THE SCIENCE WORLD
A Monthly e Magazine
ISSN:2583-2212
Popular Article
June, 2023; 3(06), 1127-1134

Botanical studies of Neem

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https://doi.org/10.5281/zenodo.8079820

Botanical Names

Azadirachta indica A.Juss

Syn. *Melia azadirachta* , *Melia indica* Hooker, *Melia indica* Brandis

Common Names

English : neem, Indian lilac
Hindi : neem, nimb
Tamil : vembu, veppan
Sanskrit : nimba, nimbou, arishtha (reliever of sickness)

Classification

Family : Meliaceae, sub-family: Melioideae, Tribe: Melieae
Genus : *Azadirachta* A.Juss
Species : *indica* A.Juss

Origin

According to Gamble (1902), the center of origin of *A. indica* is in the forests of Karnataka (south India) or the dried inland forests of Burma (Myanmar). Other authors were of the opinion that this tree originated in the forests of the Shivalik hills (foothills of the western Himalayas) or on east coast of south India. The great variety in the shape of the leaves and other morphological features support the theory of the origin of *A. indica* in upper Myanmar (Schmutterer, 1995); later it became naturalized in the forests of central and western India. The subject of origin is still controversial. Roxburgh (1874) gave its origin in India when Myanmar (Burma) was a part of India. Brandis (1921)

and Jacobs (1961) describe its origin in dry regions of Upper Myanmar (Irrawady valley, upper region of Prome). Some authors also suggest the place of origin of neem tree in parts of South India, such as Karnataka (Troup, 1921; Vartak and Ghate, 1990).

Ethnobotanical Studies

In some of the recent botanical surveys in India, some more information has been collected and reported that it as an Ayurvedic plant. In some surveys, stress was laid on finding the cure for certain diseases. It is reported neem has been used for jaundice and malaria. The use of neem in leather technology at the village level for preservation of leather goods is well known. It is also noted that it was also used for curing snake skin.

Etymology

The present popular name "neem", also spelled earlier as "nim", has been derived from the Sanskrit word "nimba" which means sprinkler, which is the short term for "sprinkler of nectar (ambrosia)". The other Sanskrit synonyms for the tree, as given in the chapter on Ayurveda, refer to its habitat and the use of it in ancient India.

The meaning of the generic name *Azadirachta* does not appear to be interpreted properly in most of the literature. It is often said that it is from the Persian words *azad*—free, and *drakhat*—tree, i.e., free tree, and when the specific name *indica* is added to it, the meaning of the botanical name becomes the free tree from India, which does not convey any specific significance of the name.

The views expressed by Watt (1889) appear to be more convincing, according to which the Persians were well conversant with the allied tree *Melia azedarachh* also commonly known as the China berry, but in Persian as *"Azadarakhat"* (the corrupted form of it in most of the north Indian languages is *Dharek*). As discussed with a Persian scholar in Panjab University, India, *aza* means bitter in Persian and *drakhat* means tree, so the name of the China berry in Persian stood for "bitter tree". When the neem was introduced into Iran, to distinguish it from the China berry, which it resembled to a major extent, neem was called *Aza-drakhat Hindi,* i.e., the bitter tree from India, which led to the present botanical name *Azadirachta indica,*

Distribution

In India the tree is most widely used. It is grown from the southern tip of Kerala to the Himalayan hills, in tropical to subtropical regions, in semiarid to wet tropical regions, and from sea level to about 700 m elevation. It is now well established in at least 30 countries, particularly those in the regions along the Sahara's southern fringe, where it has become an important provider of both fuel and lumber. Although widely naturalized, it has nowhere become a pest. Indeed, it seems rather well "domesticated": it appears to thrive in villages and towns. Over the last century or so, the tree

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Published **25.06.2023**

has also been established in Fiji, Mauritius, the Caribbean, and many countries of Central and South America. In some cases, it was probably introduced by indentured laborers, who re-membered its value from their days of living in India's villages. In other cases, it has been introduced by foresters. In the continental United States small plantings are prospering in southern Florida, and exploratory plots have been established in southern California and Arizona.

