Morinda citrifolia L.

Rubiaceae (Rubioideae) Coffee family

canary wood (Australia), fromager, murier indien (French), I (Kosrae), Indian mulberry (English), lada (Guam, Northern Marianas), 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), weipwul (Pohnpei)

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 grows 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, medicines). 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. It has attained significant economic importance worldwide in recent years through a variety of health and cosmetic products made from leaves and fruits. These include fruit juices as well as powders made from the fruit or leaves.

Noni fruit in different stages of development (photo: S. Nelson)

Author: Scot C. Nelson, University of Hawai'i at Manoa, College of Tropical Agriculture and Human Resources (CTAHR), Department of Plant & Environmental Protection Sciences (PEPS), Cooperative Extension Service, 79-7381 Mamalahoa Hwy, Kealakekua, HI, USA 96750-7911 USA; Web: http://www.ctahr.hawaii.edu/noni/

Sponsors: U.S. Department of Agriculture's Western Region Sustainable Agriculture Research and Education (USDA-WSARE) Program and SPC/GTZ Pacific-German Regional Forestry Project. This material is based upon work supported by the Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, and Agricultural Experiment Station, Utah State University, under Cooperative Agreement 2002-47001-01327.

Publisher: Permanent Agriculture Resources (PAR), P.O. Box 428, Holualoa, HI 96725 USA; E-mail: par@agroforestry.net, Web site: http://www.agroforestry.net

Version: 2003.11.29

DISTRIBUTION

Native Range

Morinda citrifolia is native to Southeast Asia (Indonesia) and Australia. It grows in and tolerates a very wide range of soil and environmental conditions, with a notable ability to survive in harsh environments, such as those found on coral atolls or basaltic lava flows. It is naturalized in a wide range of dry to mesic sites 0–500 m in elevation. Noni can be found in solution pits or brackish tide pools near the coast, in limestone soils or outcroppings, on coral atolls, as a colonizing specie of basaltic lava flows, as well as in native forests (ca. 0–350 m at 19 degrees N or S latitude). Growth at higher elevations is possible near the equator, in disturbed forests, in dry to mesic forests, in alien grasslands, open areas near the shoreline, in pastures and coconut plantations, around villages, in a littoral forest understory, in fallow areas and waste places.

Current Distribution

The distribution of *Morinda citrifolia* is pantropical. The Indo-Pacific distribution includes Eastern Polynesia (e.g., Hawai'i, the Line Islands, Marquesas, Society Islands, Australs, Tuamotus, Pitcairn, and Cook islands), Melanesia (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. *Morinda citrifolia* 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.

Noni can grow from elevations of 500 m down to the ocean, here seen at Apia Harbor, Samoa (photo: C Elevitch)

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 Indian mulberry to that of the true mulberry (*Morus alba*). The species name indicates the resemblance of the plant foliage to that of some citrus species.

Family Rubiaceae

Subfamily Rubioideae

Common names

name	country or language
canary wood	Australia
fromager, murier indien	French
i	Kosrae
Indian mulberry	English
lada	Guam, the Northern Marianas
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

A small evergreen tree or shrub 3–10 m in height at maturity.

Form

Small trees, shrubs or sometimes lianas. There is much variation within the species *Morinda citrifolia* in overall plant form, fruit size, leaf morphology, palatability, odor of ripe fruit and number of seeds per fruit.

Flowers

Flowers perfect, with about 75–90 in ovoid to globose heads. Peduncles 10–30 mm long; calyx a truncated rim. Corolla white, 5–lobed, the tube greenish white, 7–9 mm long, the lobes oblong-deltate, approximately 7 mm long. Stamens 5, scarcely exserted; style about 15 mm long.

Leaves
Leaves opposite, pinnately veined and glossy. Blades membraneous, elliptic to elliptic-ovate, 20–45 cm long, 7–25 cm wide, glabrous. Petioles stout, 1.5–2 cm long. Stipules connate or distinct, 1–1.2 cm long, the apex entire or 2–3 lobed.

Fruit
Fruits (syncarp) are yellowish white; fleshy, 5–10 cm long, about 3–4 cm in diameter, soft and fetid when ripe.

