



Morinda citrifolia (noni)

Rubiaceae (coffee family)

canary wood (Australia); *fromager*, *murier indien* (French); *i* (Kosrae); Indian mulberry (English); *lada* (Guam, N. Mariana Islands); *kesengel*, *lel*, *ngel* (Palau); *kikiri* (Solomon Islands); *kura* (Fiji); *mangal'wag* (Yap); *mora de la India* (Spanish); *nen*, *nin* (Marshall Islands, Chuuk); *non* (Kiribati); *noni* (Hawai'i); *nono* (Cook Islands, Tahiti); *nonu*, *nonu atoni*, *gogu atoni* (Niue, Samoa, Tonga, Wallace, Futuna); *weip'wul* (Pohnpei)

Scot C. Nelson

IN BRIEF

Distribution Native to Southeast Asia (Indonesia) and Australia, it now is found throughout the tropics.

Size Typically 3–6 m (10–20 ft) tall at maturity.

Habitat Widely adapted to the tropics, 1–800 m (0–2600 ft) depending on latitude, mean annual temperatures of 20–35°C (68–95°F), annual rainfall of 250–4000 mm (10–160 in).

Vegetation Associated with a wide range of common coastal and littoral forest shrubs, as well as numerous cultivated plants.

Soils Grows in an extremely wide range of soils.

Growth rate Moderate, generally 0.75–1.5 m/yr (2.5–5 ft/yr).

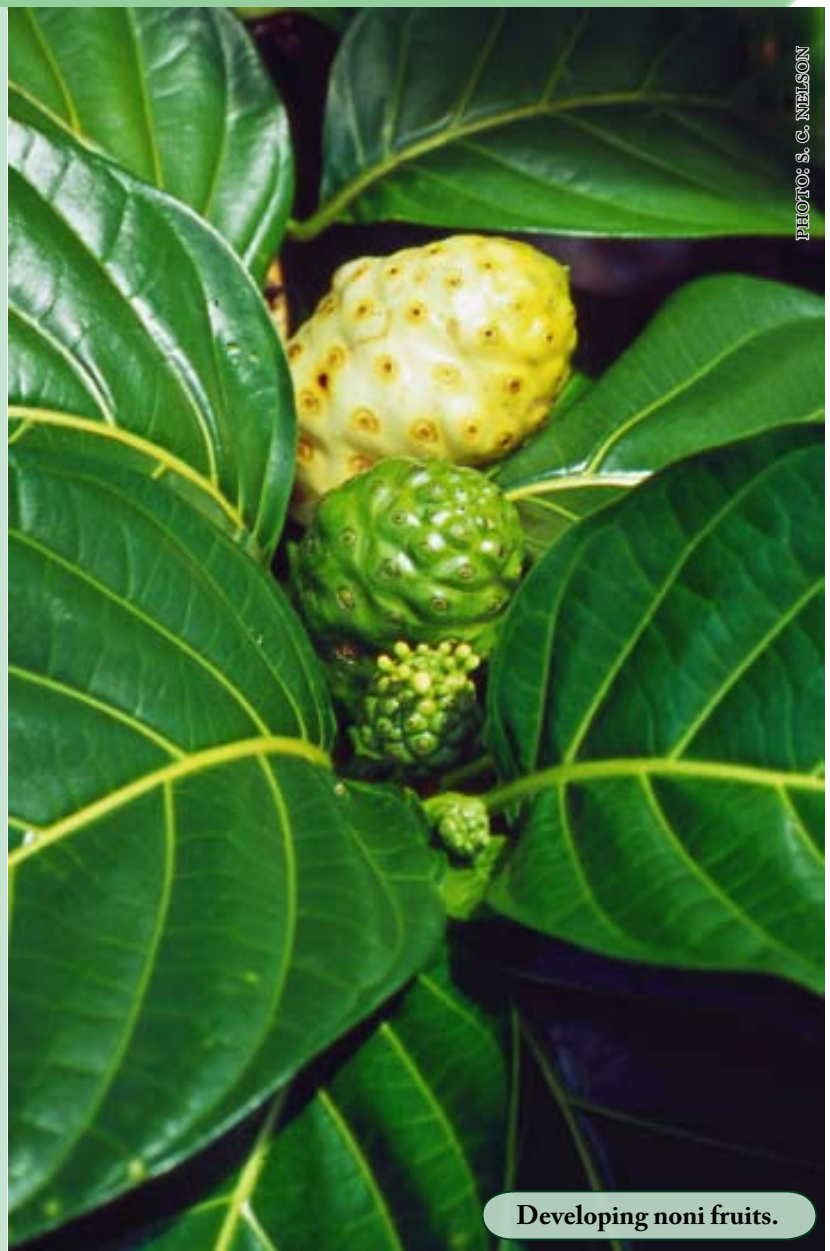
Main agroforestry uses Coastal protection, homegardens.

Main products Medicinal.

Yields Up to 80,000 kg of fruit per hectare (71,000 lb/ac) annually.

Intercropping Traditionally grown in mixed cropping systems throughout the Pacific.

Invasive potential Has naturalized outside its native range in many locations throughout the Pacific and the tropics, although it is rarely considered a pest.



PHOTOS: S. C. NELSON

Developing noni fruits.