Description

Neem trees are attractive broad-leaved evergreens that can grow up to 30 m tall and 2.5 m in girth. Their spreading branches form rounded crowns as much as 20 m across. They remain in leaf except during extreme drought, when the leaves may fall off. The short, usually straight trunk has a moderately thick, strongly furrowed bark. The roots penetrate the soil deeply, at least where the site permits, and, particularly when injured, they produce suckers. This suckering tends to be especially prolix in dry localities. Neem can take considerable abuse. For example, it easily withstands pollarding (repeated lopping at heights above about 1.5 m) and its topped trunk resprouts vigorously. It can also freely coppices after repeated lopping at near-ground level. Regrowth from both pollarding and coppicing can be exceptionally fast because it is being served by a root system large enough to feed a full-grown tree. The small, white, bisexual flowers are borne in axillary clusters. They have a honey like scent and attract many bees. Neem honey is popular, and reportedly contains no trace of azadirachtin. Previous botanic names were Melia indica and M. azadirachta.The latter name (not to mention neem itself) has sometimes been confused with M. azedarach, a West Asian tree commonly known as Persian lilac, bakain, dharak, or chinaberry. The taxonomy of all these closely related species is so complex that some botanists have recognized as many as 15 species The fruit is a smooth, ellipsoidal drupe, up to almost 2 cm long. When ripe,it is yellow or greenish yellow and comprises a sweet pulp enclosing a seed. The seed is composed of a shell and a kernel (sometimes two or three kernels), each about half of the seed's weight. It is the kernel that is used most in pest control. (The leaves also contain pesticidal ingredients, but as a rule they are much less effective than those of the seed.) A neem tree normally begins bearing fruit after 3-5 years, becomes fully productive in 10 years, and from then on can produce up to 50 kg of fruits annually. It may live for more than two centuries. Neem is a large-sized evergreen tree, but younger trees in dry localities may become leafless for a short period, and new leaves may appear in March-April, which are pinkish green in color. The tree may grow up to a height of 20m and a girth of 2.5m.

a) Stem

The color of the bark varies according to the part of the plant, its age and locality. The younger branches have a lighter color bark but in a mature trunk it may be grey to greyish black,

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rough, feebly fissured, and exfoliating. The inner surface of the bark is fibrous and pinkish brown. Small deposits of gum may be present on the stem in some places, but occasionally in some trees, which are quite old and in a humid climate, a fetid sap may be exuded from the trunk.

b) Root

It is normally dicotyledonous in nature, but in more than half of the population, vesicular—arbuscular mycorrhizal (VAM) infection is present due to *Glomus* and *Cigaspora* at 250 cm length. The intensity of infection varies with the availability of water. Neem appears to be a highly mycorrhizal-dependent species. It was concluded that a deep-rooted growth habit along with VAM infection may be a survival mechanism when competing for nutrients and water with shallow-rooted and fast-growing plant species. It appears that VAM not only increases the nutrient uptake of the plant but also makes the tree tolerant to root diseases, transplant shock, toxicity of heavy metals and seasonal extremities like drought, etc. It has also been said that *Phytophathora tinnamoni* which is destroying neem worldwide, may be attacking those trees that lack mycorrhiza, as VAM forms a cover on the root and thus protects the plant from pathogens.

c) Leaves

These are alternate, exstipulate, on a long slender petiole, dorsal side darker green, ventral light in color, leaves 20–40 cm long, dense at the end of branches, alternate, leaflets 7–15, sometimes up to 17, variable in shape, particularly with respect to the central axis. The leaves appear smooth but closer examination of young leaves near the shoot apex reveals the presence of resin-secreting glands. The lower portion of the leaf stalk is covered over with extra floral nectaries. Leaves are bitter to the taste. It was observed that the flattening of twigs and crowding of leaves with prominent ridges and furrows with a disturbed phyllotaxy. The leaflets are 2–7 cm long and 1–4cm broad, imparipinnate, lanceolate, upper side bigger than the lower but it may vary within a population, often alternate, obliquely falcate, coarsely and bluntly serrate. The breadth of lamina and the degree of dentation on the margin of leaflets vary from locality to locality. In general, leaflets from dry arid areas have narrow lamina and sharp teeth along the sides.

d) Flowering

Generally, the tree starts flowering at three to five years of age and becomes fully productive at the age of about ten years. The reproductive phase lasted 3–4 months. In general, the beginning of flowering was marked by the simultaneous appearance of a new flush of leaves and the inflorescence primordia during February/ March. Blooming became evident in the