Seeds
Seeds have a distinct air chamber , and can retain viability even after floating in water for months. [$2n = 22, 44$]

How to distinguish from similar species
The wood of *Morinda citrifolia* 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:

Morinda citrifolia var. citrifolia The primary topic of this article, of greatest cultural, economic and medicinal value and in greatest abundance in the Pacific region; a morphologically diverse species and with no clear sub-populations bearing unique characteristics, there exist large-fruited and small-fruited members of this group.

Morinda citrifolia var. bracteata Small-fruited variety with conspicuous bracts. Found in Indonesia and other parts of the area between the Indian and Pacific Oceans.

Morinda citrifolia cultivar 'Potteri' An ornamental plant 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 (also called pawpaw, *Carica papaya*), palms (e.g., betel nut palm, *Areca catechu*), coconut (*Cocos nucifera*), *Pandanus* spp., *Hibiscus tiliaceus*, *Cordyline fruticosa*, and *Piper* species (e.g., kava, *Piper methysticum*). Some of these associates are understory and some are overstory for noni. Noni grows as a recent introduction around villages or in home gardens, in back yards and along streams and gulches.

ENVIRONMENTAL PREFERENCES AND TOLERANCES

Climate
Elevation range 1–500 m, dependent on latitude and environment.

Mean annual rainfall 250–4000 mm

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

Mean annual temperature 20–35°C

Mean maximum temperature of hottest month 32–38°C

Mean minimum temperature of coldest month 5–18°C

Minimum temperature tolerated 12°C

Soils
Soil texture Tolerates a wide range of soils.

Soil drainage Noni tolerates a wide range of drainage conditions including seasonally waterlogged, but the preference is for free, well-drained soils.

Soil acidity Can grow in a wide range of acidity levels, from acidic to alkaline.

Special soil tolerances 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
Grows well in full sun.

Shade
Noni can grow in a wide range of light intensities, from 0% to over 80% shade.

Fire
Can regenerate after fire by sprouting new foliage through roots or stems.

Waterlogging
Withstands and even thrives in brackish tide pools. It can also tolerate flooded conditions for a long period of time.

Salt spray
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.

Unusual locations
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.

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

Noni growing under coconuts in pahoehoe lava flow at 10 m elevation at Pu'uhonua o Honaunau, Island of Hawai'i (photo: C. Elevitch)

Abilities

Regenerate rapidly
Noni plants regenerate well, even after severe pruning ("stumping").

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

Pollard
Noni may be cut back to the trunk to promote the growth of a dense head of foliage.

GROWTH AND DEVELOPMENT

Growth Rate
Growth is moderate, generally 0.75–1.5 m/year.

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).

Yields (quantity per year)
Fruit yield per year varies among noni varieties or genotypes and upon the environment (soil, water) and cultivation system and/or ecosystem. Yearly yield may be only a few pounds per year for tall, spindly plants growing under heavy forest shade. Yields up to approximately 80,000 kg/hectare or more may be realized with large-fruited genotypes grown in monoculture (about 120 plants per hectare) in full sun with heavy fertilization.

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

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.

PROPAGATION

Noni is relatively easy to propagate. It can be propagated 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 turned fully soft, translucent, and characteristically odorous. For seed production, the riper the fruit, the better. Collect from plants that have desirable characteristics, such as large fruit for fruit production, or vigorous leaf growth for hedges, etc.

Seed Processing

Let the fruit ripen fully until it all turns soft 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 that the seeds. The soft, fibrous flesh will slowly be removed from the seeds as they are rubbed against the screen. It may take 15 minutes to completely remove the clinging flesh. Rinsing the pulp in water periodically helps remove the flesh. The seeds have an air bubble trapped inside, so contrary to 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 completely removed, 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, one year is thought to be a reasonable storage time.

Germination is high for fresh seeds, often over 90%. There are approximately 40,000 seeds per kg.

Noni seeds can remain viable floating in water for months (photo: S. Nelson)

Time to outplanting

Noni seedlings (if not direct seeded into the ground) may be outplanted from about 2–12 months after germination. Young noni seedlings (8–12 weeks old; 10–15 cm tall) may require more care and may be more vulnerable to the environmental fluctuations and pest attack than older seedlings. Older seedlings, grown in full sun in 2- or 3-liter 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.

Pre-planting seed treatment

Without pretreatment, noni seeds germinate sporadically over 6–12 months. Scarification of the tough seed coat of noni, 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. 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 air temperature of approximately 38°C.

Potting media

Weed and nematode-free natural or local forest soils mixed with sand, volcanic cinders and/or composted organic matter are excellent for seedling production of noni. A preferred potting 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 for 15 minutes) prior to using. Most nurseries prefer and utilize 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.

