Azadirachta indica A. Juss. Neem, margosa

Meliaceae Mahogany family

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Azadirachta indica A. Juss., commonly known as neem in English and Hindi and margosa and paraíso de India in Spanish, is a medium-sized to large tree characterized by its short, straight bole, furrowed, dark-brown to gray bark, and dense, rounded crown of pinnate leaves (fig. 1). Native to south Asia, neem is widely planted and naturalized in semi-arid areas throughout Asia and Africa. It has been introduced to several Caribbean islands where it is grown principally for shade, fuelwood, and numerous nonwood products obtained from the leaves, fruits, and bark. These include medicinal and insecticidal agents. Except in frost-prone and dry regions, neem is evergreen.

HABITAT

Native and Introduced Ranges

Although its precise native range is not known, neem is thought to be indigenous to south Asia where it grows in natural forests in the drier regions of southern India and Myanmar (formerly Burma) (*28*) (fig. 2). For many centuries, perhaps millenia, neem has been cultivated in India, Pakistan, Sri Lanka, Bangladesh, Myanmar, Thailand, southern Malaysia, and the drier Indonesian islands from Java eastward. It has become naturalized in various localities throughout that region (*3, 10, 28, 82*). During the 19th century, neem was introduced to Fiji and Mauritius where it has since become naturalized. Neem has also spread to other islands in the South Pacific (*3*).

Neem was introduced into west Africa at the beginning of this century and, more recently, to other tropical and subtropical regions in the Middle East, Central and South America, the Caribbean, and southern Florida (*2, 54, 74*). In the Caribbean region, neem has become naturalized following its introduction as an ornamental and shade tree in Haiti, the British Virgin Islands, Antigua, Trinidad, and Surinam (*3, 47, 48*). Small-scale plantations have been established in the Dominican Republic, Cuba (*11*), southern Florida, Arizona, and on the Baja California peninsula (*54*). More extensive plantings have been established during the past 10 years in northern Australia where neem is being evaluated as a species for reforestation of bauxite strip mines.[1]

[1]Wood, Tim. 1993. Personal communication. On file with: Agridyne Technologies, Inc., 417 Wakara Way, Salt Lake City, UT 84108.

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Climate

Throughout neem's native and introduced ranges, the mean annual temperature ranges from 21 to 32 °C (*7*). In India, it grows in regions with absolute minimum and maximum shade temperatures of 0 and 49 °C, respectively (*78*). The normal rainfall within this range varies between 450 and 1150 mm per year (*78*), although neem sometimes grows on sites receiving as little as 250 mm of annual rainfall. In India, neem is used in afforestation programs in arid and semiarid regions of Andhra Pradesh, Bihar, Gujarat, Maharashtra, Rajasthan, and Uttar Pradesh. In the Sahelian zone of Africa, it is one of the best species for planting on sites receiving less than 600 mm of annual rainfall with a dry season of 5 to 7 months duration (*7*).

Figure 1.—*A neem* (Azadirachta indica *A. Juss.) tree growing in India.*

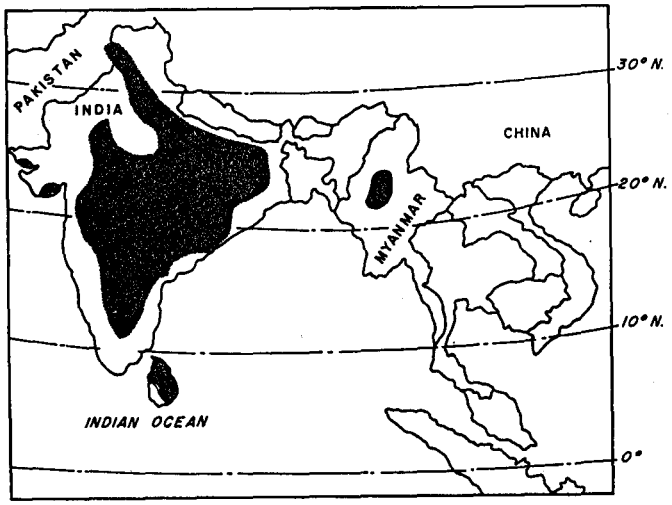

Figure 2. – *The approximate native and naturalized range of neem* (Azadirachta indica *A. Juss.) in south Asia, shown by the shaded area.*

Soils and Topography

In India, neem grows in the lowland plains and in montane areas that reach an elevation of approximately 1,850 m. In its introduced range, neem is cultivated from sea level to a 1,500-m elevation (*7, 54*).

