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Intercropping coconuts with nitrogen-fixing trees

The open and well-lit lands under coconut plantations are commonly intercropped with coffee, cacao, and various annual crop combinations—or used for cattle pasture. All coconut intercropping practices take advantage of the extra resources available during the different coconut tree growth stages, substantially increasing the overall productivity of the land under this long-duration crop (Liyanage et al. 1984). Intercropping, like grazing livestock under coconut, is a traditional practice historically adopted by farm families to increase and diversify farm cash and food production.

Successful intercropping increases returns from coconut plantations. A study in Western Samoa compared the profitability of a coconut monocrop with several intercropping possibilities. Results indicate that in all cases, intercropping more than doubles the returns from coconut (Opio 1986). Often intercropping actually increases coconuts yields. Experiments conducted at the Coconut Research Institute of Sri Lanka demonstrate that intercropping with clove, black pepper, cacao, cinnamon, coffee, and a variety of annuals, increases coconut yields (Liyanage 1984). The likely explanation is that the palms benefit from cultural treatments applied to the intercrops—such as fertilization, weeding and tillage. A cultivated understorey also makes for easier collection of fallen coconuts.

Coconut intercropping and pasture practices that include nitrogen fixing trees are gaining attention as sustainable and productive land-use adaptations. Nitrogen fixing trees add rich organic matter to the often nutrient-poor soils of coconut plantations. At the same time, they provide additional farm products such as fuelwood and fodder. Tree leaf mulch—or "green manure"—buildssoil structure and sustains soil fertility in farming systems that include perennial crops such coconut. This is especially important on atolls and in costal areas where nutrient-poor coral-based soils predominate.

The fuelwood produced by these trees can be used by smallholders instead of coconut leaves and husks which can then be returned to the soil. Nitrogen fixing trees also produce nutritious protein-rich fodder that supplements pasture feed, reducing grazing pressure during periods when pastures are especially susceptible to degradation.

Selecting the Right Tree Species

Tree species must be selected according to soil and climate conditions, understorey shade intensity, land and labor availability, use/product requirements, and marketing possibilities.

- Choose trees that yield locally marketable or useful subsistence products such as fuelwood, fodder, or medicine.
- Choose trees that re-sprout vigorously after repeated pruning or lopping. These trees yield more green manure, fodder, and fuelwood.
- Choose trees that are shade-tolerant. The degree of tolerance required depends on the age and spacing of the coconut trees.
- Choose trees that are adapted to local site conditions such as annual rainfall amount and frequency, soil pH, and soil texture/drainage.

Research and field experience to date illustrates that *Leucaena leucocephala* and *Gliricidia sepium* both perform well in the coconut understorey—yielding useful fodder, fuelwood, and green manure.

Gliricidia sepium continues to yield copious amounts of succulent, high-protein leaf material after repeated lopping. It is moderately shade tolerant and performs well in acid soils where *Leucaena* does not.

Gliricidia sepium (Little and Wadsworth 1964)

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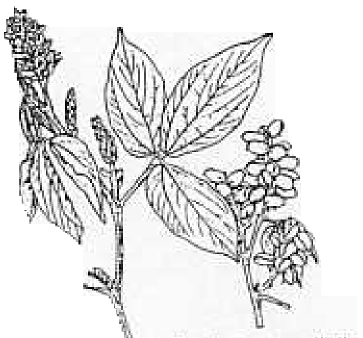
Gliricidia is especially suited for introduction into pastures because large cuttings (up to 5 cm in diameter and 2 m in length) can be established rapidly, with little effort. Such cuttings are almost immediately able to withstand browsing by livestock and competition from surrounding pasture plants.

Leucaena leucocephala does not tolerate dense shade but it grows well in most coconut understorey situations (Reynolds 1988). It prefers well-drained alluvial and coralline soils and will not tolerate waterlogging. Common *Leucaena* is losing favor because it is susceptible to the defoliating psyllid insect pest. It also performs poorly in acid soils. Breeding efforts to develop superior, psyllid-resistance varieties and interspecific hybrids have produced some promising results.