Light requirement

Noni seeds can germinate in conditions ranging from deep shade to full sun. Most uniform germination is achieved in light partial shade (20–30%).

Rooted cutting (left) and seedling (right) ready for outplanting (photos: S. Nelson)

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 1 part peat to 1 part perlite or vermiculite only. Warm, moist and light conditions are beneficial for optimal germination.

After the germination and early establishment phases, partial shade (20–30%) is used for growing out the individual seedlings in containers.

Establishment Phase (2–3 months)

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 1 part perlite to 1 part peat. Cover lightly with 5–10 mm of potting media. Keep moist with a fine sprayer so as not to disturb the seeds or the media. The seedlings trays or pots may be kept in shade or in full sun. An even temperature of 38°C is recommended, which can be achieved with bottom heat.

Active Growth Phase (8 months)

When the seedlings reach the 4-leaf stage, carefully transplant to individual containers for the growth phase. Root training pots approximately 2.5 in square by 5 in deep or larger work well. One gallon root-training containers can also be used.

Seedlings should be grown in light 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 of woody stem tissue (being at least 150–180 days old) has excellent performance after outplanting.

Propagation from stem cuttings

The size of stem cuttings is arbitrary, but 20–40 cm 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.

Other notes on nursery culture

As an alternative to sowing noni seeds in seed germination beds, young noni seedlings may 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.

Seedling development

After outplanting, the first year of seedling development is slow due to transplant shock and the establishment of root systems. In Years 2–3, seedling growth is much more rapid as the crown gains size and photosynthetic mass.

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 natural 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 monoculture on lands previously used for fruit or vegetable crops tends to be exposed to new pests and pathogens that may not be present or abundant 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 gosypii*), 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 haemorroidalis*), and an unidentified specie 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. Insect damage may be more severe in relatively dry or low-rainfall locations or in full-sun plantings as an expansive monocrop.

Pathogens and biotic diseases

In damp, high-rainfall or flooded areas, noni is prone to certain plant diseases caused by fungi (leaf spots (*Colletotrichum* sp. and others); stem, leaf and fruit blights (*Phytophthora* sp.; *Sclerotium rolfsii*). Noni is very susceptible to attack and damage caused by several species of root-knot nematodes (*Meloidogyne* spp.), which can be minimized by avoiding previously used agricultural soils and planting in more rocky locations, if possible. Some foliar diseases caused by fungi (leaf spots and blight) may significantly inhibit leaf growth and fruit development.

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 and purpling and marginal necrosis. 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. Design 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 of phytotoxicity if different pesticides are used on the different crops must also be considered.

AGROFORESTRY/ENVIRONMENTAL PRACTICES

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

Homegardens
Noni is well suited for home gardens; a single plant is sufficient to meet the needs of one or more families

Boundary markers
Noni is relatively well suited for boundary markers due to its persistence and ability to survive harsh conditions and extended periods of drought.

Animal fodder
Noni fruits are useful as animal feeds or fodder (pets and livestock).

Woodlot
Noni is very compatible with lowland forest or woodlot plant species throughout the Pacific. Noni itself is not managed for wood production.

Native animal/bird food
Leaves of noni are used for fodder (e.g., Niue); ripe fruits are a natural source of food for birds, rodents and insects.

Wildlife habitat
Noni supports bird populations as a source of food for them.

Bee forage
Noni flower nectaries are very attractive to honey bees.

Coastal protection
Noni can help to stabilize lands in harsh or unstable coastal environments

Ornamental
The cultivated *M. citrifolia* variety 'Potteri' is a beautiful and functional ornamental plant with small fruits and green and white variegated leaves. 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 insect species.

Ripe noni fruit (photo: S. Nelson)

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 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).

Terminal bud
Medicinal uses (e.g., Northern Marianas); used as food (e.g., Kiribati)

Nut/seed
The seeds are used to make a fetid oil rubbed into hair as an insecticide or insect repellent.

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.

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)
Teas from the leaves are used as treatment for malaria, general febrifuge and analgesic (Africa); 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); seed oil (scalp insecticide); 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 (fruit); toothaches (fruit); sties (flowers or vapor from broken leaves); stomachache; "ghost medicine;" fractures; diabetes; loss of appetite; urinary tract ailments; abdominal swelling; hernias; stings from stonefish; and human vitamin A deficiency (leaves). They are also used as a medicinal poultice or body wrap (e.g., Micronesia).