INTRODUCTION

Morinda citrifolia, known commercially as noni, grows widely throughout the Pacific and is one of the most significant sources of traditional medicines among Pacific island societies. This small evergreen tree or shrub is native from Southeastern Asia (Indonesia) to Australia, and now has a pantropical distribution. Noni is noted for its extremely wide range of environmental tolerances. It can grow in infertile, acidic, and alkaline soils and is at home in very dry to very wet areas. It is found naturally in relatively dry to mesic sites or lowland areas in close proximity to shorelines, or as an important forest understory species in low-elevation Pacific island forests and rainforests. Noni's extensive range of environmental tolerances also includes exposure to wind, fire, flooding, and saline conditions. Although not considered to be invasive to a degree that threatens ecosystems, noni is treated as a weed in some settings, is very persistent and difficult to kill, and is one of the first plants to colonize harsh waste areas or lava flows. All parts of the plant have traditional and/or modern uses, including roots and bark (dyes, medicine), trunks (firewood, tools), and leaves and fruits (food, medicine). The medicinal applications, both traditional and modern, span a vast array of conditions and illnesses, although most of these have yet to be scientifically supported. Noni is well suited for intercropping within traditional agroforestry subsistence farming systems or as a monocrop in full sun. The tree has attained significant economic importance worldwide in recent years through a variety of health and cosmetic products made from its leaves and fruits. These include fruit juices as well as powders made from the fruit or leaves.

DISTRIBUTION

Native range

Noni is native to Southeast Asia (Indonesia) and Australia. It can be found in disturbed forests, dry to mesic forests, alien grasslands, open areas near the shoreline, pastures and coconut plantations, in littoral forest understories, fallow areas, waste places, and around villages.

Current distribution

The distribution of noni is pantropical at latitudes of 19° N or S. The Indo-Pacific distribution includes Eastern Polynesia (e.g., Hawai'i, Line Islands, Marquesas, Society Islands, Australs, Tuamotus, Pitcairn, and Cook Islands), Melanesia



Noni can grow from elevations of 500 m (1640 ft) down to near sea level; here seen at Apia Bay, Samoa. PHOTO: C. ELEVITCH

(e.g., Fiji, Vanuatu, New Guinea, New Caledonia, and the Solomon Islands), Western Polynesia (e.g., Samoa, Tonga, Niue, 'Uvea/Futuna, Rotuma, and Tuvalu) and Micronesia (e.g., Pohnpei, Guam, Chuuk, Palau, the Marshall Islands, and the Northern Marianas), Indonesia, Australia, and Southeast Asia. Noni has also become naturalized on the open shores of Central and South America (from Mexico to Panama, Venezuela, and Surinam) and on many islands of the West Indies, the Bahamas, Bermuda, the Florida Keys, and parts of Africa.

BOTANICAL DESCRIPTION

Preferred scientific name

Morinda citrifolia L.

The botanical name for the genus was derived from the two Latin words *morus*, mulberry, and *indicus*, Indian, in reference to the similarity of the fruit of noni to that of true mulberry (*Morus alba*). The species name indicates the resemblance of the plant foliage to that of some citrus species.

Family

Rubiaceae (coffee family), subfamily Rubioideae

Common names

canary wood (Australia)
fromager, *murier indien* (French)
i (Kosrae)

Indian mulberry (English)
lada (Guam, Northern Mariana Islands)
mangal'wag (Yap)
kesengel, lel, ngel (Palau)
kikiri (Solomon Islands)
kura (Fiji)
mora de la India (Spanish)
nen, nin (Marshall Islands, Chuuk)
non (Kiribati)
noni (Hawai'i, Marquesas)
nono (Cook Islands, Tahiti)
non, nonu atogi, gogu atogi (Niue, Samoa, Tonga, 'Uvea/
 Futuna)
weipwul (Pohnpei)

Size and form

Noni is a small evergreen tree or shrub 3–10 m in height at maturity. The plant sometimes supports itself on other plants as a liana. There is much variation in overall plant form, fruit size, leaf size and morphology, palatability, odor of ripe fruit, and number of seeds per fruit.

Flowers

Flowers are perfect, with about 75–90 in ovoid to globose heads. Peduncles are 10–30 mm (0.4–1.2 in) long, the calyx a truncated rim. The corolla is white, 5-lobed, the tube greenish white, 7–9 mm (0.28–0.35 in) long, the lobes oblong-deltate, approximately 7 mm (0.28 in) long. There are five stamens, scarcely exerted; the style is about 15 mm (0.7 in) long.

Leaves

Leaves are opposite, pinnately veined, and glossy. Blades

are membranous, elliptic to elliptic-ovate, 20–45 cm (8–18 in) long, 7–25 cm (3.5–10 in) wide, and glabrous. Petioles are stout, 1.5–2 cm (0.6–0.8 in) long. Stipules are connate or distinct, 1–1.2 cm (0.4–0.5 in) long, the apex entire or 2–3-lobed.

Fruit

The fruit (technically known as a syncarp) is yellowish white, fleshy, 5–10 cm (2–4 in) long, about 3–4 cm (1.2–1.6 in) in diameter, and soft and fetid when ripe.

Seeds

Seeds have a distinct air chamber, and can retain viability even after floating in water for months.

Rooting habit

Noni has a rooting habit similar to that of citrus and coffee, with an extensive lateral root system and a deep taproot.

How to distinguish from similar species

The wood of noni is a yellowish color and the fruits have a unique and distinct disagreeable odor when ripe.

GENETICS

There is a relatively high degree of genetic (e.g., morphological) variability of the fruit and leaf within the species. Known varieties include the following:

Morinda citrifolia var. *citrifolia*, the primary focus of this profile, is of greatest cultural, economic, and medicinal value, and is in greatest abundance in the Pacific region. This is a morphologically diverse species and with no clear



Left: *Morinda citrifolia* var. *bracteata* fruit and leaves. PHOTO: W. MCCLATCHEY Right: *Morinda citrifolia* cultivar 'Potteri' with its variegated leaves. PHOTO: S. C. NELSON

sub-populations bearing unique characteristics; there exist large-fruited and small-fruited members of this group.

