Department of **Agriculture and Fisheries**
Biosecurity Queensland

Neem tree

Azadirachta indica

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Contents

Summary

The neem tree is native to the seasonally dry, tropical woodlands of north-east India and perhaps parts of Asia. During the last 20 years, it has been enthusiastically promoted in Queensland and around the world as a potentially valuable new crop, mainly as a source of azadirachtin, an insecticide that can be extracted from its seeds and leaves. However, many plantations have failed and neem has escaped cultivation to become naturalised at numerous sites across northern Australia, including North Queensland.

Neem has escaped cultivation to form naturalised (wild) populations in India, Ghana, Kenya, Fiji and Puerto Rico. However, there is very limited evidence to suggest that it is a major weed overseas with only a single publication that loosely describes neem as a 'significant threat to native vegetation in Kenya'. Without detailed scientific information on the significance of its impact overseas, it is difficult to make an evidence-based prediction as to whether neem will become a major or a minor weed in Queensland.

Visual observation by experienced pest management officers in North Queensland suggests that neem is currently spreading along the sandy beds and banks of some rivers in the Gulf region of north-west Queensland. A similar scenario appears to be developing at other sites scattered across northern Australia. Since neem is estimated to produce 44 000–200 000 bird-dispersed seeds each year, its capacity for future population development could be high.

Based on an analysis of climate and habitat types favoured by neem within its native range and elsewhere, habitats most at risk of invasion in Queensland are predicted to be the sandy beds and banks of rivers and creeks across our seasonally dry tropical savannas (mainly areas where annual rainfall is 400–1200 mm, and perhaps in drier zones where groundwater is available at depths of no more than 12 m below the soil surface). Climatically, neem appears less suited to subtropical areas and is not predicted to spread in cool temperate areas. Also, it is not expected to spread on heavy clay soils or seasonally-waterlogged sites.

Identity and taxonomy

Taxa: *Azadirachta indica* A. Juss

Synonyms: *Melia azadirachta* L., *Antelaea azadirachta* (L.) Adelbert

Common names: Neem, neem tree, Indian-lilac (Canada), margosa, nimtree and margosier. In North Queensland, the common name 'neem' is erroneously applied to *Melia azedarach* ('white cedar'), a morphologically similar, but smaller, plant.

Taxonomy and related species:

Neem is a member of the Meliaceae family. The only congener is *A. excelsa*.

Description

Neem is fast-growing tree, generally 15–20 m tall (sometimes up to 40 m tall), with a crown diameter up to 20 m (Figure 1).

Neem is evergreen but can shed most of its leaves under dry conditions. The compound (pinnate) leaves are alternate, 20–40 cm long, with 20–30 dark green, serrated leaflets, each about 3–8 cm long. The terminal leaflet is often absent. Young leaves are reddish to purplish in colour.

Petioles are 70–90 mm long. The bark is deeply fissured. Flowers are cream coloured, perfumed and arranged in axillary clusters (each cluster is called an inflorescence). Each inflorescence is 15–25 cm long and comprises 150–250 individual flowers. Each flower is about 1 cm in diameter with five petals, ten stamens and one style (Figure 2).

Figure 1. Neem growing at the base of a eucalypt in North Queensland (photo: EPA Queensland).

Figure 2. Flowers of *A. indica* (photo: used with permission—Forest and Kim Starr, Plants of Hawaii. www.hear.org/starr/hiplants/images/thumbnails/html/azadirachta_indica.htm).

The ovary is syncarpous, superior, 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) (Figure 3).

Neem has a strong root system with a deep tap root and extensive lateral roots. Suckers can be produced following damage to the roots (Hearne 1975).

Figure 3. Fruit of *A. indica* (photo used with permission: William M Ciesla, Forest Health Management International, Bugwood.org).

Reproduction, seed longevity and dispersal

In North Queensland, neem flowers profusely over the winter/spring dry-season. The flowers are pollinated by bees and other insects. Male and female flowers are produced on the same tree.

Fruiting starts when plants are 2–5 years old and reaches full production at 10–15 years of age.

Seed production varies from 11 to 50 kg/year/tree, with an average of 20.5 kg/year/tree. Since each kilogram has about 4000 seeds, annual seed production per tree is estimated to be 44 000–200 000.

Fruit are consumed and presumably dispersed by birds and bats (NRC 1992; Hearne 1975) and possibly feral pigs. Great bower birds (*Chlamydera nuchalis*) have been observed feeding on the fruits in North Queensland (D Panetta 2002, pers. comm.).