Medicinal uses or purported applications (contemporary, worldwide)
Purported treatments for 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.

Flavoring/spice
The leaves of noni are used to wrap fish or other meats/foods during cooking.

Masticant/stimulant
Fruits of noni are used as an appetite and brain stimulant.

Timber
The wood of noni was/is used in light construction, canoe parts and paddles, axe handles, and digging sticks.

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

Craft wood/tools
The wood of noni was/is used to construct handles for tools (e.g., adzes). Roots used for carving (e.g., Niue).

Canoe/boat/raft making
The wood of noni was/is used to make canoe parts and paddles.

Wrapping/parcelization
The leaves are used to wrap food for cooking (e.g., the Cook Islands).

Dye
The bark contains a red pigment used for making dyes. The roots also contain a yellow pigment used in making dyes. Dyes from noni were/are used to color clothing and fabrics.

Food for animals
Leaves used for livestock fodder (e.g., Niue, India); the leaves used to feed silkworms (e.g., India); the fruit is used as pig food (e.g., Puerto Rico).

Spice
The leaves used to wrap and flavor food before cooking.

Repellant
A fetid oil obtained from seeds is used as scalp insecticide or insect repellant (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.

Ripe fruit ready for processing (left) and noni juice product (right) (photos: S. Nelson)

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), leaf powders (for encapsulation or pills).

Spacing 4–5 m within 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.

Yield Up to 80,000 kg of fruit per hectare, depending upon 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. The juice separates naturally from the fruit pulp eventually, 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.

Fruit powders

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

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.

Market

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

Newly planted commercial field (photo: S. Nelson)

INTERPLANTING/FARM APPLICATIONS

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

Some interplanting systems include:

- Traditional subsistence farming intercropping: breadfruit, kava, papaya, mango, coconut, cordage plants, banana, timber species, coastal shrubs and grasses.
- Modern commercial intercropping: papaya, coconut.

Noni can 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 1

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

Description Traditional, low yield, sustainable system

Other crops/yields/services banana, coconut, papaya, breadfruit, betel nut, citrus, kava, yam, taro, sweet potato, cassava.

Spacing Random/natural

Example 2

Location Northern Marianas

Description Traditional, low yields/sustainable system

Other crops/yields/services coconut, banana, pasture.

Spacing Random/natural

Example 3

Location Hawai'i

Description Newly developed, moderate-high yields/ unknown (experimental or very new practice).

Other crops/yields/services Interplanting with papaya

Spacing 4–5 m between plants within rows

RECOMMENDED READING

McClatchey, W. 2002. From Polynesian Healers to Health Food Stores: Changing Perspectives of *Morinda citrifolia* (Rubiaceae). Integrative Cancer Therapies 1(2): 110–120.

Nelson, S.C. 2001. Noni cultivation in Hawaii. Univ. of Hawaii CTAHR–Cooperative Extension Service PD–19.

Nelson, S.C. (Ed). 2003. Proceedings of the 2002 Hawaii Noni Conference. Univ. of Hawaii CTAHR–Cooperative Extension Service Proceedings P–1/03. 50 pp.

Valentine, N. 1999. A Preliminary Report on Non-timber Forest Products in Some Pacific Island Countries (with a case study on Morinda citrifolia). SPC/UNDP/AusAID/FAO Pacific Islands Forests and Trees Support Programme. RAS/97/330, Working Paper No. 6.

Wagner, W.L., D.H. Herbst, and S.H. Sohmer, 1999. Manual of Flowering Plants of Hawai'i (Revised Edition); University of Hawai'i Press.

PUBLIC ASSISTANCE

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

University of Hawai'i at Manoa
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://www2.ctahr.hawaii.edu/

INTERNET

"The Noni Website" (University of Hawaii at Manoa) 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`

LITERATURE

This publication relied upon a comprehensive bibliography for Morinda citrifolia, organized as follows by several categories of information.

Hawaiiana and ethnobotany

Abbott, I.A. 1992. La'au Hawai'i: traditional Hawaiian uses of plants. Honolulu, Hawai'i, Bishop Museum Press.

Abbott, I. and C. Shimazu. 1985. The Geographic Origin of the Plants Most Commonly Used for Medicine by Hawaiians. Journal of Ethnopharmacology 14: 213–222.