Morinda citrifolia var. *bracteata* is a small-fruited variety with conspicuous bracts. Found in Indonesia and other parts of the region between the Indian and Pacific Oceans.

Morinda citrifolia cultivar 'Potteri' is an ornamental type, with green and white leaf variegation, distributed throughout the Pacific.

Associated plant species

Noni is associated with a wide range of common coastal and littoral forest shrubs and tree species in its native habitat. It grows as an introduced plant in agroecosystems near the shoreline of Pacific islands in open areas or as a cultivated component of agroforestry and subsistence agriculture, and is therefore associated with such plants as breadfruit (*Artocarpus altilis*), banana (*Musa* spp.), papaya (*Carica papaya*), palms (e.g., betel nut palm, *Areca catechu* and coconut, *Cocos nucifera*), pandanus (*Pandanus* spp.), beach hibiscus (*Hibiscus tiliaceus*), ti (*Cordyline fruticosa*), and *Piper* species (e.g., kava, *Piper methysticum*). Some of these associated species are understory and some are overstory for noni. Noni grows as a recent introduction around villages or in homegardens, in back yards, and along streams and gulches.

ENVIRONMENTAL PREFERENCES AND TOLERANCES

Climate

Elevation range

1–800 m (3.3–2600 ft), depending on latitude and environment.

Mean annual rainfall

250–4000 mm (10–160 in)

Rainfall pattern

Noni can tolerate a wide range of precipitation patterns, including summer, winter, bimodal, and uniform.

Dry season duration (consecutive months with <40 mm [1.6 in] rainfall)

At least 3–4 months depending on age, size of tree, temperature, relative humidity, and soils.

Mean annual temperature

20–35°C (68–95°F)

Mean maximum temperature of hottest month

32–38°C (90–100°F)

Mean minimum temperature of coldest month

5–18°C (40–64°F)

Minimum temperature tolerated

12°C (54°F)

Soils

Noni grows in a very wide range of soils and environments, with a notable ability to survive in harsh environments, such as those found on coral atolls or basaltic lava flows. It can also be found in solution pits or brackish tide pools near the coast, in limestone soils or outcroppings, on coral atolls, as a colonizing species of basaltic lava flows, as well as in native forests.

Soil drainage

Noni tolerates a wide range of drainage conditions including seasonal waterlogging, but it prefers free, well drained soils.

Soil acidity

It can grow in a wide range of acidity levels, from acidic to alkaline.

Special soil tolerances

Noni tolerates shallow, saline, sodic, and infertile soils.

Tolerances

Drought

Mature, cultivated noni can easily withstand drought for 6 months or more. Wild noni plants growing in arid conditions can spend their entire lives in conditions of perpetual drought.

Full sun

The plant grows well in full sun.

Shade

Noni can grow in a wide range of light intensities, from full sun to over 80% shade.

Fire

It can regenerate after fire by sprouting new foliage from roots or stems.

Waterlogging

Noni withstands and even thrives in brackish tide pools.



Growing in a crack in lava rock, noni is tenacious in this hot, windy, and dry area of Kona, Hawai'i. PHOTO: C. ELEVITCH

GROWTH AND DEVELOPMENT

Growth rate

The growth rate is moderate, generally 0.75–1.5 m/yr (2.5–5 ft/yr), slowing as the tree reaches maturity.

Flowering and fruiting

Noni flowering and fruiting is continuous throughout year. Fluctuations in flowering and fruiting may occur due to seasonal effects (temperature, rainfall, sunlight intensity and duration).

Reaction to competition

Noni does not compete well with grasses or with grassy weeds in deep soils as an agricultural monocrop. However, it is a good forest understory plant that can tolerate very harsh conditions and plant competition from forest trees, including allelopathic species. In fact, noni is one of the few plants that can thrive beneath the canopy of ironwood (*Casuarina equisetifolia*) trees.

It can also tolerate flooded conditions for long periods of time.

Salt spray

It is very salt-resistant and tolerant of ocean salt spray. Noni is tolerant of extreme salinity in general and is thought to possibly gain nutritional benefit from the minerals contained in seawater.

Wind

Although windy areas are not advised for commercial production, noni can grow in windswept locations. However, yields and overall plant growth of noni in such areas are diminished.

Abilities

Regenerate rapidly

It has the ability to regenerate from shoots or root suckers rather than from seed, producing small thickets or groves.

Self-prune

Noni is not considered to be self-pruning, although the woody branches of this plant are brittle and may be relatively easily broken during overly heavy fruiting loads or during high winds.

Coppice

Noni plants regenerate well, even after severe pruning. Noni may be cut back to the trunk (“stumping”) to promote the growth of a dense head of foliage.

PROPAGATION

Noni is relatively easy to propagate from seeds, stem or root cuttings, and air-layering. The preferred methods of propagation are by seed and by cuttings made from stem verticals.

Propagation from seed

Seed collection

Noni flowers and fruits year-round. Fruits are harvested when they start turning white, or even when they have become fully ripe, i.e., turned soft, translucent, and characteristically odorous. For seed production, the riper the fruit, the better. Collect fruit from plants that have desirable characteristics, such as large fruit for fruit production, vigorous leaf growth for hedges, etc.