Neem is tolerant of most soil types including dry, stony, shallow soils, lateritic crusts, Vertisols, highly leached sands, and clays (*78*). It is well adapted to soils with pH values ranging from 5.0 to 8.5, but grows best on deep, porous, well-drained soils with a pH of 6.0 to 6.5 (*7, 31*). It is moderately tolerant of highly alkaline soils with high levels of sodium, carbonates, and bicarbonates (*29*) and has been successfully established on steep, highly eroded sites (*15, 30*) as well as on degraded soils with calcareous hardpans close to the surface (*15*). Neem's growth is poor on seasonally waterlogged sites, silty sands, silty alluvial flats, and poorly drained clays (*78*) as well as dry sands where the dry season water table is below 18 m in depth (*7*). On soils deficient in zinc or potassium, growth of neem trees is poor (*54*). The growth rate of neem appears to be closely related to soil-moisture availability. Growth is best on freely drained sites where the water table fluctuates between an approximate depth of 3 to 5 m throughout the year.

Neem is a useful species for improving soil fertility on degraded dry sites due to the quality of its leaf litter and relatively rapid rate of leaf decomposition (*58*). On fallow, sandy loam Ferric Acrisols in Togo, topsoil pH and calcium concentrations under 5-year-old neem stands increased at a more rapid rate than those in adjacent stands of *Acacia auriculiformis* A. Cunn. ex Benth. and *Albizia lebbek* (L.) Benth. (*25*). Increases in soil pH from 5.0 to 7.0 under neem stands have been observed elsewhere in Africa (*7, 58*).

Associated Forest Cover

In India, neem is found in a variety of dry evergreen, deciduous, and thorn forest types (*14*). In northern dry evergreen forests, it is commonly associated with *Albizia amara* Boivin, *A. lebbek, Manilkara hexandra* (Roxb.) Dub., *Sapindus emarginata* Vahl., and *Tamarindus indica* L. In northern desert thorn forests, it grows in association with *Acacia leucophloea* Willd., *A. senegal* Willd., *Balanites aegyptiaca* (L.) Del., *Flacourtia indica* (Burm.f.) Merr., *Holoptelea integrifolia* Planch., and *Prosopis cineraria* (L.) Druce. In very dry teak forests, its associates include *Anogeissus latifolia* Wall., *Boswellia serrata* Roxb., *Lannea coromandelica (Houtt.)* Merr., *Sterculia urens* Roxb., and *Tectona grandis* L.f. In southern tropical dry mixed deciduous forests, neem grows with *Acacia catechu* Willd., *A. latifolia, A. leucophloea, Bauhinia* spp., *Boswellia serrata,* and *Terminalia tomentosa* W. & A., as well as in successional forests dominated by *Acacia* spp. and *Anogeissus pendula* Edgw. Neem is also found in southern tropical thorn forests with *Acacia catechu, A. chundra* Willd., *A. ferruginea* DC., *A. latronum* Willd., *A. leucophloea, A. nilotica* (L.) Del. ssp. *indica* (Benth.) Bren., *Albizia amara,* and *Chloroxylon swietenia* DC.

LIFE HISTORY

Reproduction and Early Growth

Flowering and Fruiting. – Neem flowers are borne in narrow, branched clusters (panicles) 5 to 15 cm long (fig. 3). Individual flowers are composed of 5 light-green, rounded calyx lobes; 5 white, oblong, rounded petals 0.5 cm long; 10 stamens united in a tube; and a pistil with a rounded ovary and slender style. In its native range and in the Caribbean, neem flowers between March and May (*12, 48*). In the Sudan-Sahelian zone of Africa, flowering generally occurs between April and July (*7*).

The olive-shaped fruits (drupes) are 1.0 to 2.0 cm long, smooth, and greenish yellow to yellow when mature. Neem fruits ripen from June to August in India and between September and December in the Sudan-Sahelian zone of Africa (*7, 12, 78*). Fruits usually contain a single elliptic seed, occasionally two, surrounded by a sweet pulp, which has a strong garliclike odor. Fruit production usually begins when trees are 3 to 5 years old and is profuse when trees become fully productive at approximately age 10 (*3, 54, 74*).