Baldwin, R.E. 1979. Hawai'i's Poisonous Plants. Petroglyph Press.

Beckwith, M. 1970. Hawaiian Mythology. University of Hawai'i Press.

Beckwith, M. 1972. The Kumulipo. University of Hawai'i Press.

Buck, P.H. 1957. (Te Rangi Hiroa); Arts and Crafts of Hawai'i. Bishop Museum Press.

Chun, M.N. 1994. Native Hawaiian Medicine. Honolulu, HI: First People's Productions.

Chun, N.Y. 1995. Hawaiian Canoe Building Traditions. Kamehameha Schools Press.

Degener, O. 1945. Plants of Hawai'i National Park illustrative of plants and customs of the South Seas. Ann Arbor, Michigan, Edward Brothers.

Dixon, A.R., H. McMillen and N.L. Etkin. 1999. Ferment This: The Transformation of Noni, a Traditional Polynesian Medicine (*Morinda citrifolia*, Rubiaceae). Economic Botany 53:51–68.

Elkins, R. 1997. Hawaiian Noni (*Morinda citrifolia*). Woodland Publishing.

Emerson, N.B. 1965. Unwritten Literature of Hawai'i. Charles E. Tuttle Co., Inc.

Fornander, A. 1967. Collection of Hawaiian Antiquities and Folklore. Bishop Museum Press, 1916–20.

Gutmanis, J. 1994. Kahuna La'au Lapa'au: The Practice of Hawaiian Herbal Medicine. Hong Kong: Island Heritage Publishing.

Handy, E.S.C. 1985. The Hawaiian Planter: His Plants, Methods and Areas of Cultivation. Bernice P. Bishop Museum.

Handy, E.S.C. and M.K. Pukui. 1958. The Polynesian Family System in Ka'u, Hawai'i. Charles E. Tuttle Co.

Handy, E.S.C. and E. Green. 1972. Native Planters in Old Hawai'i. Bishop Museum Press.

Handy, E.S.C., M.K. Pukui and K. Livermore. 1934. Outline

of Hawaiian Physical Therapeutics. Bishop Museum Press, Honolulu, HI.

Hargreaves, D. and B. Hargreaves. 1964. Tropical Trees of Hawai'i. Hargreaves Co., Inc.

Holmes, T. 1981. The Hawaiian Canoe. Editions Ltd.

Ka'ai'akamanu, D.K. and J.K. Akina. 1973. Hawaiian Herbs of Medicinal Value. Charles E. Tuttle, Co.

Kahiolo, G.W. 1978. He Mo'olelo No Kamapua'a: The Story of Kamapua'a. Translated by T. Mookini.

Kay, E.A. 1995. Natural History of the Hawaiian Islands: Selected Readings II. The University of Hawai'i Press.

Kefford, N.P. 1997. Workshop on kava, noni and other Hawai'i medicinal herbs. University of Hawai'i at Manoa, College of Tropical Agriculture and Human Resources.

Krauss, B.H. 1976. Ethnobotany of Hawai'i. The University of Hawai'i Press.

Krauss, B.H. 1981. Native Plants Used as Medicine in Hawai'i. 2nd ed. Honolulu, HI: Lyon Arboretum.

Krauss, B.H. 1993. Plants in Hawaiian Culture. The University of Hawai'i Press.

Kent, H.W. 1986. Treasury of Hawaiian Words in 101 Categories. University of Hawai'i Press.

Kepler, A.K. 1998. Hawaiian Heritage Plants (Revised Edition). University of Hawai'i Press.

Kepler, A.K. 1990. Trees of Hawai'i. University of Hawai'i Press.

Kuck, L.E., and Tongg, R.C. 1958. A Guide to Tropical and Semi-Tropical Flora. In: Hawaiian Flowers and Flowering Trees. Charles E. Tuttle, Co.

Kwiatkowski, P.F., and N.K. Pohaku 1991. A Hawaiian Petroglyph Primer. Ku Pa'a, Inc., Honolulu, Hawai'i.

Lucas, L. 1982. Plants of Old Hawai'i. Honolulu, Hawai'i. The Bess Press.

McBride, L.R. 1975. Practical Folk Medicine of Hawai'i. Hilo, Hawai'i. The Petroglyph Press

Palmer, R.M.J. 1987. Maui Organic Growing Guide. Oasis Maui, Inc.