Seed processing

After picking, let the fruit ripen fully until it all turns soft (almost mushy) and translucent. This may take 3–5 days if only semi-ripe fruits were collected. Once the fruits have fully softened, press them against a screen or colander with holes slightly smaller than the seeds. The soft, fibrous pulp will slowly be removed from the seeds as they are rubbed



Noni seeds can remain viable floating in water for months.
PHOTO: S. C. NELSON

against the screen. It may take 15 minutes to completely remove the clinging flesh. Rinsing in water periodically helps float off the pulp. The seeds have an air bubble trapped inside, so unlike most other seeds, healthy noni seeds float in water.

If the seeds are to be used immediately, soft fruits can be suspended in water and subjected to short pulses in a blender, very sparingly, to remove most of the flesh while

slightly scarifying the seeds (see next section). If the seeds are to be stored, the flesh should be removed completely, then the seeds air-dried and stored in a paper bag in a cool room with low humidity. It is unknown how long seeds remain viable; however, 1 year is thought to be a reasonable storage time.

Germination is high for fresh seeds, often over 90%. There are approximately 40,000 seeds/kg (18,000 seeds/lb) for Hawaiian noni.

Pre-planting seed treatment

Without pretreatment, noni seeds germinate sporadically over 6–12 months. Scarification of the tough seed coat, although not a requirement, can shorten the time required for seed germination and increase the overall germination percentage. Scarification can be achieved by any physical method that abrades, damages, penetrates, or cuts open the seed coat. A simple method is to place ripe fruits in a blender and pulse the blending mechanism a few times to cut open the noni seeds before separating them from the pulp. A more time-consuming method that results in higher germination percentage consists of clipping off the tip of noni seeds near the embryo to allow water to penetrate the seed coat.

Germination time for scarified noni seeds is 20–120 days, depending upon temperature, environment, and variety or genotype. Seed germination can be rapid and uniform (20 days) in full sun to partial shade and mean temperature of approximately 38°C (100°F).

Potting media

Weed and nematode-free natural or local forest soil mixed with sand, volcanic cinder and/or composted organic matter are excellent for seedling production. A preferred pot-



A very reliable—but time-consuming—way to scarify noni seeds is to clip the pointed end of the seeds with a fingernail clipper, which allows water to quickly enter the seed coat. Left: Unclipped seed. Middle: Properly clipped seed. Right: Seed clipped too much, exposing embryo (visible as white spot at lower right). PHOTOS: S. C. NELSON



Rooted cutting (left) and seedling (right) ready for outplanting. PHOTOS: S. C. NELSON

ting medium for noni seeds is light and well drained but inherently moisture-retaining, slightly acidic to slightly alkaline (depending on locally available source material), aerobic, and high in organic matter derived from compost or peat. Nematode-infested soils or media should be avoided or treated with heat (at least 50°C [122°F] for 15 minutes) prior to using. Most nurseries prefer natural potting media rather than commercial media for noni production. Mulch (e.g., cinder, sawdust, leaf litter, or sand) may be placed over the seeds for weed control and moisture retention.

Growing area

A rain- and wind-protected but sunlit area (such as a cold-frame with a clear film roof) is recommended for germination in trays. Germinate the seeds in trays filled with one part peat to one part perlite or vermiculite only. Warm, moist, and light conditions are beneficial for optimal germination. Noni seeds can germinate in conditions ranging from deep shade to full sun. Most uniform germination is achieved in light partial shade (20–30%). After the germination and early establishment phases, partial shade (20–30%) is used for growing out the individual seedlings in containers.

Establishment phase

Sow the scarified seeds evenly in germination trays or pots filled with a moisture-retaining, sterile or pathogen-free growth medium, perhaps a mixture consisting of one part perlite to one part peat. Cover lightly with 5–10 mm (0.2–0.4 in) of potting media. Keep moist with a fine sprayer so as not to disturb the seeds or the medium. The seedling

trays or pots may be kept in shade or in full sun. An even temperature of 38°C (105°F) is recommended, which can be achieved with bottom heat.

Active growth phase

When the seedlings reach the four-leaf stage, carefully transplant them to individual containers for the growth phase. Root-training pots approximately 6 cm (2.5 in) square by 12 cm (5 in) deep or larger work well. Four-liter (1 gal) root-training containers can also be used.

Seedlings should be grown in partial shade and moved into full sun after 1–2 months. Keep seedlings spaced well apart to allow maximum penetration of sunlight and air circulation. In some cases, amending with additional fertilizer such as a light top-dressing of slow-release or organic 8-8-8 will aid in growth and development.

The size of noni plants at time of outplanting depends on the seedling age, fertility of the medium, pot size, noni variety, and the shade level used for seedling cultivation. A hardened seedling having at least 20–25 cm (8–10 in) of woody stem tissue (being at least 150–180 days old) has excellent performance after outplanting.

Time to outplanting

Noni seedlings (if not direct-seeded into the ground) may be outplanted about 2–12 months after germination. Young noni seedlings (8–12 weeks old; 10–15 cm (4–6 in) tall) may require more care and may be more vulnerable to environmental fluctuations and pest attack than older seedlings. Older seedlings, grown in full sun in 2- or 3-liter (2–3 quart) pots for 24–36 weeks, are preferred for their vigor and ability to establish quickly. Even older seedlings (1–3 years old) may be outplanted if they are healthy and not significantly root-bound. For older seedlings, loosen root systems gently by hand after removing them from their pots or containers.

Seedling development

After outplanting, the first year of seedling development is slow due to transplant shock and the establishment of a root system. Afterward, seedling growth is much more rapid as the crown gains size and photosynthetic mass.

