates are of interest for human health as their hydrolysis metabolites have both positive (e.g. anti-carcinogenic) and negative (e.g. toxic) effects. The



Photo: J.S. Siemons and M.H. van den Berg
detail of flowering crown



flowering and fruiting branches



Photo: H.C.D. de
Biosystematics Group, Wageningen

flower

seed contains a protein (cationic polyelectrolyte) that acts as a flocculant in water purification. It also contains a non-protein flocculant that is more effective in purifying low-turbidity water. A number of compounds with medicinal properties have been isolated. The fruit and leaf contain oxalic acid, the bark moringinine, the stem vanillin, the flower kaempferol and quercetin and the root spirochin and pterygospermin. The wood is white and soft, and has a specific gravity of 0.27.

Adulterations and substitutes

Moringa oleifera and *Moringa stenopetala* (Baker f.) Cufod. have many characteristics in common. Uses as a vegetable and water purifier are similar. They share several medicinal uses and both have high contents of oil in the seeds. *Moringa oleifera* has a faster development and yields fruits and seeds quickly. *Moringa stenopetala* is better suited to a drier climate; yields of seeds are higher with a higher yield of coagulant. *Moringa peregrina* (Forssk.) Fiori, the Ben-oil producer of ancient Egypt, produces seeds with similar oil content and has several medicinal uses as well.

Description

Deciduous to semi-evergreen shrub or small tree up to 10 m tall; trunk up to 45 cm in diameter; bark whitish, grey or pale buff, smooth or rarely rugose, corky; young shoots purplish or greenish white, puberulous. Leaves alternate, 6.5–60 cm long, 2–3-pinnate, with 4–6 pairs of pinnae; stipules absent, but petiole with stipitate glands at base; leaflets elliptical to obovate, 0.5–2(–3) cm × 0.3–1.3(–2) cm, rounded to cuneate at base, apex rounded to emarginate. Inflorescence a spreading, many-flowered panicle 8–30 cm long. Flowers bisexual, zygomorphic, 5-merous; sepals free, 7–14 mm long, often unequal; petals free, oblong-spatulate, 1–2 cm long, unequal, the largest erect, velvety pubescent, white or cream; stamens 5, filaments 7–8 mm long, anthers waxy yellow or orange, alternating with 3–5 staminodes; ovary superior, stalked, cylindrical, 3–5 mm long, pink at base, densely hairy, 1-celled, style slender, glabrous, without stigmatic lobes. Fruit an elongate 3-valved capsule 10–50 cm long, 9-ribbed, brown when ripe, many-seeded. Seeds globose, 1–1.5 cm in diameter, with 3 thin wings 0.5–2.5 cm long.

Other botanical information

Moringa is the only genus of the *Moringaceae*, a family related to *Brassicaceae*. It comprises 13 species, of which 8 are endemic to the Horn of Africa. *Moringa oleifera* is most closely related to *Moringa concanensis* Nimmo (also from India) and *Moringa peregrina* (Forssk.) Fiori (from the region around the Red Sea, the Horn of Africa, Yemen and Oman). These 3 species share a slender tree habit and the zygomorphic flowers.

Growth and development

Germination rates for fresh seeds are around 80%, going down to about 50% after 12 months storage, but no seeds survive 2



open pod

years of storage. Initially the tree grows at a remarkable rate; 3–4 m growth in a year is not unusual. Young trees raised from seed start flowering after 2 years. In trees grown from cuttings the first fruits may be expected 6–12 months after planting. Flowering often precedes or coincides with the formation of new leaves. In Nigeria flowering occurs throughout the year.

Ecology

Moringa oleifera grows well at lower elevations. In East Africa it is found up to 1350 m altitude, but its adaptability is shown by a naturalized stand at over 2000 m in Zimbabwe. It is drought tolerant and is found in locations with as little as 500 mm annual rainfall. It can be grown in a wide range of soils but fertile, well-drained soils are most suitable. Light frost is tolerated.

Propagation and planting

In Africa *Moringa oleifera* is mostly propagated by seed; in India the use of cuttings is more common as trees raised from seed produce inferior fruit. Seed is either sown directly in the field at the onset of the rainy season or in an irrigated nursery during the dry season. It is sown at a depth of 2 cm.

Germination takes (3–)7–14 days and seedlings benefit from shade (about 50%). Initially they are watered twice a day, but this is reduced to once a day when seedlings are 10–15 cm tall. Seedlings grow to 15–25 cm in 2 months; after 3 months they are 40 cm tall and ready for planting out. Planting out should coincide with the onset of the rains. Manure is applied in each hole.