Pukui, M.K. 1983. 'Olelo No'eau—Hawaiian Proverbs and Poetical Sayings. Bishop Museum Press.

Pukui, M.K. and S.H. Elbert. 1986. Hawaiian Dictionary. University of Hawai'i Press.

Pukui, M.K., E.W. Hoirtig and C.A. Lee. 1979. Nana I Ke Kumu—Look To The Source, Vol. I and II. Queen Liliuokalani Children's Center.

Pukui, M.K., S.H. Elbert and E.T. Mookini.1976. Place Names of Hawai'i. University of Hawai'i Press.

Stevens, R.L. 1981. Organic Gardening in Hawai'i. Petroglyph Press.

Tabrah, F.L. and B.M. Eveleth. 1966. Evaluation of the Effectiveness of Ancient Hawaiian Medicine. Hawaii Medical Journal 25: 223–230.

Williams, J.S. 1997. From the Mountains to the Sea: A Hawaiian Lifestyle; Kamehameha Schools Press.

Pacific islands and tropics

Biggs, B.G. 1985. Contemporary healing practices in east Futuna. In: Parsons, C.D.F. ed.

Cambie, R.C. and J. Ash. 1994. Fijian Medicinal Plants. CSIRO, Australia.

Clarke, W.C., and R.R. Thaman. 1993. Agroforestry in the Pacific Islands: Systems for Sustainability. United Nations University Press.

Charlot, J. 1983. Chanting the Universe. Emphasis International.

Dittmar, A. 1993. *Morinda citrifolia* L: Use in Indigenous Samoan Medicine. Journal of Herbs and Medicinal Plants, Vol. 1(3).

Dodd, E. 1990. The Island World of Polynesia. Windmill Hill Press.

Fornander, A. 1969. An Account of the Polynesian Race. Charles E. Tuttle Co., Inc.

Guppy, H.B. 1917. Plants, seeds and currents in the West Indies and Azores. Covent Garden, London, England: Williams and Norgate.

Henderson, C.P., and I.R. Hancock. 1989. A Guide to the Useful Plants of Solomon Islands. Ministry of Agriculture and Lands, Solomon Islands.

Jansen, A.A.J., S. Parkinson and A.F.S. Robertson (Eds). 1990. Food and Nutrition in Fiji: An Historical Review. Vol. 1, Food Production, Composition and Intake. The University of the South Pacific, Suva, Fiji.

McClatchey, W. 1996. The Ethnopharmacopoeia of Rotuma. Journal of Ethnopharmacology 50:147–156.

McCormack, G. 1998. Noni—A Miracle Medicine? Cook Islands Natural Heritage Project.

Merlin, M., A. Capelle, T. Keene, J. Juvik, and J. Maragos. 1994. Plants and Environments of the Marshall Islands. East-West Center.

Morton, J. 1992. The ocean-going noni, or Indian Mulberry (*Morinda citrifolia*, Rubiaceae) and some of its "colorful" relatives. Economic Botany 46:241–256.

Singh, Y., T. Ikahihifo, M. Panuve, and C. Slatter. 1984. Folk Medicine in Tonga. A Study on the Use of Herbal Medicines for Obstetric and Gynecological Conditions and Disorders. Journal of Ethnopharmacology 12: 305–325

Valentine, N. 1999. A Preliminary Report on Non-timber Forest Products in Some Pacific Island Countries (with a case study on *Morinda citrifolia*). SPC/UNDP/AusAID/FAO Pacific Islands Forests and Trees Support Programme. RAS/97/330, Working Paper No. 6.

Wee ,Y.C. 1992. A Guide to Medicinal Plants. Singapore Science Centre.

Whistler, W.A. 1980. Coastal Flowers of the Tropical Pacific. Pacific Tropical Botanical Garden.

Whistler, W.A. 1992. Polynesian Herbal Medicine. Lawai, Kaua'i, Hawai'i. National Tropical Botanical Garden.

Whistler, W.A. 1991. Polynesian Plant Introductions. In: Cox, P.A., Banack, S.A., eds. Islands, Plants, and Polynesians. Portland, OR: Dioscorides Press, pp. 41–66.

Whistler, W.A. 1992. Tongan Herbal Medicine. Isle Botanica, Honolulu, Hawai'i, 89–90 pp.

Whistler, W.A. 1992. Polynesian Herbal Medicine. National Tropical Botanical Garden.