Using volunteer seedlings

As an alternative to sowing noni seeds in seed-germination beds, young noni seedlings can be collected carefully from forest areas and transplanted into pots. Noni may

also be sown onto raised mounds and outplanted as bare-root seedlings, although this is not a preferred method of seedling production.

Propagation from stem cuttings

Varying sizes of stem cuttings can be used, but 20–40 cm (8–16 in) cuttings are manageable and effective. Stem cuttings may root in 3 weeks and be ready for outplanting in 6–9 weeks. As with plants derived from seeds, rooted stem cuttings may be grown in pots for up to 26 weeks or more with excellent results when outplanted.

DISADVANTAGES

Potential for invasiveness

Noni has naturalized outside its native range in many locations throughout the Pacific and the tropics. Although not considered invasive to the degree that it threatens ecosystems, noni is recognized for its ability to persist and to disperse and colonize without a specific biological dispersal agent, such as humans, rodents, and birds. For example, noni seeds float for long periods of time in ocean water or streams and rivers and can remain viable for months during their journey until their deposition on a suitable substrate. Noni is considered to be a weed in some locations (e.g., in some agroforestry or diversified farming settings in Micronesia).

Susceptibility to pests/pathogens

Noni is susceptible to attack by a wide range of pests and disease-causing pathogens. However, the damage depends upon the pest or pathogen and upon the environment. When grown in a diverse, forested ecosystem, noni usually suffers from few significant pest and disease problems or damage. Conversely, when grown in a modern monocultural farming system, noni is much more susceptible to attack by many more pests and diseases and with greater intensity than in natural ecosystems. In addition, noni grown in monocultures on lands previously used for fruit or vegetable crops tends to be exposed to new pests and pathogens that may not be abundant or even present in forest or natural ecosystems.

Insect pests

Noni is susceptible to attack and damage by a range of insects, such as aphids (e.g., the melon aphid, *Aphis gossypii*), scales (e.g., the green scale, *Coccus viridis*), weevils (unidentified species), leaf miners (unidentified species), whiteflies (e.g., the Kirkaldy whitefly, *Dialuerodes kirkaldyi*), caterpillars (e.g., croton caterpillar, *Achaea janata*), thrips (e.g.,

the greenhouse thrips, *Heliothrips haemorrhoidalis*), and an unidentified species of eriophyid mite. Overuse of fertilizer can attract sap-feeding insects (e.g., aphids, whiteflies, scales) that cause a buildup of sooty mold on noni leaves. Stress from lack of nutrients or root problems may also lead to infestations of whiteflies or scales. Insect damage may be more severe in relatively dry or low-rainfall locations or in full-sun plantings as an expansive monocrop. Of the insect pests, whiteflies and scales are perhaps the most destructive. They can be controlled with sprays of insecticidal soaps and oils. In some locations, leaf miners periodically cause severe damage to noni leaves.

Pathogens and biotic diseases

In damp, high-rainfall or flooded areas, noni is prone to certain plant diseases caused by fungi or fungus-like organisms: leaf spots (*Colletotrichum* sp. and others) and stem, leaf, and fruit blights (*Phytophthora* sp. and *Sclerotium rolfsii*). The fungal leaf spot diseases are relatively minor but can be a nuisance in some locations. They can be minimized by sanitation (picking up or removing severely diseased leaves) or by periodic application of approved fungicides. Some foliar diseases caused by fungi (fungal leaf spots, or “black flag disease” caused by the fungus-like *Phytophthora*) may significantly inhibit leaf growth and fruit development.

The most common and severe pest problem for noni is root-knot disease caused by root-knot nematodes (*Meloidogyne* spp.). These soil-dwelling, root-parasitic roundworms are very destructive to noni and must be kept out of the nursery. The disease can cause farm failure. To keep nematodes out of nurseries, use soil-less media or only heat-treated soil for seedlings. Once established in a field, root-knot nematodes are virtually impossible to eradicate and can eventually result in plant death. Therefore, it is recommended that seedlings infected with nematodes never be planted (they should be destroyed). Avoid planting noni where it does not grow naturally, and avoid fields where other crops have been planted. Rocky soils are best for noni cultivation. Proper use of irrigation, fertilizer, and composts can help minimize damage caused by root-knot nematodes (for more information, see “the Noni Website” listed under “Internet” below).

Nutritional deficiencies and abiotic diseases

Noni can display a wide range of abnormal foliar symptoms due to deficiencies in fertility elements (e.g., nitrogen, iron, and phosphorous). Deficiencies in iron or other minor elements are expressed as interveinal chlorosis or scorching of leaf margins. Deficiencies in phosphorous are expressed as leaf curling, purpling, and marginal ne-

crisis. Symptom development and expression for nutrient deficiencies on noni depend on the setting (natural vs. agricultural), overall plant stress factors (water, disease, root health, and fertilizer practices) and overall demand for nutrition and/or production (low to high).

Parasitic weeds

Noni is susceptible to infection by some coastline parasitic seed plants, including dodder (*Cuscuta* spp.) and *Cassytha filiformis*.

Host to crop pests/pathogens

Several significant pests and pathogens of general agricultural concern are also problematic for noni (e.g., ants, sap-feeding insects, and root-knot nematodes). These pests have wide host ranges and may initiate or cause significant damage to some crops (e.g., vegetables). Because noni attracts ants, some sap-feeding insects such as aphids may be a concern for certain vegetable intercropping designs with noni. Farm management plans should take into consideration the common pests and diseases that may attack the components of an interplanted system. Issues regarding pesticide spray drift and potential contamination of products and phytotoxicity must also be considered.