Seed Production and Dissemination. – There are normally between 4,000 to 5,000 seeds per kilogram found in neem fruits, although published data on seed weights range from 900 to 6,300 seeds per kilogram (*7, 15*). Seeds are dispersed by birds.

The fruits should be collected from branches when fully ripe or from the ground within 1 to 2 days after fruit fall. The fruits are then spread on mats under light shade and air-dried for 4 to 5 days (*72*). After drying, they may be stored at ambient temperature in cloth sacks before sowing.

Seedling Development. – Germination in neem is epigeous (*7*). Neem seeds do not require scarification, although depulping and cleaning seeds before sowing greatly improves germination (*46*). Germination is commonly between 60 and 85 percent for cleaned seeds sown within a week of collection (*7, 11, 46*). Seeds do not retain their viability for more than 2 months and should be sown within 2 weeks of collection. The rapid loss of viability after 2 weeks is accompanied by, or possibly due to, fermentation of the cotyledons, which causes a change in their color from green to brown (*72*).

Germination begins from 4 to 10 days after sowing and is usually complete within 3 to 5 weeks (*11, 46*). Seeds may be sown either in seedling containers or in open beds at a spacing of 2.5 cm in lines 15 cm apart. The seeds should be lightly covered with soil and watered sparingly. Nursery soils should be loose and freely drained. Shade is not necessary but may be useful under extremely hot conditions (*7*). Seedlings grown in open beds should be thinned to a 15- by 15-cm spacing when they are approximately 2 months old.

Seedling growth in the nursery is moderate and is greatly hindered by competition. Seedlings develop a moderately long, terete primary root with a moderate number of lateral roots distributed along its length. Under good conditions, seedlings usually reach plantable size (10 cm in height) in 2 to 3 months (*11*) and attain heights of 0.6 to 1.5 m in 12 months (*78*). In northern India, where the growing season is restricted to 7 or 8 months, nursery-grown seedlings attain heights of 10 to 20 cm after 1 year, 50 to 100 cm after 2 years, and 150 to 210 cm after 3 years (*78*).

Plantations can be established at the beginning of the rainy season by direct sowing, by planting container-grown seedlings, or by using stump plants (*78*). In India, direct sowing has been found to be the most economical and successful method provided that seeds are sown as soon as possible after collection. Depending on local conditions, good results have been obtained through direct sowing by dibbling in bushes, broadcast sowing, and sowing in lines, mounds, or ridges (*78*). Seedlings raised in the nursery can be planted when they reach 7 to 10 cm in height and have a taproot that is usually about 15 cm long (*78*). For bare-root plantings, stem and root pruning is recommended. On very dry sites, larger seedlings of at least 45 cm in height are often preferred. Stumps from 1- to 2-year-old seedlings prepared by cutting back the stem to 2.5 cm and the taproot to 25 cm are commonly planted in India.

Natural regeneration of neem is very good except on heavily grazed sites and under conditions of severe competition from grasses. Under natural conditions, the seeds are usually dispersed during the rainy season and germinate within 2 weeks. Neem establishes itself well under thorny scrub vegetation (*17*) and on poor, dry soils.

Vegetative Reproduction. – Neem coppices freely when felled. In Tamil Nadu (India), it was found that high cutting combined with trimming of shoots resulted in lower mortality of stools (3.8 percent) than low cutting (9 percent). Pollarding offers the additional advantage of protection from grazing by livestock and is commonly practiced in west Africa (*7*). Injured roots around felled trees often produce root suckers, especially in dry localities (*15*). Neem may be propagated vegetatively using branch cuttings with best results obtained when cuttings are treated with indolebutyric acid (IBA) (*7*).