Leucaena leucocephala (Vergara 1982)

Leucaena diversifolia and *Flemingia macrophylla*, though not yet tested or used to any extent in coconut plantations, would probably also perform well.

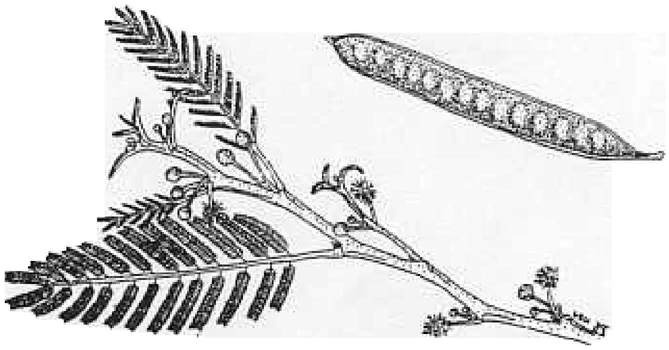
Flemingia does not produce as much woody biomass (fuelwood) or as digestible a fodder as *Leucaena* or *Gliricidia*. Where low soil moisture and periodic drought limit coconut production, however, this tree can produce large amounts of water-conserving, soil-enriching mulch.



Flemingia macrophylla

Flemingia leaves take a relatively long time to decompose. Piled around coconut trees they form a thick layer of rich organic mulch. This layer of mulch prevents weed germination, retains soil moisture, and slowly releases nutrients such as N, P, and K—right on top of the coconut root zone.

Leucaena diversifolia is a promising alternative to *L. leucocephala* in certain environments. It is more drought sensitive than its relative, but it shows more psyllid resistance and its leaves contain about half the mimosine content of *L. leucocephala*. (Mimosine is a toxic amino acid that can adversely affect the health of some livestock if eaten in large quantities.) *L. diversifolia* tolerates partial shade and is especially well adapted to cooler, wetter conditions and higher elevations. It does not appear to tolerate excessively saline or sodic soils so its use in the Pacific is limited to larger islands or interiors. A well-known hybrid between tetraploid *L. diversifolia* and *L. leucocephala* has potential.



Leucaena diversifolia (Dr. Diane Ragone 1984)

Nitrogen Fixing Tree Establishment and Management

Spacing and Arrangement. Experienced farmers in humid areas recommend planting trees at least 2 m from any coconut palm. In dryer areas, trees should be limited to the central meter of any alley between two rows of coconuts. This way, if coconuts are spaced 9 meters apart—as is recommended in drier areas—there will be close to 4 m between a nitrogen fixing tree and any coconut. This is assuming that coconuts are in a triangular arrangement as is recommended by most. Researchers agree that the triangular coconut arrangement makes more efficient use of available resources such as sunlight.

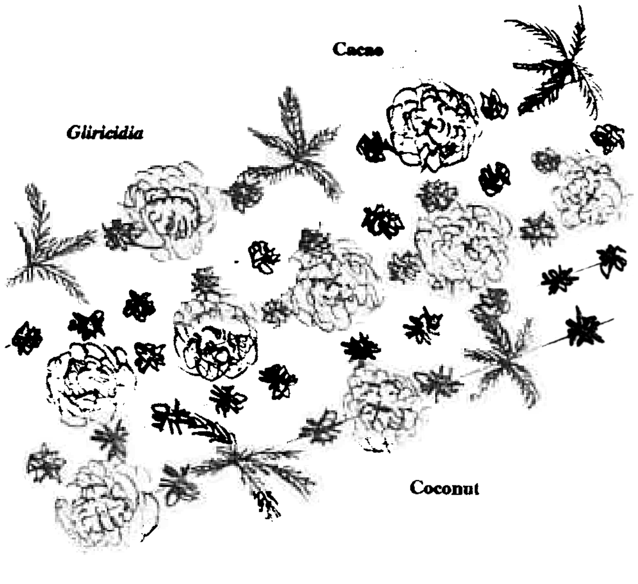
Where soil water is more limiting, opportunities to intercrop nitrogen fixing trees with coconut will be fewer. In the extreme case, it may be best to limit intercrops to shallow-rooted annuals or pastures. However, if there is enough water to grow a healthy coconut crop, nitrogen fixing trees can probably also be included. It is reasonable to assume that if annual rainfall exceeds 1900 mm, competition for water will not be a problem (Plucknett 1974; Liyanage 1984).