AGROFORESTRY/ENVIRONMENTAL PRACTICES

Mulch/organic matter

Although noni regrows well after pruning, noni plants are generally not managed for mulch production in agroforestry situations.

Homegardens

It is well suited for homegardens; a single plant is sufficient to meet the needs of one or more families.

Boundary markers

Noni can be used for boundary markers due to its persistence and ability to survive harsh conditions and extended periods of drought.

Animal fodder

The fruits and leaves are useful as animal feed or fodder (pets and livestock).

Woodlot

Noni is very compatible with lowland forest or woodlot



Noni growing under coconuts in pāhoehoe lava flow at 10 m (33 ft) elevation at Pu'uhonua o Hōnaunau, island of Hawai'i. PHOTO: C. ELEVITCH

plant species throughout the Pacific. Noni itself is not managed for wood production.

Native animal/bird food

Ripe fruits are a natural source of food for birds, rodents, and insects.

Bee forage

The flower nectaries are very attractive to honey bees.

Coastal protection

Noni is tenacious enough help to stabilize lands in harsh or unstable coastal environments.

Ornamental

Although the naturalized *M. citrifolia* (the wild and cultivated noni types) is considered by many to be a beautiful plant with shiny green foliage, some object to its use as an ornamental plant due to the strong and sometimes offensive odor of ripened fruits and because the fallen fruits attract many flies and other insects. The cultivated *M. citrifolia* variety 'Potteri' is a beautiful and functional ornamental plant with small fruits and green and white variegated leaves.

USES AND PRODUCTS

Fruit

Used in local medicines (juice, poultice) and as a famine food (e.g., by Hawaiians, Australian aborigines). Unripe

fruits are cooked in curries and ripe fruits are consumed raw with salt (e.g., Burma). Fruit is cooked and mixed with coconut and eaten as stimulant on long sea voyages (e.g., Nauru).

Leaf vegetable

Very young leaves are cooked as vegetables and eaten with rice in Java and Thailand; mature leaves are wrapped around fish before cooking and then eaten with the cooked fish. The terminal bud is used as food (e.g., Kiribati).

Beverage/drink/tea

Dried leaves or fruits are used to make infusions and teas for medicinal use.

Medicinal

Leaves, fruits, stems, and roots are used in various medicinal preparations, healing protocols, and treatment methods throughout the Pacific region.

Medicinal uses (traditional) Treatment for malaria, general febrifuge, and analgesic (leaf tea); laxative (all parts of the plant); jaundice (decoctions of stem bark); hypertension (extract of leaves, fruit, or bark); boils and carbuncles (fruit poultice); stomach ulcers (oils from the fruit); scalp insecticide (seed oil); tuberculosis, sprains, deep bruising, rheumatism (leaf or fruit poultices); sore throat (gargling

a mash of the ripe fruit); body or intestinal worms (whole fresh fruits); laxative (seeds); fever (leaf poultice); cuts and wounds, abscesses, mouth and gum infections, toothaches (fruit); sties (flowers or vapor from broken leaves); stomach ache, fractures, diabetes, loss of appetite, urinary tract ailments, abdominal swelling, hernias, stings from stonefish, and human vitamin A deficiency (leaves). The leaves are also used as a medicinal poultice or body wrap (e.g., Micronesia). The terminal bud has medicinal uses (e.g., Northern Marianas).

Medicinal uses or purported applications (contemporary, worldwide) Purported value of noni for treatment of ailments including attention deficit disorder, addictions, allergies, arthritis, asthma, brain problems, burns, cancer, cardiovascular disease, chemical sensitivity, chronic fatigue, diabetes, digestive problems, endometriosis, fibromyalgia, gout, hypertension, immune deficiency, infection, inflammation, jet lag, multiple sclerosis, muscle and joint pain, polio, rheumatism, severed fingers, sinus, and veterinary medicine have yet to be validated.

Flavoring/spice

The leaves are used to wrap fish or other meats and foods during cooking.

Masticant/stimulant

Fruits are believed to be as an appetite and brain stimulant.

Timber

The wood can be used in light construction, canoe parts and paddles, axe and adze handles, and digging sticks.

Fuelwood

The trunk is used for firewood (e.g., in Kiribati).

Craft wood

Roots are used for carving (e.g., Niue).

Wrapping/parcelization

The leaves are used to wrap and flavor food for cooking (e.g., Cook Islands).

Dye

The bark contains a red pigment and the roots contain a yellow pigment, both used in making dyes. Dyes from noni were traditionally and are still used to color clothing and fabrics.

Food for animals

Leaves are used for livestock fodder (e.g., Niue, India) and



Ripe noni fruit. PHOTO: S. C. NELSON

to feed silkworms (e.g., India). The fruit is used as pig food (e.g., Puerto Rico).

Repellent

A fetid oil obtained from seeds is used as scalp insecticide or insect repellent (e.g., Hawai'i).

Ceremonial/religious importance

Traditionally used as a "ghost medicine," based on the religious belief that ghosts are repelled by the odor of the fruit or plant.

URBAN AND COMMUNITY FORESTRY

Noni is an attractive shrub which is generally well suited for homegardens and landscapes, but only where the odoriferous, fallen fruits do not create a nuisance. The tree produces fresh fruits year-round, so fruits are always available. It thrives in waste areas and is a very hardy roadside plant throughout the Pacific. The plant is easy to care for, responds well to severe pruning, and does not require much fertilizer or water.