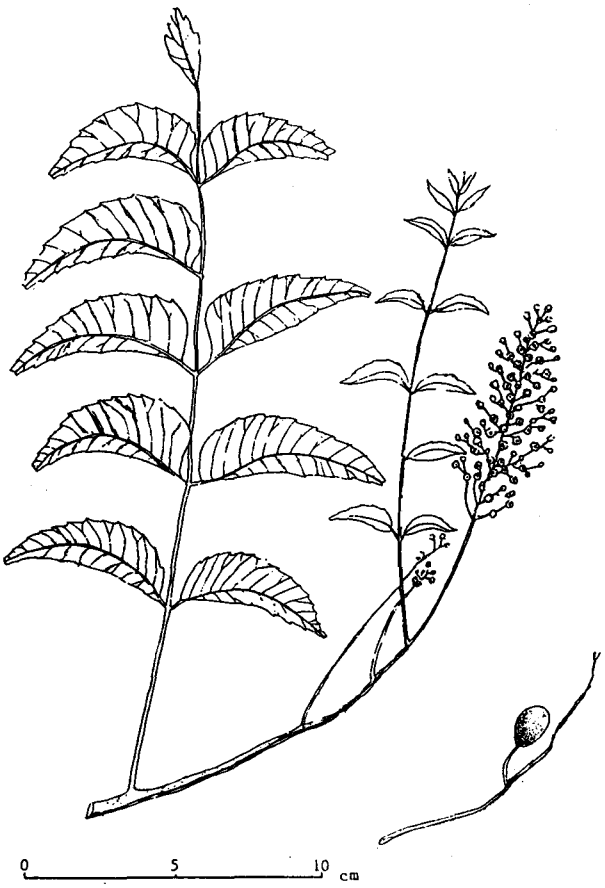

Figure 3. – *Foliage and fruit of neem* (Azadirachta indica *A. Juss.*) *(48).*

Sapling and Pole Stage to Maturity

Growth and Yield. – Growth rates of neem vary considerably depending on site quality and location. In general, average diameter at breast height (d.b.h.) increments of between 0.7 and 1.0 cm per year are typical across a broad range of site conditions in India (*62, 78*). On favorable sites, growth is fairly rapid after the first year. In two 8-year-old plantations established at an initial spacing of 2.5 by 2.5 m on relatively fertile clays in Cuba, mean annual d.b.h. and height increments were between 2.4 and 3.4 cm and 1.8 and 1.9 m, respectively (*11*). Similar height growth increments have been reported for amenity plantings in Haiti (*47*).

In west Africa on good sites receiving approximately 800 mm of annual rainfall, average heights and total fuelwood yields in 4-year-old neem plantations of 3 to 5 m and 10 to 12 m^3/ha, respectively, have been reported (*7*). Yields of less than 2 m^3/ha/yr were reported in fuelwood plantations established at a 4- by 4-m spacing on a site receiving between 600 and 1200 mm of annual rainfall near Ouagadougou, Burkina Faso (*68*). Across a range of site conditions in northern Nigeria, total fuelwood yields of 2 to 18 m^3/ha were obtained in 8-year-old plantations (*7*).

On poor sites in India with saline-alkaline soils and a shallow calcareous hardpan, growth rates are slower. Under such conditions, mean tree height, basal area, and total aboveground biomass in block plantations were 2.7 m, 1.9 m^2/ha, and 1.7 t/ha at 4 years, and 3.1 m, 4.8 m^2/ha, and 6.2 t/ha at 8 years, respectively (*16*). Under these conditions, trees can be expected to attain heights of 6 to 12 m with d.b.h.'s of 20 to 26 cm at age 20. On saline soils in northern India, mean tree height and d.b.h. of 9.0 m and 25.5 cm, respectively, were reported for a 24-year-old plantation (*69*).

Little data exist on growth rates of neem in older stands. In one poorly managed 44-year-old plantation in Uttar Pradesh (India), average tree height and d.b.h. were 10.7 m and 26 cm, respectively (*78*). In areas of India where neem has been harvested for timber, a rotation length of 40 to 50 years and a mean d.b.h. of 32 cm at harvest are expected. In one 30-year-old plantation in Cameroon with a stand density of 287 trees per hectare, the mean stem diameter and basal area were 33 cm and 25 m^2/ha, respectively (*7*).

Adult trees attain heights of 7 to 30 m and stem diameters of 30 to 80 cm (*3, 7*). Mature trees usually produce 30 to 50 kg of fruit annually and may live for 200 years or more (*3*).

