Coconut Genetic Resources – Genetic and Molecular Approaches

MJ Ratnambal, PM Khumaran, V Arunachala, V Niral, Anuradha Upadyay and VA Parthasarathy
Central Plantation Crops Research Institute, Kasaragod–671124, Kerala

Key Words: Coconut, Germplasm, Isozymes, Palms, RAPD

Coconut (Cocos nucifera L.) is one of the most important palms of the world. It is presumed that the generic name Cocos as well as name 'coconut' are derived from the Spanish word 'coco' meaning monkey face probably a reference to three scars on the base of the shell resembling a monkey's face (Rosengarten, 1984). The origin of coconut was placed by Martius (1850) on the West Coast of Central America near Isthmus of Panama. On the basis of evidences for cultivation of coconuts in Sri Lanka by about 300 BC as well as the discovery of a fossil (Pliocene) cocos in New Zealand (Hill, 1929) and in the deserts of Rajasthan (Kaul, 1951), the theory of Central American origin has been disputed. Early Spanish explorers discovered the cultivation of coconut on the Pacific coast of Panama in pre-Colombian times. The available evidence point to the domestication of coconut in the Indo-Pacific area (de Candolle, 1886; Beccari, 1970; Vavilov, 1951; Corner, 1966 and Child, 1974). According to the most widely accepted theory, the origin of coconut is in the old world, somewhere in the South-East Asia or Pacific Island from where it might have been transported to other regions either by man or sea currents.

In coconut there are two distinct varieties namely talls and dwarfs. Tall palms, sometimes referred as var. *typica* are the most commonly cultivated in all the coconut growing areas in the world. They generally grow to a height of 25-30 m and have a comparatively long pre-bearing age of 6-10 years. They are normally cross-pollinated.

Fruit is generally medium to large in size and nuts mature within a period of 12 months. The copra content is usually over 150 g/nut and oil percentage varies from 66-70. The common tall varieties found in India are West Coast Tall, East Coast Tall, Tiptur Tall, Orissa Tall, Lakshadweep Ordinary, Andaman Ordinary *etc.*

Dwarf palms sometimes referred to as var. *nana* (Griff.) Nar., are characterized by their short stature. They are quicker to come to bearing (3-4 years) and short-lived. The have thin trunks without a swollen base or 'bole' and fully developed fronds rarely exceed four meters. Dwarfs are identified by the colour of their fruits. They are presumed to have originated from tall palms either through mutation (Menon and Pandalai, 1958) or by breeding in talls (Swaminathan and Nambiar, 1961). In India three important dwarf types found are: Chowghat Green Dwarf, Chowghat Orange Dwarf (from Kerala) Gangabondam Green Dwarf (from Andhra Pradesh).

Among the coconut growing nations, India is the first country to initiate coconut research in the world. Collection, conservation and evaluation of coconut germplasm were done to exploit the high yielding potential in some of the germplasm accessions.

The earliest exotic introduction into the country was in 1924 from the Philippines, Malaysia, Fiji, Indonesia, Sri Lanka and Vietnam. The germplasm exchange programme was intensified in 1952 and in 1958, survey for selection of indigenous germplasm was started.

At present Central Plantation Crops Research Institute (CPCRI), Kasaragod, India is maintaining the world's largest assemblage of germplasm comprising of 270 accessions out of which 120 are exotic types. The exotic collection comprises of 96 talls, 23 dwarfs and one semi tall and the indigenous collection includes 133 talls and 17 dwarfs. The exotic collections are from 27 countries of South and South-East Asia, Caribbean Island, Ocean Island, Pacific Ocean Island and African countries.

During 1981, with financial assistance of IPGRI, 23 accessions were collected from 6 Pacific Ocean countries and these are being maintained at CARI, Andamans (erstwhile World Coconut Germplasm Centre under CPCRI). During 1997, under ADB Phase-I, 15 accessions were collected as embryos from 3 Indian Ocean Islands *viz.*- Seychelles, Mauritius and Madagascar. Under ADB Phase-II in 2000, 8 accessions were collected from 3 Indian Ocean islands *viz.*-Maldives, Re-union and Comoros. During 2001, 2 accessions were collected from Sri Lanka.

