A Global Strategy
for the conservation and use of Coconut Genetic Resources
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Coconut genetic resources for enhanced livelihoods

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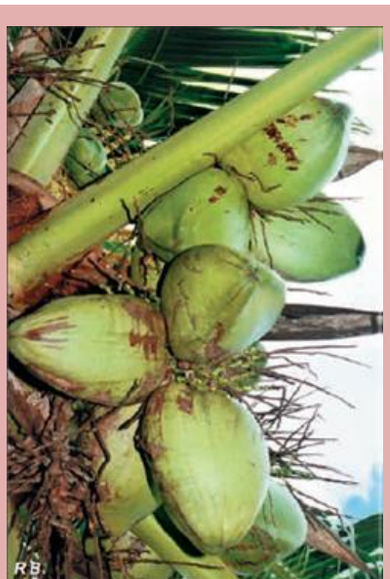

Niu Kafa Tall Tonga (NKF03), typical type from Indo-Atlantic genepool. (R. Bourdeix, CIRAD)

Phenotypic diversity is considerable in terms of fruit morphology, vegetative traits and disease resistance. Most (but not all) of the Pacific group coconuts are of the Niu Vai type, as described by Harries (1978). This type is characterized by round fruits with high water content and a low proportion of husk. In addition, they exhibit early germination and possess erect stems. Likewise, most of the varieties from the Indo-Atlantic group are of the Niu Kafa type as described by Harries, with sensitivity to lethal diseases caused by phytoplasmas, curved stems, and triangular fruits with thick husk, low water content (because the nut – and therefore its vacuole – is small), and slow germination. Correlations between microsatellite data and fruit morphology traits may indicate that at least some of the morphological differences between Indo-Atlantic and Pacific coconuts pre-existed human intervention.

2.1.2 Coconut domestication

The coconut palm is a coastal plant, naturally adapted to high insolation in tropical environments and sandy, saline soils. Protected by a thick husk and capable of retaining viability while floating for long periods in sea water, its fruit is well adapted for long-distance dispersal by oceanic currents. Natural inland propagation is restricted by its low competitive ability for light among rainforest plants, intense intraspecific competition due to its large seed mass, lack of dispersal agents and susceptibility to predation of its fruits and seedlings by mammals. Ethnobotanical and linguistic evidence suggests its domestication began in two different regions in the Pacific and Indian Ocean respectively.

Crop domestication is a co-evolutionary process triggered by a combination of conscious or unconscious selection and modification of the crop environment, resulting in reductions in the plant's capacity for autonomous reproduction and propagation. The particular traits associated with this loss of autonomy constitute the domestication syndrome. Different populations of the same species may present different syndromes and hence different degrees of domestication. In the case of coconut, only the Malayan Dwarf-types appear to be fully domesticated, while the Tall forms are highly variable in their domestication status, between the extremes of the "wild" populations bearing small fruit on some uninhabited atolls and the populations characterized by very large fruit associated with human habitats.

Considering the importance of oceanic dissemination for a strand plant, the coconuts' domestication syndrome has been associated with (1) thickness of the fruit's husk for flotation, seed protection and speed of germination, (2) fruit shape, and (3) the proportion of coconut water in the fruit, affecting flotation. Indeed, angular oblong fruits appear more stable than round fruits when deposited by the sea close to the

high-tide line. Fruits with thick husks may have a natural advantage for being carried further, longer and faster on sea currents. As germinating seeds do not remain viable when floating in seawater, greater delayed germination seems a further advantage for long distance travel (Harries 1978). Thus, the coconut's range of natural dispersal has been estimated indirectly through flotation experiments, deducing maximum travel times from duration of retained seed viability, and computing maximal distances travelled from estimates of current velocity.

A first shortcoming of this speculative approach is the lack of precise data on the main dispersal parameters. Their variation among wild populations is unknown, so the information is mostly based on cultivated materials. While seedling emergence may occur on the tree in some rare cases, germination can take from 1 to 19 months (Zizumbo-Villarreal and Arellano-Morin 1998). Furthermore, there are both advantages and disadvantages arising from slow germination. For example, very slow germination may be related to low vigour or potentially increase the risk of predator consumption of the young seednuts but is a useful trait for transporting nuts over long distances. Also, different properties can be related to different dispersal strategies. The particular properties of differently sized fruits – small versus large – growing on different bunches of the same palm have not been studied (Bourdeix et al. 2005b).