Rooting Habit.—Established neem trees form deep taproots and an extensive lateral root system. Such trees are strong competitors for available soil moisture. A study of rooting patterns and root biomass distribution in 6-year-old trees at a semiarid site in northern India found that for trees with an average d.b.h. of 9.5 cm and an average crown spread of 4.2 m, the mean taproot length and lateral root spread were 1.2 m and 1.5 m, respectively (*77*). In this study, roots comprised 9.9 percent of the total tree biomass. Approximately 80 percent of the total root biomass was found in the upper 30 cm of the soil profile. In comparison with 11 other species planted at the site (including *Acacia* spp., *Albizia lebbek, Dalbergia sissoo* Roxb., *Eucalyptus tereticornis* Sm., *Populus deltoides* W. Bartram ex Marshall, and *Prosopis cineraria*), the root-spread to crown-spread ratio was much lower for neem (0.36) than for 10 of the other species (0.39 to 1.26).

The fine roots are often associated with mycorrhizal fungi. In Senegal, associations with vehiscular-arbuscular (VA) mycorrhizae of the genera *Glomus* and *Gigaspora* have been described (*23*).

Reaction to Competition.—Neem is a light-demanding species, but it tolerates moderate shade during the early stages of growth. It is intolerant of grass competition during the seedling and sapling stages, requiring weeding to ensure its survival, particularly in dry areas (*7, 78*). In thorny scrub formations in India, seedlings have a good capacity for pushing their way through the canopy (*17*). Neem is more often cultivated in linear plantings along roadsides and field borders rather than in block plantations due to its strong, light-demanding character (*7*). In India, plantation monocultures of neem are rare. It is mostly raised in mixed-species plantations and managed under the selection method.

In India, neem is planted using the taungya method in lines 3.0 to 5.5 m apart with *Acacia nilotica*. It is intercropped with a variety of field crops, usually cotton, sesame, and pigeon pea, for up to 4 or 5 years (*78*).

In west Africa where neem is widely used in fuelwood plantations, trees are commonly planted at an initial spacing of 2.4 by 2.4 m and managed on an 8-year rotation (*54*).

Damaging Agents.—Neem appears to be relatively resistant to damage by insect pests and pathogens. In northwestern India, it was one of the few tree species largely unaffected by the severe migratory locust invasions of 1926–27 and 1962 (*3, 37*). In central and south India, two scale insects, *Palvinaria maxima* (neem scale) and *Aspidiotus orientalis* (Homoptera: Cossidae) and the larvae of *Helopeltis theivora* (Lepidoptera: Cossidae) cause severe damage to young trees (*54, 76*). Serious defoliation in neem plantations in India by *Ascostis selenaria imparata* (Lepidoptera: Geometridae) has also been reported (*9*). Other defoliating insects known to cause minor damage include: fire ants, *Solenopsis* spp. (*60*); *Latoia lepida* (Cram) (*59*); an eriophyid mite, *Calipitrimerus azadirachtae* (*79*); *Cryptocephalus ovulum* (Coleoptera: Chrysomelidae) (*79*); *Orthacris simulans* (Orthoptera: Acrididae) (*79*); and the lepidopterans *Laspeyresia aurantiana* (Eucosmidae) and *Cleora cornaria* (Geometridae) (*9, 79*). The red borer, *Zeuzera coffeae,* and the nymphs of *Helopeltis antonii* (Lepidoptera: Cossidae), occasionally damage the woody stems of saplings in India (*9*).

Heavy infestations of the yellow scale or cochineal, *Aonidiella orientalis* (Homoptera: Diaspididae), which attacks the leaves and young stems, have been reported during the past 20 years in Sudan, Chad, Cameroon, and Niger (*19, 54*). In Nigeria and elsewhere in west Africa, occasional infestations by termites, particularly *Apate monachus, Macrotermes bellisous, Microtermes* spp., and *Gryllotalpa* sp., and plant parasitism by *Lorantius* spp., have been observed (*7, 58*). Leaf-cutting ants, *Acromyrmex* spp., are known to defoliate neem trees in Central and South America (*54*).