Whistler, W.A. 1996. Wayside Plants of the Islands: a Guide to the Lowland Flora of the Pacific Islands. The University of Hawai'i Press.

Agricultural research and extension

Nelson, S.C. 2001. Noni cultivation in Hawaii. Univ. of Hawaii CTAHR–Cooperative Extension Service PD–19.

Books in popular press

D'Raye, T. 1998. Simply Noni—Ancient Health Miracle for Modern Times. Awieca Publishing, Inc.; March 2000, 2nd edition.

Elkins, R. 2002. The Noni Revolution: The Tropical Wonder That Can Fight Disease Boost Energy and Revitalize Your Health. Woodland Publishing.

Fairechild, D. 2001. Noni: Aspirin of the Ancients. Flyana Rhyme.

Gibbons, E. 1967. Beachcomber's Handbook. David McKay Co., Inc.

Navarre, I. 2001. 76 Ways to Use Noni Fruit Juice. Direct Source.

Solomon, N. 1998. Noni: Nature's Amazing Healer. Woodland Publishing Co., Utah.

Solomon, N. 2000. Tahitian Noni Juice: How Much, How Often, For What. Direct Source.

Solomon, N. 1999. The Noni Phenomenon. Direct Source.

Solomon, N. 1998. Liquid Island Noni (*Morinda citrifolia*. Woodland Publishing Co, Utah.

Medical and health research

Daniel, E.M., A.S. Krupnick, Y. Heur, J.A. Blinzler, R.W. Nims, and G.D. Stoner. 1989. Journal of Food Composition and Analysis, vol. 2, pp. 338–349.

Fong, S.T., A. Johnson, C-T. Ho, K. Csiszar. 2001. Extracts of *Morinda citrifolia* (noni) exhibit selective anti-tumor activity against breast and colon carcinoma cell lines. Poster presented at: Building Bridges with Traditional Knowledge Summit meeting; May 30, 2001; Honolulu, HI.

Heinicke, R.M. 1985. The pharmacologically active ingredient of noni. Pacific Tropical Botanical Garden Bulletin 15:10–14.

Hiramatsu, T., M. Imoto, T. Koyano and K. Umezawa. 1993. Induction of normal phenotypes in ras-transformed cells by damnacanthal from *Morinda citrifolia*; Cancer Letters 73(2–3):161–6.

Hirazumi, A. and E. Fususawa. 1999. An immunomodulatory polysaccharide-rich substance from the fruit juice of *Morinda citrifolia* (noni) with anti-tumor activity. Phytotherapy Research 13:380–7.

Hirazumi, A., E. Furusawa, S.C. Chou, and Y. Hokama. 1996. Immunomodulation contributes to anti-cancer activity of *Morinda citrifolia* (noni) fruit juice. Proceedings of the Western Pharmaceutical Society 39:7–9.

Hirazumi, A., E. Furusawa, S.C. Chou, and Y. Hokama. 1994. Anticancer activity of *Morinda citrifolia* (noni) on intraperitoneally implanted Lewis lung carcinoma in syngenic mice. Proceedings of the Western Pharmaceutical Society 37:145–6.

Issell, B. 2001. The Noni Study. Honolulu, HI: Cancer Research Center of Hawai'i, Clinical Studies, www.hawaii.edu/crch/CenStudyNoni.htm.

Leistner, E. 1975. Isolation, identification and biosynthesis of anthraquinones in cell suspension cultures of *Morinda citrifolia* [Article in German] Planta Medica Supplement 214–224.

Levland, O., and H.O. Larson. 1979. Some Chemical Constituents of *Morinda citrifolia* (Noni); Planta Medica 36: 186 – 87.

Liu, G., A. Bode, W.Y. Ma, S. Sang, C-T. Ho, and Z. Dong. 2001. Two novel glycosides from fruits of *Morinda citrifolia* (noni) inhibit AP-1 transactivation and cell transformation in the mouse epidermal JB6 cell line. Cancer Research 61:5749–56.

Limyati, D.A., and B.L. Juniar. 1998. Jamu Gendong, a kind of traditional medicine in Indonesia: the microbial contamination of its raw materials and end product. Journal of Ethnopharmacology (633):201–8.

Mueller, B.A., M.K. Scott, K.M. Sowinski, and K.A. Prag. 2000. Noni juice (*Morinda citrifolia*): hidden potential for hyperkalemia? American Journal of Kidney Diseases 35(2):330–2.