Bunches of the variety "Micro Laccadives Tall" originating from Laccadives Islands in India, conserved and photographied in Côte d'Ivoire.

A second inadequacy is the assumption that dispersal is essentially mechanistic, rather than probabilistic, based on common variables for the species. It does not take into account the potential impacts of rare events such as tsunamis or more frequent events like hurricanes on long distance dispersals.

Thus, differentiating wild coconuts from Tall cultivars selected and propagated by humans is complex. A big rounded fruit with a thin husk, selected by seafarers as food and water reserves have been opposed to the supposedly wild type with an oblong angular fruit and small nut. However, large and long thick-husked fruits were also selected by Polynesians and Arabs to produce ropes from the husk fibres (coir). A round fruit may have resulted from long-term selection within seemingly wild populations (Leach et al. 2003).

All Malayan-type Dwarfs descend from the same ancestral population originating from South-east Asia. In spite of a low genetic diversity of neutral markers, they exhibit a high phenotypic polymorphism, resulting in a large number of Dwarf cultivars, which are closely related but can be quite easily distinguished due to discrete differences in colour and fruit shape and a relatively fragile trunk. Malayan Dwarf-types show different combinations of traits that are attractive for humans (short

stature, precocity, sometimes sweet water) with traits that favour reliable reproduction of this desirable phenotype (such as colour of the germinating sprout-for orange and yellow forms). Its short stature and short leaves are suitable for the environment where it is usually found (close to human habitations), but make it a poor competitor in the wild, where it would soon disappear owing to its low vigour, low wind tolerance and comparatively short life span.

The origin of this phenotypic diversity of Malayan Dwarf-types is multiple:

- When the self-pollination syndrome was acquired, the ancestors were still heterozygotes and allelic segregation resulted in a number of distinct lines;
- In addition, mutation may have introduced new polymorphism;
- The above factors together with recombination among Dwarf coconuts contributed to the enhanced diversity;
- Dwarf x Tall recombination apparently occurred in Papua New Guinea (Ashburner et al. 2001). This would explain the larger diversity in this region compared to South-east Asia, and the existence of a number of semi-Tall cultivars. This is probably a rare event, because the Dwarf habit depends on several independent traits. Despite the advice of breeders, many farmers plant the progeny of Dwarf x Tall hybrids (from natural pollination or from advanced material) and this could result in new attractive Dwarf phenotypes being selected.

Domestication in Malayan Dwarf-types appears to be a rather recent event. The rate of meiotic abnormalities (during sexual cell division) in Malayan Dwarf-types is intermediate between that in cross-pollinated Tall-types and self-pollinated Semi-Tall types (Swaminathan and Nambiar 1961). This suggests that elimination of genetic load through selfing is still under way. Comparisons of the abnormality rates among allogamous and autogamous Tall and Dwarf coconuts could provide us with a means of evaluating the number of generations since acquisition of autogamy.

Other coconut populations might also be described as domesticated: in particular, the group of other short-statured coconut types called “Compact Dwarfs”. The first description of this type was the previously-mentioned variety “Niu Leka” in Fiji: a genetically dominant phenotype, cross-pollinating and similar to a Tall coconut except for the very short internodes, often short frond petioles and short fronds overall. Recent surveys conducted in Fiji and French Polynesia indicate that many “Compact Dwarf” cultivars are yet to be described and collected, some of them probably being advanced progenies of crosses between Malayan-Dwarf types and other Compact Dwarfs.

Domestication events can create population bottlenecks and cause a reduction in coconut genetic diversity, as “selective sweeps” of favourable alleles may occur. For both Dwarf-types, the genetic determinants of dwarfism are not yet fully understood. They appear to depend on several genetic factors. Understanding the genes underlying the phenotypic and structural changes as a result of past domestication is important for the future of coconut breeding and improvement.