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Published **25.06.2023**

second week of March and the peak-time of blooming was in the third/ fourth week of April. Fruiting started 2 weeks after the commencement of blooming. Flowering culminated at the end of May in all populations. Fruits became mature by the third week of June. By the last week of July, all fruits had dropped under the canopy and seeds germinated *en masse* during rains in July/August. Trees growing in areas with a warm winter bloom first, followed by areas where the winter is comparatively cooler. Depending on the locality, flowering may range from January to May. Sporadic flowering in September-October has been observed quite often, in addition to that in February-March. An abnormal seedling was reported during December from these trees and suggested that these trees may be used as germ plasm. In the Murshidabad area of West Bengal (India), the tree flowered throughout the year.

e) Inflorescence

The inflorescence is an axillary or a terminal panicle 16.6 + 2 cm in length (n = 100). Each flowering branch had 12 + 5 (range = 8–18) panicles and a panicle produced 91 +21 bisexual flowers that opened acropetally. Anthesis occurred between 16.00 and 07.00 hours and open flowers were retained for 3–4 days. During the peak-time of flowering, a panicle presented 10 +7 (range = 3–21) open flowers in a day.

f) The Flower:

The buds are small, hermaphrodite, numerous, stalked, arranged in long, slender, very lax elongated axillary panicles, shorter than the leaves, bracts minute, deciduous. Flower buds open in the evening and are more scented at night. These buds give rise to 4–5 mm long whitish pink flowers.

- *Calyx:* Sepals 3 to 5 wide, imbricate, rounded, blunt, ciliate, sepals smooth and thin.
- *Corolla:* Petals 5, imbricate and oblong, oval in the bud, spreading, spathulate, somewhat twisted with a conduplicate claw, smooth outside, finely pubescent within. The number of petals may be 4–8, which is not genetically based.
- *Androecium:* stamens 10, situated at the base of a hypogymous disk, the stamina filament combined into a long, cylindrical, erect tube, somewhat dilated below as well as at the top, furrowed and smooth externally, hairy within, terminating above in 10 blunt, thick, recurved trifid lobes, anther smooth erect, closely placed, introse, oblong, two celled. The pollen grains are 3–4 corporate, prolate-spheroidal or sub-prolate, apocolpium medium, exine smooth, slightly thickened at the aperture.
- The pollen grains are tetra-colporate, shed at the two-cell stage and have suborbiculate to smooth exine. On average, the pollen grains measured 43.7 + 2.4 mm (n = 100) in diameter and contained

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Published **25.06.2023**

starch grains as reserve material. The viability of freshly released pollen grains was 71.4 +1.6% (*n* = 400 flowers) and pollen became completely non-viable 10–11 days after anthesis. A flower produced 3763 + 374 pollen grains (*n* = 100 flowers) and invariably six ovules in an ovary; the pollen:ovule ratio was ~ 627 (520–813; *n* = 100 flowers).

- *Gynoedum:* carpels, 3–5, syncarpous, superior, as many locule with 2 ovules in each loculus, style about the length of the staminal tube, stigma 5 lobed, placentation parietal. The ovary is trilocular at the base, becoming unilocular at the ovule-bearing region. The pollen tube is monosiphonous, and enters the ovule through a micropyle. One of the synergids is destroyed. Syngamy precedes triple fusion, resulting in an enlarged zygote. Twin embryos occur commonly; the number of seed per embryo may be 1–3. The gametophyte develops in the usual way; the embryo sac is of Polygonum type. Study of premature fallen fruits indicated that embryo abortion is common.
- The stigma belongs to the dry-papillate category. Each stigma has an apical, papillate, non-receptive and a trilobed crown supported over a distinctly papillate rim of receptive zone. Receptivity is attained 12 h after anthesis and is retained for up to 2 days after anthesis. A receptive stigma supported significant pollen germination and increased peroxidase activity. The papillae of the crown are round-tipped and measure 60 + 10.8 mm.
- Pollen grains do not adhere to the non-receptive papillae and usually fall onto the receptive papillae underneath. The papillae in the receptive zone were 78.4 + 20.8 mm (*n* = 100) long, densely crowded, unicellular, unbranched, and pointed at the tip.
- Lipids are present in the peripheral region of the receptive papillae. The style is hollow-type and lined with glandular stylar canal cells and forms a continuum between the stigma and the ovary. The canal cells at the stigma-style interface are papillate and glandular.
- *Pollination:* The flowers are cross-pollinated in general, in spite of bisexual flowers and the absence of self-incompatibility. Pollination is occasionally entomophilous but usually anemophilous. Freshly opened flowers of Neem are white and sweet scented. Nectar is secreted in traces during anthesis and is usually seen glistening at the base of flowers between 06.30 and 18.00 hours. Foraging activity started from 05.30 to 06.30 hours. During the entire foraging period in a day (06.30 to 10.30 hours), 287 + 46 insects visited a flowering branch (*n* = 50). The peak time of visitation was between 07.30 and 08.30 hours and 08.30 and 09.30 hours, during which 95+12 insects were recorded. A total of 13 insect species (seven Hymenoptera, three Lepidoptera and one species each from Diptera and Thysanoptera) were identified as regularly foraging on the flowers. The most dominant Hymenoptera was *Apis*. Honeybees carried out