Narayanan B.A., O. Geoffrey, M.C. Willingham, G.G. Re, and D.W. Nixon. 1999. Cancer Letters, vol. 136, pp.215–221.

Sugiura, K., and C.C. Stock. 1955. Studies in a tumor spectrum. III. The effect of phosphoramides on the growth of a variety of mouse and rat tumors. Cancer Research 15:38–51.

Sylvester, E.J. 1986. Target Cancer. Charles Scribner's Sons, N.Y.

Wang, M., H. Kikuzaki, K. Csiszar, C.D. Boyd, A. Maunakea, S.F. Fong, G. Ghai, R.T. Rosen, N. Nakatani, and C.T. Ho. 1999. Novel trisaccharide fatty acid ester identified from the fruits of *Morinda citrifolia* (Noni). Journal of Agricultural Food Chemistry 47:4880–2.

Wang, M., H. Kikuzaki, Y. Jin, N. Nakatani, N. Zhu, K. Csiszar, C.D. Boyd, R.T., Rosen, G. Ghai, and C.T. Ho. 2000. Novel glycosides from noni (*Morinda citrifolia*). Journal of Natural Products 63:1182–3.

Younos, C., A. Rolland, J. Fleurentin, M.C. Lanhers, R. Misslin, F. Mortier. 1990. Analgesic and behavioral effects of *Morinda citrifolia*; Planta Medica 56(5):430–4.

Zenk, M.H., H. el-Shagi, and U. Schulte. 1975. Anthraquinone production by cell suspension cultures of *Morinda citrifolia*. Planta Medica Supplement 79–101.

Botany

Byrd, A.G. 1992. Tropica: Color Cyclopedia of Exotic Plants and Trees. Roehrs Co., East Rutherford, New Jersey.

Chapin, M.H. 1990. Noni. Hawai'i Plant Conservation Center of the National Resource in Tropical Botany.

Johansson, J.T. 1994. The genus *Morinda* (Morindae, Rubiodeae, Rubiaceae) in New Caledonia: taxonomy and phylogeny. Opera Botanica 122:1–67.

Neal, M. 1965. In Gardens of Hawai'i. Bishop Museum Press.

Wagner, W.L., D.H. Herbst, and S.H. Sohmer. 1999. Manual of Flowering Plants of Hawai'i (Revised Edition); University of Hawai'i Press.

Periodicals

Anon. 1994. Phytochemicals. Newsweek Magazine, April 25.

Fackelman, K. 1997. Science News 151: 274–275.

Fairechild, D. 1999. Noni and 'Awa: Hawai'i Agriculture's Newest Hope. Spirit of Aloha (Aloha Airlines in-flight magazine).

Kaltsas, H. 2001. Noni: From Legend to Promising Nutraeutical. Alternative Medicine Journal, January, 2001.

Khan, D. 1999. Fijian Businessman Exports *Morinda citrifolia* juice. Pacific Islands Forest and Trees Newsletter No. 2/99 pp. 7.

TenBruggencate, J. 1992. Native Plants Can Heal Your

Wounds, Honolulu Sunday Star Bulletin and Advertiser, Feb. 9, Honolulu, Hawai'i.

Miscellaneous

Kanahele, G.H. 1988. A Hawaiian Sense of Place, Course I and II. Sponsored by Hotel Hana Maui, 1988 (included study-book).

Zepernick, B. 1972. Arneipflanzen der Polynesier. Berlin, Germany: Verlag von Dietrich Reiner.

Review articles

McClatchey, W. 2002. From Polynesian Healers to Health Food Stores: Changing Perspectives of *Morinda citrifolia* (Rubiaceae). Integrative Cancer Therapies 1(2): 110–120.

Ph.D. dissertations and M.S. theses

Hirazumi, A.Y. 1997. Antitumor studies of a traditional Hawaiian medicinal plant, *Morinda citrifolia* (noni), in vitro and in vivo. [Doctoral dissertation]. University of Hawai'i, Honolulu, HI.

McClatchey, W. 1993. The Traditional Medicinal System and Ethnopharmacopoeia of Rotuma. [Master's thesis]. Brigham Young University, Provo, UT.

O'Rourke-George, L. 1989. An ethnobotanical study of traditional medicine in Tonga. [Master's thesis]. Brigham Young University, Provo, UT.