The seeds of neem appear to be short-lived. Rajiv Rai (1996) discusses published work which indicates that neem seeds are viable for a period of only 8–10 days from the date of collection and comments that 'they are difficult to propagate in the nursery.' Similarly, Read and French (1993) stated that 'neem is propagated primarily through seed, which has a short viability of 3–4 weeks'.

There are often large numbers of neem seedlings regenerating under mature neem trees (NRC 1992). Neem trees can live for up to 200 years.

Nurseries propagate neem from seeds and tip-cuttings. Specimens can also be grown from root suckers (NRC 1992, Hearne 1975).

Ecology and preferred habitat

Climatic preference

Neem is adapted to subarid and subhumid areas with tropical and subtropical climates at altitudes between sea level and 700 m. Mean annual temperatures within its natural range are typically 21–32 ˚C (preferred temperature range of around 9.5–37 ˚C) (Stoney 1997). Neem can tolerate high summer temperatures (up to 50 ˚C) but does not tolerate frost or temperatures below 4 ˚C (leaf fall and death may result). Neem grows best in areas where annual rainfall is 450–1200 mm (with optimum growth where annual rainfall is around 1100 mm), but can tolerate annual rainfall as low as 150 mm if its roots can access ground water within 9–12 m of the ground surface (Stoney 1997). Once established, it is very drought tolerant and can survive 7–8 month dry seasons.

Preferred soil and vegetation types

Neem has a reputation for surviving in harsh, dry, infertile soils and can certainly survive in a range of soil types, including sandy, rocky and very dry sites. However, it is perhaps best adapted to deep, permeable, sandy soils. Its extensive, deep root system is presumably an adaptation to seasonally dry sites. Neem does not tolerate seasonally or permanently waterlogged (poorly drained) soils such as low-lying silty clays and clays, or saline soils or sites where sub-surface hard-pan or laterite outcrops occur (NRC 1992). It prefers a soil pH of 6.2–7.0, but can grow within a range of 5.0–8.0 pH (Stoney 1997). In the Gulf region of North Queensland, it appears to be displaying a preference for sandy river beds.

According to Lemmens et al. (1995), neem's natural habitat is 'seasonally dry, deciduous, mixed forest, occurring in association with *Acacia* spp. and *Dalbergia sissoo*'. Similarly, Champion et al. (1995) (CAB International 2000) noted that, in India and Pakistan, neem occurs naturally in dry deciduous and thorn forests.

Tolerance of fire

The response of mature neem trees to fire is unknown.

Origin and worldwide distribution

Since neem has been transported and used as a medicinal plant for centuries its origin is unclear. Most literature states that it is native to Asia, possibly originating in northern Myanmar and the Assam region of India (Stoney 1997). Hearn (1975) stated that neem is native to the coastal fringe forests of the drier tropical regions of India, Burma and Sri Lanka, usually on deep, sandy soils. It is currently widespread in India, Pakistan, Myanmar, Sri Lanka, Thailand, Malaysia and Indonesia.

Neem has been introduced and established throughout the tropics and subtropics, especially in drier areas in South-East Asia, the Pacific Islands, Australia, South and Central America, the Caribbean, sub-Saharan Africa, and the Middle East.

History of introduction

This study was unable to determine exactly when neem trees were first introduced into Australia. However, Friend (1999) claims that it was first planted in Australia in Darwin and Mackay some time between 1940 and 1944. Neem was reportedly planted in Darwin city streets and at Darwin Airport in the 1960s, as part of a government–RAAF initiative.

Friend (1999) stated that the first commercial attempt to grow neem was in 1965 when Comalco planted neem at two sites on their Weipa mine lease. These plantings were bulldozed in the mid-1980s after suffering low fruit set and yield. In the late 1980s, Comalco began trials to investigate growth rates of a new variety of neem.

Friend (1999) reported that the first Australian neem workshop, held at the University of Queensland in 1988, triggered a surge in community interest in growing neem. Soon after, landholders, scientists and companies started planting neem at numerous sites across Queensland in the belief that it was a potentially valuable crop. For example, plantations were established by Cloncurry Shire Council, the Mackay Neem Growers Association and Lismore-based Neem Oil Australia (Friend 1999). Neem was also planted at Ayr, Giru and on mining land at Charters Towers, as well as islands of the Torres Strait (Friend 1999). One of the largest plantings was on a group of properties to the west of Gilbert River (Cloncurry, Mount Isa, Normanton, Croyden and Forsyth). In 1996, 4000 trees were planted near Lakeland.