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occasional pollination between 16.30 and 18.00 hours, but the frequency was lower than that in the morning (6 +3 honeybees observed per hour in the evening). Butterflies (*Danaus chrysippus, Junonia almanac*) made a few visits (3 + 2 per hour) to the flowers. Thrips were mostly confined to the staminal tube and carried 4 + 1 (n = 20) pollen grains on their body. Honeybees (*Apis indica, Apis mellifera, Apis dorsata*) were the most effective floral foragers. Experiments (n = 300) conducted to ascertain the role of wind in pollination showed 1.8 +0.5% fruit set. The density of airborne pollen grains in the canopy was 14+2 cm^{-2} and it declined completely 8 m away from the canopy.

- *Seed Development:* A study of seed development has shown a steady increase in fruit/seed length, breadth, fresh and dry weight up to 12 weeks. The moisture content after this period started declining, with an increase in seed oil, protein and carbohydrates. The ovary is syncarpous, superior, and three-celled with 1–2 ovules per cell. The fruit is a glabrous, olive-like drupe, 1–3 cm in diameter, varying in shape from elongate oval to roundish. It is yellow when ripe and comprises a sweet pulp enclosing a single seed (rarely 2–3 seeds). Neem has a strong root system with a deep tap root and extensive lateral roots. Suckers can be produced following damage to the roots.
- *Fruit:* It is an ovoid drupe, bluntly pointed, 1–2cm long, when young and unripe smooth and green with white milky juice, yellow to brown when ripe, epicarp thin, mescocarp with scanty mucilaginous sweetish pulp, endocarp hard enclosing the seed. The fruit gets darker in color and wrinkled on maturity. The seed length varied between 11 and 18mm, width 4.5–8.5mm, and weight 100–530 mg. Among a three-year-old population it was observed that 92.3 percent of the trees had 1–100 fruits/tree, 4.36 percent 101–200 fruits/tree and 0.49 percent (one only) had more than 400 seeds/tree.
- *Seed Dispersal:* Most of the seed fall on the ground under the tree, where at that time the soil is water logged or there may be rain streams. The fruit may remain in moist conditions under the tree or occasionally may travel some distance with rain water. Since there is no dormancy, most of the seed may germinate immediately, but perish because of lack of conditions for further seedling growth. Occasionally, some fruits are swallowed by birds for their sweet pulp and the seeds are passed out of the body, undigested, because of the hard endocarp. The seeds so dropped are far away from the trees; if they germinate, the seedlings have much better chances of surviving and producing plants, as compared to undispersed seed.
- *Seedling Morphology:* Germination is epigeal. The fresh mature seed, if in humid conditions, may start germinating within a day or so, but fully dry seed may germinate from the 7th day of

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sowing and complete it in 25 days. Cotyledons are plano-convex, sub-opposite, lowest one sessile, blade obovate-oblong, stem erect. A few seedlings have an alternate cotyledon; in these, the lower cotyledon has a unilacunar two-trace node and the other a trilacunar three-trace node. In those cases where cotyledons are opposite, both cotyledons have a unilacunar two-trace or trilacunar three-trace condition. During the further course of development, the cotyledon along with the endocarp is pushed above the soil because of the elongation of the hypocotyl in the lower region. The plumule emerging from the cotyledon dislodges the endocarp. The top of the seedling at this stage is green, glabrous or with minute odorless glands. These glands are common in younger leaflets but become fewer in number as the leaf matures. The phenomenon of twin seedlings has also been observed, which may be as high as 11.27 percent. This may be due to the development of one or more than one ovules, out of five of the ovaries (penta-carpellary), giving rise to more than one seed under the same endocarp, but it may be also due to polyembryony, with a frequency of 1 out of 800.

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