Degree of competition for both soil water and nutrients depends upon a number of natural and human-made factors including the water requirements of the different plants. All coconuts require a lot of water to grow and produce. *Leucaena, Gliricidia,* and *Flemingia* do not. They can, however, take up and transpire a lot of water if it is available. In doing so, they can draw the water table down until it is out of reach of the shallower coconut tree roots. Nitrogen fixing tree water consumption may be controlled to a degree with regular harvests of fuelwood, fodder and green manure. A regularly pruned tree will transpire much less than one with a continuously full canopy.

The following examples of well-tested practices illustrate important tree establishment and management considerations. They illustrate that nitrogen fixing trees can provide a wide array of products and services when included in coconut intercropping or pasture systems.

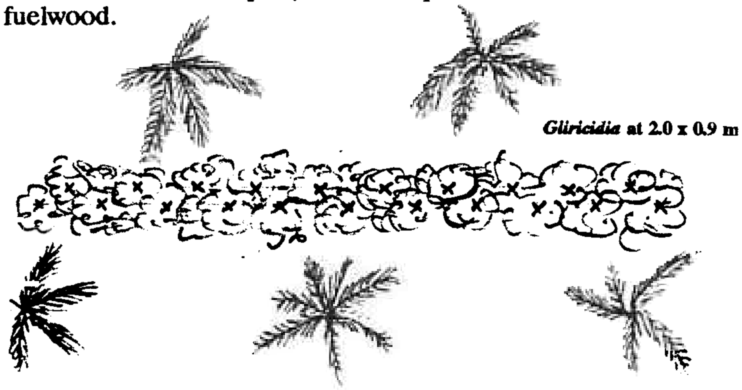
***Casuarina oligodon*, coffee and food crops.** According to Vergara and Nair (1985), farmers in the highlands of Papua New Guinea have been practicing this system since about 1960. It is one of the most promising in the Pacific region. The locally popular annual and perennial food crops, arabica coffee, and *Casuarina oligodon* are all included. Casuarina produces timber for fencing, house construction, and fuelwood. The ground is shaded continuously by a sequence of fast and slow growing species, so there is little need for weeding.

Coconut, cacao and *Gliricidia sepium*. In this system, *Gliricidia* provides shade to cacao plants and also yields fuelwood and fodder. The nitrogen fixing trees are especially useful in newly established plantations, where young coconuts do not provide adequate shade for cacao. Usually, trees are established with cuttings at spacings of 3 x 3 to 6 x 6 m. When the *Gliricidia* trees offer some shade, cacao can be planted in the understorey—typically at 2 x 2 m. The *Gliricidia* trees are periodically pruned to 2 or 3 meters to maintain a uniform canopy and provide mulch and fuelwood.



Schematic of coconut, cacao and *Gliricidia sepium arrangement*

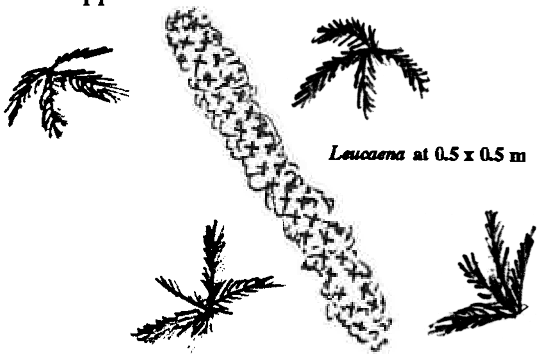
Coconut, *Gliricidia sepium* and cattle. The use of *Gliricidia sepium* trees in coconut plantations is of ancient origin (Liyanage 1987). Experimental results from Sri Lanka demonstrate that *Gliricidia*, when intercropped with coconut, controls weeds, improves soil structure through leaf fall, increases copra yields, and provides fodder and fuelwood.