While neem was heavily promoted by a few people in the 1980s, and enthusiastically planted by many more, a viable industry does not seem to have developed and many plantations have been abandoned.

Distribution in other states

In the Northern Territory, neem has escaped cultivation and started to spread at Humpty Doo. According to the Tropical Savannas Cooperative Research Centre (CRC), neem has been widely planted as a shade tree around settlements and towns in the Victoria River Downs–Sturt area. About three-quarters of the Victoria River Downs–Sturt area is within the Northern Territory, with the remainder in Western Australia. The CRC reports that neem is spreading rapidly in this region and that it is 'a cause for concern' in Arnhem Land.

In Western Australia, government agencies promoted neem as an amenity tree in the 1970s. Neem has escaped cultivation and is currently spreading around Kununurra and Broome in disturbed and undisturbed sites (Andrew Mitchell, pers. comm. 2002) and Doon Doon, Kalumburu, Crossing Falls, Mud Springs, Packsaddle, Weaber Plains Road and Cave Springs (Noel Wilson, pers. comm. in NT-WRA on neem 2007). In the east Kimberley, a 2005 survey found that 37% of boab trees appeared to be threatened by neem trees growing at their bases (Noel Wilson, pers. comm. in NT-WRA on neem 2007).

Distribution in Queensland

In Queensland, neem has been planted at numerous towns and properties. It has been sold as a nursery plant and at weekend markets for at least 20 years.

In the Gulf region of north-west Queensland, neem appears to spread only where it has access to water (such as along the banks of creeks, rivers, bore drains etc.). It generally fails to spread where it has been planted away from water.

Reports of neem starting to grow wild in Queensland have occurred since the early 1990s. Most spread appears to be occurring in the Gulf region of north-west Queensland. Locations where neem has been reported to be spreading include:

- along the Gilbert River (downstream from a commercial neem plantation of approximately 30 000 trees), halfway between Croyden and Georgetown; at one site there are thousands of wild specimens over tens of hectares (Queensland Herbarium records)
- along the Etheridge River (Etheridge Shire)
- Normanton (Carpentaria Shire Council 1999, pers. comm.)
- Mount Surprise area (Steve Goosem 1999, pers. comm.)
- Queensland Department of Primary Industries (DPI&F) neem plantation at Ayr
- Weipa (near Rio Tinto's neem plantation).

History as a weed overseas

Holm et al. (1979) listed neem as a weed of 'unknown importance' in India. Other references list neem as a weed in Fiji (PIER 2007), Ghana (Bingelli n.d.) and Puerto Rico (Randall 2002).

Listing of a species as a weed does not necessarily mean that it is a significant problem. It may simply be a ruderal species, restricted to roadsides, abandoned farmland and other highly disturbed sites, rather than actually interfering with primary production, natural values or human health. Hence, this study searched for published evidence that neem was having significant negative impacts either interstate or overseas.

The NRC (1992) stated that 'although widely naturalised, it has nowhere become a pest'. Binggeli (undated) stated that neem is 'moderately invasive', but does not quantify its impact. Cunningham (undated) stated that neem 'is invading the coastal forests (of Kenya)' and suggested that it was 'endangering survival of endemic species'. Ayensu (1974) reported that, on the Accra plains (Ghana, Africa), native rodent populations have been reduced considerably in areas where large populations of neem occur. Similarly, Decher and Bahian (1999) suggested that dense stands of neem in Ghana might reduce diversity and abundance of small mammals in savanna thickets and riverine vegetation.

Hence, this study only found limited evidence that neem is a *major* weed overseas. While it has escaped cultivation and become naturalised in a number of countries, its impact is poorly documented.

A weed risk assessment by PIER (undated) for neem in the Pacific region produced a score or 5 (= further evaluate).

Uses

Neem trees are grown commercially in plantations to produce azadirachtin, a chemical extracted from the seeds and leaves. Azadirachtin has been promoted as a new insecticide that is considered more 'environmentally friendly' than synthetic insecticides. Plantations have been established in tropical to subtropical regions of the world, including semi-arid and wet tropical regions, from sea level to about 700 m elevation (NRC 1992). After the oil has been pressed from the seeds, the residue ('neem cake') can be used in cattle and poultry feed. Neem is also used in silviculture in India and for reforestation in Asia, Central America and the sub-Saharan region (Maramorosch n.d.). It has been planted as an ornamental and has been sold by commercial nurseries in Queensland (Lawson 1997). In some towns and cities, it has been promoted as a street tree (Hearne 1975).

