A Global Strategy
for the conservation and use of Coconut Genetic Resources
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conducted on four cultivars (Assa et al. 2013). The sweeter water of immature nuts from Dwarf-type cultivars was the most appreciated.

Along with the development of new descriptors, new quality measurement tools and methods are now available for high throughput phenotyping. Near infrared spectroscopy, high performance chromatography, digital image analysis combined with proteomics and metabolomics analyses are available. Some of these tools have already been optimized for the study of coconut fruits' quality (Prades et al. 2006).

2.5.7 Breeding for drought and other abiotic stresses

A wide range of anatomical, physiological, and biochemical features contribute to various stress adaptations in plantation crops. Recent developments in biotechnology and molecular genetics are essential to fasten the breeding processes. Using diverse criteria, early mass screening methods have included:

- For drought tolerance: leaf water potential, leaf stomatal frequency, epicuticular wax content, level of lipid peroxidation, osmotic pressure applied to plantlets cultivated *in vitro* (Gomes and Prado 2007);
- For cold tolerance: measurement of coldness on leaves by electrical conductivity (Caom et al. 2009);
- For resistance to cyclones: presence of a bole, stem base width, stem height 10 and crown characteristics (weight and volume of fronds and fruits) (Labouisse et al. 2007);
- For salinity adaptation: leaf stomatal frequency, leaf gas exchange, the quantum yield of chlorophyll fluorescence, and the relative chlorophyll index (Da Silva et al. 2017).

Water is an increasingly scarce natural resource required for crop production. Growing cultivars that use water efficiently is a key step in achieving sustainable coconut production in the many areas affected by a long dry season.

Coconut killed by drought in Nuku Hiva, Marquesas Islands. (R. Bourdeix, CIRAD)

The coconut palm generally grows well where annual rainfall is between 1300 and 2500 mm or more. An average monthly precipitation of 150 mm is generally considered ideal in zones where irrigation is not practiced. A prolonged dry season lasting for up to four months may adversely affect the palms. This constraint occurs periodically in various coconut growing zones, such as in southern India (Kerala), Sri Lanka or the West African coast. In low rainfall areas and in places where the soils have poor moisture-retention ability, improvement of soil moisture retention capability will reduce damage to palms and even reduce mortality of palms when the drought is prolonged. In professionally managed large coconut plantations, and smaller farms, coconut husks are buried in various patterns to improve soil moisture retention.

The coconut needs about 44 months to develop from inflorescence primordia initiation through to fruit maturity. As a result, serious drought affects coconut yield not only during the drought period but also in the three following years by constraining the development of female flowers.

Research on drought tolerance has shown variability for revival capacity, water use efficiency, dry matter production and yield of coconut cultivars. Heterosis was observed for some of the desirable characters for drought tolerance. Results obtained in India indicated that hybrids using Talls as mother palms (Rajagopal et al. 2005).are generally more tolerant to drought when compared with Dwarfs (Malayan types) and with hybrids using Dwarfs as the mother palm (Rajagopal et al. 2005).

Maoris coming from tropical Polynesian islands tried so many times to grow coconut palms in New Zealand but never succeeded due to the cold weather[48.] Polynesians living in the Austral Islands (southern French Polynesia) also suffer greatly from scant coconut production. Because it gives any landscape a more 'tropical' look, many people attempt growing coconuts in non-tropical climates. Studies conducted in Florida shows that palms subjected to long periods of low temperature have soft, sunken, reddish areas on the trunk. These cold-damaged trunk areas are often invaded by secondary fungi and/or bacteria that cause trunk-rot and, several months later, the collapse of the entire crown. Fertilization may improve cold tolerance (Broschat 2010).

There is a significant potential market for cold-tolerant coconut varieties able to survive in countries with a temperate climate. The first cold-hardiness studies in Hainan Island (China) indicated the existence of genetic variability. The semi-lethal temperatures ranged from 7.3 to 12.4 °C according to the cultivar. Local Hainan Tall coconut varieties had the strongest growth vigour but lower yield when compared with some introduced cultivars (He-shuai et al. 2009).

Study results have contributed to refining the criteria used for collecting abiotic stress tolerant germplasm (Kumar et al. 2006). The methodologies developed were mainly used to compare varieties but not yet to commonly select individual coconut palms within a given variety.

2.5.8. Genomics and DNA markers

Germplasm curators and coconut breeders who are increasingly using the new molecular and genomics tools optimize coconut germplasm conservation and harness its potential. A wide variety of molecular markers have been used to study the evolving structure of coconut genetic diversity (Lebrun et al. 2005). Genomics contributes increased specific knowledge at various levels:

- At genus level, it helps to more precisely locate coconut's position within the cocoseae subtribe;

[48] Latitude greater than 36 degrees.