Schematic of coconut, *Gliricidia* fodder/green manure system

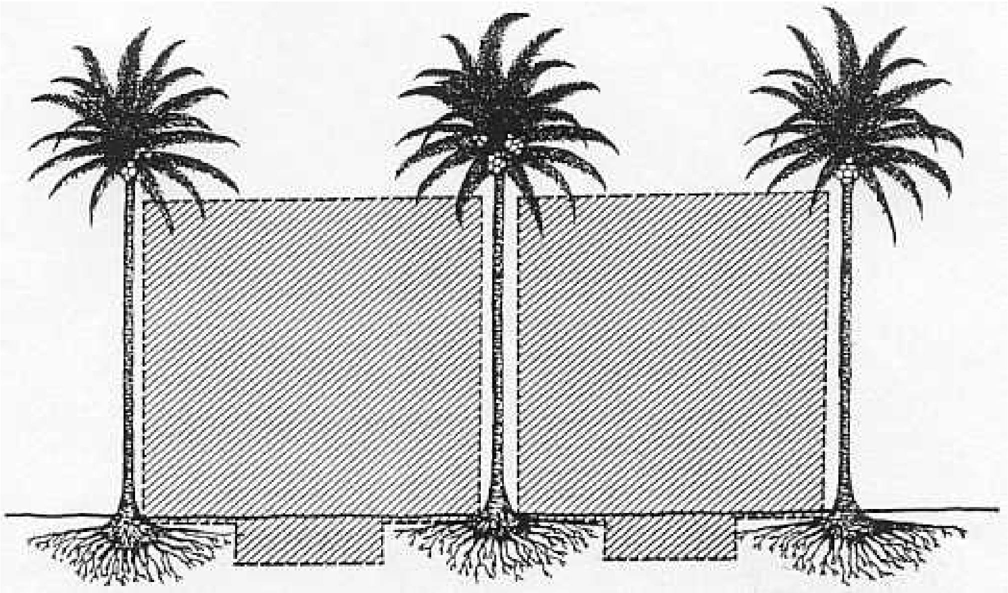
Experimental systems were established in mature coconut plantations in both wet and dry climates. Gliricidia cuttings 1.5 cm long and 2.5 cm in diameter were planted at 2.0 x 0.9 m in double rows in the coconut alleys. Cuttings were lopped one year after planting to 1 m and thereafter every six months. Loppings were dug into circular trenches around coconuts or fed as "cut and carry" fodder to cattle. Digging the leaves into trenches around the coconuts produced significant copra weight increases. A 50%/50% ration of Gliricidia leaves and Cori grass (*Brachiaria miliformis*) produced an average daily live weight gain of 700 g when fed to cattle.

Coconut, *Leucaena leucocephala* and pasture. *Leucaena* is sometimes planted into grass pasture under coconuts to provide supplemental browse.



Schematic of coconut, *Leucaena leucocephala* and pasture

The trees are commonly planted densely (0.5 m) in double rows. This arrangement keeps a good distance between the coconut and *Leucaena* root systems. This is necessary because *Leucaena* roots can be aggressively competitive, especially during dry periods. The *Leucaena* provides high-protein browse to supplement the typically lower-quality tropical grasses. It produces well even in stoloniferous grass pastures where it is difficult to maintain other legumes (Reynolds 1988). It produces best when grazed rotationally to allow recovery after all leaves have been removed.



Schematic representation of available intercropping area in coconut stand (Reynolds 1988)

Research Needs

Research is needed to test the performance of different nitrogen fixing trees as intercrops under coconut. Of particular interest would be a study of how repeated pruning affects the water uptake and root spread on nitrogen fixing trees in the coconut understorey. In addition, studies of different spacings/arrangements and resulting competitive or complementary interactions would be useful.

Further Reading

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