Cuttings are primarily used for the establishment of live fences. Branches 1–1.5 m in length with a diameter of up to 4 cm will root readily in just a few months. When grown as a short-duration crop in monoculture *Moringa oleifera* is planted at a spacing of 0.7–1 m; when planted for long-term production a common spacing is 3–5 m either way. In Tanzania *Moringa oleifera* is grown for the production of seed for oil and flocculant at a recommended density of 800 trees per ha. In alley cropping an intra-row spacing of 2 m is used. In the wet season cereals are grown between the lines, in the dry season vegetables.

Management

Moringa oleifera usually receives little care apart from watering. If planted during the dry season half-shade should be provided and watering should be done regularly until the trees are established. Manure application is essential to obtain good yields. Manure is spread over the whole field, so associated crops benefit too. Some farmers apply chemical fertilizers, mainly NPK (e.g. 15–15–15) and urea, but only at the base of the trunk. Pollarding, coppicing and lopping or pruning are recommended to promote branching, increase production and facilitate harvesting. Because its shade can be controlled well *Moringa oleifera* is suitable for planting in alley cropping and in vegetable gardens. When trees reach 1.5 m, farmers prune them

(at 50 cm from the ground or at ground level for older ones) once or twice a year. A second pruning usually takes place before ramadan because demand and prices are high during that period. After pruning, it takes about 3 weeks till leaves can be harvested. Pruned poles are used for fences around fields or houses, or to build corrals. Weed control is done manually with a hoe. In Niger *Moringa oleifera* has become so important that it is grown as a field crop.

Diseases and pests

In Niger caterpillars are the main pest of *Moringa* and timely pruning provides some control. Termites may be a problem locally. The tree is not seriously affected by diseases in India. Root-rot, related to poor drainage and caused by *Diplodia* sp., has been observed. The hairy caterpillar *Eupterote molifera* can cause defoliation and requires spraying to control it. Other pests include aphids, other caterpillars (e.g. *Heliothis armigera*), a scale insect, a borer and a fruit fly.

Harvesting

In Niger harvesting of leaves starts two and a half months after sowing. Leaves are pulled from the branches, then put in bags and transported to the market. Harvesting is done twice a month. Harvesting of green fruits may start 7 months after planting; harvesting of dry fruits for seed about 6 weeks later.

Yield

Leaf production in Niger is highest during the rainy season, when a plot of 1000 m² yields 13–14 bags per harvest, which amounts to about 27 bags or 600 kg per month. In the dry season monthly yields drop to 2–4 bags in the cool months and to 10–15 bags during the warmer months if irrigated. This is equivalent to an annual production of 27 t/ha fresh leaves. In Tanzania the seed yield of a 4-year-old tree is about 3.3 kg. In India a good tree yields 1000 fruits.

Handling after harvest

Leaves can be dried and stored. Powdering the leaves before storing is locally common. Stored seeds are susceptible to insect damage and require protective measures.

Genetic resources

Most genetic variation in *Moringa oleifera* is found in north-western India, but in the wild it is probably extinct. As it is a cross-pollinated tree, high heterogeneity in form and yield is common. Research into genetic variation in populations from Kenya, Malawi and India concluded that germplasm from at least two sources has been introduced into Kenya. The high levels of population differentiation suggest that provenance source is important in the conservation and exploitation of genetic resources. The species is widespread in the tropics and subtropics and there are numerous accessions in genebanks, e.g. in the Centre National de Semences Forestières (CNSF), Ouagadougou, Burkina Faso. In the Philippines, where the leaves are popular, a sizeable collection is maintained at the

National Plant Genetic Resources Laboratory, IPB/UPLB,
College, Los Baños.

Breeding

No breeding work has been undertaken in Africa. In India 'Jaffna' types are popular for their long fruits (60 cm to more than 1 m long). In India a short-stem type of *Moringa oleifera*, released as PKM1, has also been developed for the production of immature fruits. Many farmers grow this type as an annual (two harvests per year). For Africa the most important selection criteria would be high leaf yield, whereas selection and breeding have so far concentrated on optimizing fruit yield. There is potential for hybridization with other *Moringa* species. *Moringa stenopetala* contains flocculating agents similar to those in *Moringa oleifera* and produces bigger seeds, so it may be possible to increase yields by hybridization with this species. It may be possible to increase the oil yield of *Moringa oleifera* by producing hybrids with *Moringa peregrina* (Forssk.) Fiori, which has higher oil content (c. 50%). So far, no results of hybridization trials have been published.

Prospects

Moringa oleifera is likely to become an even more important multipurpose crop in Africa than it is at present. Research interest in several *Moringa* species is enormous. The use as a low-cost water purifier is highly valuable for sanitary improvement in remote villages. Cultivar selection and the development of hybrids have great potential. Many of the local medicinal applications are not fully substantiated by pharmacological research and warrant further research. The industrial demand for *Moringa* oil is likely to increase as novel applications are developed.

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