Size in an urban environment

The size of a noni tree in an urban environment depends upon soil qualities and spacing. Plants growing in full sun and without competition can reach a height of about 6 m (20 ft) or more with a canopy spread of 2.4–3.6 m (8–12 ft) diameter. Crowded or shaded noni plants tend to be less vigorous and become stunted.

Rate of growth in a landscape

Young noni plants grow relatively slowly in a landscape, about 30–60 cm (1–2 ft) per year in height, depending on environment. Upon reaching maturity, noni plants grow much more slowly in height, becoming mostly more dense within the canopy. Plants derived from cuttings tend to become established more rapidly than plants derived from seeds, but also tend to remain more prostrate and do not grow as tall as seedlings.

Root system

Noni has a deep taproot and an extensive surface-feeding root system. The tree may not compete well in a landscape with plants that have aggressive, surface-feeding roots, such as grasses. Noni is not considered to have an invasive root system, although once a noni plant is established in a landscape it is very difficult to kill. Volunteer plants growing in cracks in cement or asphalt or other undesirable locations should be uprooted as early as possible.

Products commonly used in a Pacific island household

Noni leaves and fruits are commonly used for medicine in Pacific island households. One or two mature trees can easily supply the needs of a family.

Light requirements

Noni is commonly found growing in full sun along sunny roadsides, at the edges of clearings, or in open fields such as the 'a'a and pāhoehoe lava fields of the island of Hawai'i. However, the plant grows very well in full sun to about 80% shade.

Water/soil requirements

Noni has no special or unusual water or soil requirements. It tolerates a wide range of soil conditions including acidic to alkaline, saturated to dry, and well drained to compacted soils.

Life span

A noni plant, without significant pest or disease attack or other stresses, may be expected to live for at least 40–50 years in a landscape, probably longer.

Varieties favored for use in homegardens or public areas

The variegated noni, *M. citrifolia* cultivar 'Potteri', is a popular landscaping type of noni due to its beautiful leaves. Variegated noni is also used medicinally, although fruit yields tend to be lower and fruits are smaller than regular Hawaiian noni. Otherwise, seedlings grown from seed collected from trees with desirable qualities (e.g., large fruit) can be planted.

Seasonality of leaf flush, flowering, fruiting

Noni fruit production varies somewhat with the seasons in the Pacific, with more fruit being produced in summer than in winter. However, noni produces new leaves and fruits all year long wherever it is grown.

Exceptional ornamental values

The variegated noni has exceptional ornamental value due to its unusual leaf coloring and relative rarity in the landscape. Noni plants have exceptional value for being salt-tolerant and able to grow in rocky areas or on old lava flows.

Use as living fence, hedge or visual/noise barrier

Noni plants can have a very dense canopy and be very useful as hedge plants or living fences. The plants can thrive

where other plants have difficulty growing. Noni can withstand heavy pruning although more frequent, light pruning can be used to ensure adequate foliage always remains to serve hedge functions.

Birds/wildlife

Noni flowers attract honeybees. Fallen noni fruits may attract rats and pigs.

Maintenance requirements

Noni is a low-maintenance landscape plant. It responds well to mulching as long as the mulch is kept away from direct contact with stem. Noni can be pruned or thinned to virtually any extent without damaging the plant. “Stumped” plants may grow back even bushier than before. Plants require very little fertilizer, but do respond well to periodic applications of organic or inorganic, balanced fertilizers. Extra phosphorous may be applied to simulate flowering and fruit production. Typical balanced fertilizers used include 13-13-13 and 16-16-16. To stimulate flowering and fruit production use 10-20-10 if a soil test indicates that phosphorous levels are low. If noni leaves are turning yellow, they could be fertilized with about 225–450 g (0.5–1 lb) of fertilizer per plant, depending on age. The plants also respond very well to foliar fertilizers. Because noni plants are salt-tolerant, it is very unusual for their root systems to be burned by excess fertilizer.

Special considerations regarding leaf, branch, and fruit drop

Fruit drop occurs year round. Dropping fruits are not considered to be a hazard to humans or animals during normal conditions or during storms. People could slip on ripe fruits along footpaths and sidewalks. Noni trees do not topple easily during foul weather, although branches can break, especially when heavy with fruit. Climbing noni trees should only be done with caution, as branches can suddenly crack off.

Nuisance issues

The fruits have a strong, unpleasant aroma which is considered by some to be a nuisance. The foul odor of noni fruits is considered by many to be a significant detriment to using noni in a landscape.

Hazards

Noni plants are not toxic to humans or animals, nor are there any spines, thorns, etc., on the plant.

Common pest problems

Insect pest and plant disease problems of noni are usually less common and severe in mixed plantings in urban environments. The types of problems encountered depend on the environment in which noni is grown. In wetter locations, for example, fungal leaf spots and blights might occur. In drier locations, insect infestations may become established. The most common pest problem for noni in the urban landscape is perhaps root-knot nematodes, the small plant-parasitic roundworms that cause conspicuous galls and swellings on roots that severely weaken the plant. Root-knot nematodes are best controlled by avoiding them, i.e., by starting with nematode-free seedlings and by planting the seedlings in a nematode-free location. If nematodes are present, their effects can be minimized by adding compost around plants or other forms of organic mater to the soil and by the use of foliar fertilizers. Noni plants in the urban landscape may also become infested with ants and sap-feeding insects such as scales, aphids, whiteflies, and mealybugs. These sap-feeding insects may be controlled with regular sprays of soapy water or a mixture of soap, water, and vegetable oil.