Several fungal pathogens causing root rot, white sap rot, heartrot, white spongy rot, and leaf spot (caused by *Glomerella cingulata*), have been reported (*54, 63, 76*). A bacterium, *Pseudomonas azedarachtae,* has been reported to cause leaf spot and blight disease in India. In Niger and elsewhere in the Sahel, widespread dieback and mortality of neem have occurred in recent years. While previously thought to be caused by biotic agents such as fungi, viruses, or bacteria, neem decline in the Sahel is now believed to be due primarily to site-related stresses such as low soil moisture, competition, intercropping, and soil compaction (*19*).

In many parts of neem's native and introduced ranges, particularly in India and the Sudan-Sahelian zone of Africa, trees suffer considerable damage through grazing by wild and domesticated animals and lopping of branches by humans. In both regions, the leaves are used as fodder for camels and goats and the young twigs, for toothbrushes.

Neem is very sensitive to frost, especially at the seedling and sapling stages. Although it can withstand extended periods of drought, it is highly susceptible to fire damage (*50*). Neem is windfirm, and its branches are seldom broken except during severe storms.

SPECIAL USES

Neem sapwood is grayish white, and the heartwood is mottled and pinkish red when first exposed. It fades to reddish brown and resembles mahogany on drying (*28, 78*). The wood is scented, moderately hard and heavy, and medium- to coarse-textured with narrowly interlocked grain. Annual growth rings are distinct, numbering 2.0 to 2.4 per cm of radius (*28*). The specific gravity of neem wood is approximately 0.68 g/cm^3, or between 0.74 and 0.81 g/cm^3 for air-dried wood (*28*). It has a crushing strength of 420 kg/cm^2 and a coefficient of elasticity of 70 t/cm^2 (*28*). It is hard, has good nail-holding properties, and is not difficult to saw, resembling teak in this respect. It is easy to work by hand or machine but does not take a good polish. The timber seasons well, is durable even under open conditions, and is resistent to attack by termites and other insects. Neem wood is used for general construction, paneling, furniture, carts and agricultural implements, boat building, carvings, and drums. It is com-

monly used in India for the backing of cupboards and bottoms of drawers to repel moths. A popular species for shade and ornamental plantings in the drier parts of India, neem is used particularly along roads in cities and villages. In Asia and Africa, neem has been planted extensively for reforestation of degraded lands and for fuelwood production (*7, 54*). As a fuelwood, it has a relatively high calorific value of 6.94 kcal/g (*15*).

Neem is one of the best known and most valued trees in south Asia where it is held sacred by Hindus due to its disease-preventing properties. In many Indian communities, neem traditionally has an important place in social, cultural, and religious events (*3*). Neem is an important source of traditional medicinal preparations within the Ayurvedic, Unani, Tibbi, and numerous tribal medicinal systems (*10, 20, 34*). Various parts of the tree reportedly have analgesic, anthelmintic, antiperiodic, antipyretic, antiseptic, antisyphilitic, astringent, demulcent, diuretic, emmenagogic, emollient, and purgative actions. Medicinal preparations made with neem components have been used to treat boils, eczema, eye diseases, headaches, hepatitis, leprosy, malaria, rheumatism, scrofula, and ulcers (*18, 20, 41, 54*). Neem extracts have been shown to possess antibacterial, antidiabetic, antifungal, and antiviral properties (*49, 54*).

The deep yellow, acrid oil extracted from neem seeds (approximately 20 to 40 percent by weight), commercially known as margosa oil and sometimes used as an inferior-quality lamp oil, is used in traditional Indian medicine for its antiseptic and anthelmintic properties and as an external application in the treatment of rheumatism. Recent studies have shown that neem oil acts as a powerful spermacide, which may have important implications for the development of inexpensive contraceptives (*54*). Neem oil contains myristic and lauric acids and is a useful raw material for the manufacture of cosmetics, lubricants, waxes, and other products (*54, 58*). In south Asia, it is currently utilized on a commercial scale in the manufacture of soaps, toothpastes, and other products (*10, 21*). Approximately 60 percent of neem oil produced in India is used for soap manufacture (*3*). The seeds are used to prepare insecticides and shampoos. An amber-colored gum obtained from the wounded bark is valued as a stimulant and tonic. The bitter root and stem bark, as well as the young fruits and flowers, are also attributed with having tonic properties and are used to cure intermittent fever (*10, 44*). The leaves are used to keep insects away from books and clothes, for the preparation of an antiseptic lotion, and to make poultices for wounds and a variety of skin ailments (*10*).