Those advocating the planting of neem as a commercial crop cite a wide range of potential benefits (Table 1). Some go as far as saying neem is 'a tree for solving global problems' (NRC 1992). While neem has a range of potential uses, most commercial interest lies in the pest control properties of neem extracts. While azadirachtin and other neem extracts have been shown to have insecticidal properties, the commercial viability of producing these insecticides appears less certain. In 1988, an economic assessment of neem concluded that 'neem has little current demand with no local production and only small volumes of imports'.

Table 1. Potential uses of neem (adapted from Benge 1986).

Potential use	Details
Pesticide	The biologically active compound is azadirachtin (extract of neem seed), repellent for a broad spectrum of agricultural and household insects.
Garden ornamental	An attractive tree with perfumed flowers.
Shade	Planted as a shade tree for livestock in arid areas—well adapted to hot, seasonally dry regions in tropical Queensland.
Stockfeed	Protein-rich stockfeed is obtained by chemical processing of neem cake.
Timber	Used for timber and a fuel source.
Veterinary	The biologically active fraction separated from neem kernels shows antiviral activity against certain viruses and has blood-sugar lowering and antimicrobial properties. Leaves can be used as a poultice to treat cattle wounds and sores and to repel worms in livestock.
Medicinal uses	Compounds derived from various parts of the neem tree are used to treat fevers, thirst, nausea, vomiting, some skin diseases, heat rash and boils.
Contraception	Components of neem oil are reported to have contraceptive properties.
Soil improvement	Neem leaves and twigs can be used as mulch and fertiliser. Neem seed cake is an organic manure with insecticidal properties and relatively high nitrogen content.
Soap	Neem oil replaces edible vegetable oil used in soap making. Soap has medicinal properties.

RIRDC (2001) suggested that there are a number of factors currently operating against commercial production in Australia. Changes in the tax system relating to forestry plantations have also weakened the viability of this industry. Nevertheless, there is continuing interest in neem and its products, with small plantations in south-eastern Queensland and some marketing of locally produced trees and products at weekend markets and specialist stores across Queensland and in other states.

Pests and diseases

Neem trees are generally pest-free, due perhaps to the presence of azadirachtin and other insecticidal compounds. However, neem plantations have been badly damaged by a scale insect (*Aonidiella orientalis*) in Africa, and to a lesser extent in India (NRC 1992). Certain species of ants, moths and bugs are also known pests of neem (NRC 1992). Live specimens are susceptible to borers and termites (Hearne 1975).

Pest potential in Queensland

While this study was unable to find clear evidence of neem having a major impact as a weed overseas, there is good evidence from several countries that it can escape cultivation and naturalise within suitable habitats. Without properly researched and published evidence of major impact elsewhere, it is difficult to predict whether neem will become a major or a minor problem in Queensland.

Field observations by experienced local and state government pest management staff suggests that neem is likely to become more abundant and widespread along the sandy beds and banks of some rivers in the Gulf region of north-west Queensland. While it has only been cultivated in this region for a relatively short time, it has already formed small, wild populations that appear to be spreading. A similar scenario appears to be developing at other sites scattered across northern Australia. Since neem is estimated to produce 44 000–200 000 bird-dispersed seeds each year, its spread might be rapid. However, without a history as a major weed overseas, its potential impact on agriculture or natural biodiversity cannot be predicted with any confidence, and is open to speculation.

Considering literature on the plant's ecology and climatic preferences, habitats most at risk of invasion in Queensland are predicted to be the sandy beds and banks of rivers and creeks across our seasonally dry tropical savannas. Neem appears well adapted to alluvial sands where its deep roots can take advantage of underlying water tables. Climatically, neem appears less suited to subtropical areas and is not predicted to spread in cool temperate areas. Also, it is not expected to spread on heavy clay soils or seasonally or permanently waterlogged sites.

Cattle are unlikely to impede the spread of neem since its foliage is very bitter and generally not eaten. Similarly, the natural presence of azadirachtin in the leaves of neem is likely to protect the species from predation by native insects and other invertebrates, perhaps contributing to its apparent vigour and giving it a competitive advantage over other plants.

There is some evidence that neem extracts can affect certain aquatic life including fish and tadpoles (NRC 1992) and some speculation that chemical compounds leached out of neem leaf litter might affect aquatic wildlife. There is also concern over the plant's potential impact on native insect populations (Lonsdale 1999, pers. comm.).

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