COMMERCIAL PRODUCTS

The primary commercial products from noni include beverages (fruit juice, juice drinks), fruit powders (for manufacture of reconstituted juice or juice drink products made from dried ripe or unripe fruits), toiletries (lotions, soaps, etc.), oil (from seeds), and leaf powders (for encapsulation or pills).

Site selection

Although choice of soil type is not a critical consideration, areas that do not support natural populations of noni should be avoided for commercial plantations.

Spacing

Spacing of 4–5 m (13–16 ft) within and between rows is common.

Management objectives

Year 1: Land clearing and preparation; weed control; plant establishment.

Year 2: Promote vegetative growth of seedlings.

Year 3 and thereafter: Promote flowering and fruiting.

Yields

Annual fruit yield varies among noni varieties or genotypes and depends upon the environment (soil, water) and cul-

tivation system and/or ecosystem. Yearly yield may be only a few pounds per year for tall, spindly plants growing under heavy forest shade. Annual yields of up to approximately 80,000 kg/ha (71,000 lb/ac) or more may be realized with large-fruited genotypes grown in monoculture (about 716 plants/ha [290 plants/ac]) in full sun with heavy fertilization. Yields depend upon many factors, including soil fertility, environment, genotype, and planting density.

Processing required

Fermented fruit juice

Ripe fruits are washed and sometimes pulped before they are placed into large fermentation containers, sometimes with added water. With time, the juice separates naturally from the fruit pulp, and ferments naturally via a bacterial (acidification) process. The preferred minimum processing (fermentation) time for fermented juice products is 60 days; thereafter the juice is drained from the fermentation vessel and bottled. Fermented juice (when uncontaminated and with low pH, e.g., approximately 3.5–4.0) will store well at room temperature without pasteurization. The juice is bottled in glass or plastic containers.

Fresh-squeezed fruit juice

The juice is pressed directly from ripe fruits using a mechanical device and bottled directly into glass or plastic containers and not allowed to ferment. These products are either pasteurized or refrigerated to preserve their integrity.

Re-constituted fruit juice and fruit juice drinks

These products are made from dehydrated fruits (green or ripe).

Fruit juice drinks

Raw juice is mixed in various proportions with other compatible liquids (e.g., other fruit juices, coconut milk, etc.).

Fruit juice concentrates

Fermented juice is subjected to flash evaporation or other evaporation technology to produce concentrated juice (a percentage of water is removed). The concentrate may be used to produce a range of juice products or cosmetics.



Newly planted commercial field. PHOTO: S. C. NELSON



Ripe fruit ready for processing (left) and noni juice product (right). PHOTOS: S. C. NELSON

Fruit powders

Fruits (whole or seedless, green or ripe) are dried and crushed into powders and sold wholesale to drink or tablet/capsule manufacturers.

Fruit leather

Another product is noni fruit leather, which is a thin sheet of dehydrated fruit pulp.

Oil

Oil is derived from pressed seeds.

Leaf powders

Dried leaves are crushed into powders and used to produce a range of products for internal consumption or cosmetic use.

Markets

The market for products is worldwide, with the largest markets in North America, Mexico, Asia, and Australia. The worldwide market for noni products was an estimated US\$400 million in 2002.

INTERPLANTING/FARM APPLICATIONS

The benefits of interplanting may include fewer disease and pest problems. However, negative plant pest and disease interactions are also possible with some interplanting systems.

Some interplanting systems include

- traditional subsistence farming intercropping with breadfruit, kava, papaya, mango, coconut, cordage plants, banana, timber species, coastal shrubs, and grasses
- modern commercial intercropping with papaya and coconut.

Noni can also thrive in forest understory settings and can benefit from the composting organic matter and mulch provided by associated plant species (benefits include nutrition, weed suppression, soil structure, and soil moisture retention).

Example system 1

Location

Federated States of Micronesia (e.g., Pohnpei).

Description

Traditional, low-yield, sustainable system.

Other crops/yields/services

Other crops in the system include banana, coconut, papaya, breadfruit, betel nut, citrus, kava, yam, taro, sweetpotato, and cassava.

Spacing

Random/natural.

Example system 2

Location

Northern Marianas

Description

Traditional, low-yield/sustainable system.

Other crops/yields/services

Coconut, banana, pasture.

Spacing

Random/natural.

Example system 3

Location

Hawai'i.

Description

Newly developed, moderate-high yields (experimental).

Other crops/yields/services

Interplanted with papaya.

Spacing

The spacing is 4–5 m (13–16 ft) between plants within rows.

PUBLIC ASSISTANCE AND AGROFORESTRY EXTENSION

The Cooperative Extension Service (CES) of the University of Hawai'i can assist landowners with questions relating to noni.

University of Hawai'i at Mānoa
College of Tropical Agriculture and Human Resources
Cooperative Extension Service
Komohana Agricultural Complex
875 Komohana St., Hilo, HI 96720
Tel: 808-959-9155; Fax: 808-959-3101
Web: <<http://www.ctahr.hawaii.edu>>

Extension offices for agroforestry and forestry in the Pacific: <<http://www.traditionaltree.org/extension.html>>.

INTERNET

“The Noni Website” (University of Hawai'i at Mānoa) by the author is full of practical information about noni: <<http://www.ctahr.hawaii.edu/noni/>>.

“Sorting *Morinda* names” maintained by the University of Melbourne presents a wide range of noni names and references: <<http://gmr.landfood.unimelb.edu.au/Plantnames/Sorting/Morinda.html>>.

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Species Profiles for Pacific Island Agroforestry (www.traditionaltree.org)

Morinda citrifolia (noni)

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