In northern India, the sap obtained following incision of the trunk base is used as a stomach tonic and cooling drink (*10*). Throughout southern Asia, the bitter-tasting leaves are cooked and eaten with other vegetables, or dried and eaten raw. The pulp of the fruit is occasionally eaten, and the twigs are very commonly used to clean teeth in south Asia and Africa (*7, 10*). Fresh leaves are commonly used as fodder for cattle throughout neem's native and introduced ranges. The bark is rich in tannins and is used for tanning in south Asia and Africa (*7*).

The leaves, as well as the seed cake remaining after the oil has been pressed from the seeds, are used as mulches for agricultural crops (*10, 74*). Neem seed cake is rich in nitrogen and other nutrients (*15, 58*), and when used as a soil amendment along with inorganic fertilizers, has been shown to inhibit nitrification processes and thus facilitate a gradual, more efficient release and use of inorganic nitrogen by agricultural crops (*7, 41, 58*).

In recent years, neem has been the subject of increased study as a source of natural pesticides (*33, 54, 66*). The leaves, fruits, seeds, and bark yield azadirachtin, salanin, meliantriol, and several related triterpenoids, or liminoids, of proven pesticidal value against a broad range of insect pests and nematodes affecting vegetable, grain, and citrus crops (*3, 18, 41, 53, 54, 65, 66, 67, 80*). Neem's insecticidal properties vary among provenances, depending on tree age and local climatic conditions (*7*). A systemic pesticide, azadirachtin, is found in particularly high concentrations in neem seeds (0.15 to 0.27 percent).[1] Although these substances are generally considered to be harmless to non-target organisms such as earthworms, spiders, bees, ladybugs, and mammals, including humans (*54, 66*), several studies have indicated that seed extracts may be toxic to rats and other rodents (*3, 57*).

Numerous laboratory and field trials using leaf extracts, seed kernel extracts, and powdered seeds applied to crops as a foliar spray or powder, have demonstrated the efficacy of neem's natural pesticides as insect-repellent and feeding deterrent agents (*13, 24, 32, 36, 38, 39, 40, 43, 45, 51, 54, 55, 58, 61, 64, 65, 66, 70, 73, 81*). Reduction in fecundity, ovicidal activity, larval mortality, and developmental abnormalities among a variety of coleopteran, dipteran, hemipteran, heteropteran, homopteran, hymenopteran, lepidopteran, orthopteran, and thysanopteran pests exposed to neem extracts, particularly azadirachtin, have been reported (*1, 8, 26, 27, 43, 52, 54, 65, 66, 67, 71, 73, 75, 80, 81*). Dried leaves, as well as leaf and seed extracts, are widely used in Asia and Africa as an effective means for protecting stored crops, particularly cereals, pulses, and maize, against attack by insect pests including bruchid beetles and other coleopteran and lepidopteran larvae (*3, 22, 35, 37, 56*).

The value of neem as a source of antibacterial, antifungal, antiviral, and nemacidal agents for use in agriculture merits continued study (*54*). In India, intercropping of vegetable crops with neem was found to result in significant reductions in populations of numerous species of nematodes (*4, 5, 6*). Incorporation of neem seed-oil cake into soils as an organic amendment in tomato fields resulted in significant population declines for a number of phytophagous nematodes, including *Tylenchorhynchus brassicae, Hopolaimus indicus, Heliotylenchus erythrinae,* and the larvae of *Meliodogyne solani* (*42*). In this experiment, a reduction in the occurrence of infection by certain fungi (*Rhizoctonia solani* and *Fusarium oxysporum* f. *lycopersici*) was also noted.

GENETICS

Within neem's native Asian range, there is considerable variation among populations with respect to growth rates, environmental requirements, and phytochemistry. The extensive plantations established throughout west Africa are derived from only a few provenances obtained from India, Burma (now Myanmar), and Sri Lanka between 1915 and 1928 (*7*).

Botanical synonyms of *Azadirachta indica* include *Melia azadirachta* L. and *M. indica* Brand. (*48*). The species is often confused with *M. azedarach* L., although the leaves, flowers, and seeds of the two species are easily distinguishable.

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