Out of the total 270 accessions, passport data has been entered in the CGRD for 242 accessions and

characterization for 74 accessions. The characterized germplasm has been catalogued in two publications. Coconut Descriptor Part–I was published in 1994 which describes 48 accessions while, Coconut Descriptors Part-II describing 26 accessions was released as CD-ROM during 2000.

The CPCRI has been identified as the implementing agency for the establishment of the International Coconut Genebank for South Asia (ICG-SA). A compact block of about 100 palms in each accession is being established, which would enable to hold enough population for further study and supply to other member countries.

Fourteen cultivars were planted at ICG-SA during 1998 and 15 cultivars during 1999 at a population rate of 45/90 seedlings/accession.

Prospection and collection visits were intensified in the past five years to preserve the coconut diversity available in the country and the Indian Ocean islands. Thirty-one exotic collections were made from six islands of Indian Ocean region. Exploration, prospection and collecting activities were intensified in several parts of India – Orissa (10), West Bengal (11), Tamil Nadu (1), Kerala (25), Goa and Maharashtra (12), Andaman and Nicobar Islands (47), Lakshadweep Islands (11), which helped to enrich our indigenous collections in the gene bank.

Some of the useful collections made in these visits include Guelle rose having pink coloured embryos (marker), Coco Gra Tall, a Macapuno type jelly like endosperm elite high yielding accessions from Kerala, accessions having freak traits such as horned fruits, beaked fruits, *etc.*

Studies on genetic erosion of coconut genetic resources is presently undertaken in recent exploration trips to investigate the extent of loss of diversity. Different indicators such as area under the crop, competition from other crops, area under traditional varieties and high yielding hybrids/varieties, knowledge of land races by the local people *etc.*

Breeding programmes in the country utilise the rich diversity collected by CPCRI from India and abroad as well as AICRP (Palms) centres. Evaluation and selection of the accessions led to the recommendation/ release of varieties *viz.*- Chowghat Orange dwarf (tendernut purpose), Chandrakalpa (Lakshdweep Ordinary), VPM-3 (Andaman Ordinary), Philippines ordinary, Kamarupa, (Assam Tall). Hybridization programmes utilise the accessions such as Gangabondam, Laccadive Ordinary, Philippines Ordinary, Malayan Yellow Dwarf as one of the parents in recently released successful hybrids.

Biochemical (isozymes) and molecular markers are widely used for characerisation and cataloguing of germplasm in different crops. In coconut, isozymes and RAPD makers have been identified to differentiate and classify coconut accessions.

Eight talls and six dwarfs were studied for isozyme polymorphism using seven enzyme systems. Intra population and inter-population variation was observed with PPO, EST, PER, MDH, ADH and GOT. Enzyme polymorphism was higher in Talls as compared to Dwarf populations possibly due to their breeding nature.

Among dwarfs, GDD showed highest enzymes polymorphism while GBGD showed least enzyme polymorphism. Within each enzyme system differences in inter-population variation were observed between cultivars except in ACP and ADH. For EST, MOD showed highest intra-population variation, while MYD, GDD and GBGD did not show any variation. In case of PER, only GDD showed intra-population variation while for MDSH, only MODE showed intra-population variation. For PPO, GDD showed highest intra-population variation, while both CGD and GBGD had least variation. A comparison of polymorphic indices indicates that PPO showed highest polymorphism followed by GOT, EST, PER and MDH, respectively.

Of the eight tall genotypes studied, JVT showed maximum enzyme polymorphism while SNRT showed least polymorphism. All enzyme system (except ACP) detected intra-population variation. For EST and PER, JVT showed highest intra-population variation, while it was absent in SNRT. For PPO, PHOT showed greater intra-population variation, while it was low in SNRT. In case of MDH, ADOT showed highest variation, followed by WCT, JVT, LCT, PHOT and KPDT and LMT while it was absent in SNRT. For ADH, ADOT showed maximum variation, while it was least in KPDT and absent in SNRT and LMT. A comparison of polymorphic indices of the talls indicates that, PER showed maximum polymorphism followed by PPO, MDH, ADH, EST, respectively.

RAPD markers were used to characterise the coconut germplasm. Hundred primers were screened for their ability to detect polymorphism in coconut. Only 34% primers were polymorphic. The number of polymorphic bands/primer ranged from 1-16.

To understand the intra-population variation in coconut, DNA from 81 palms was amplified with 8 polymorphic primers. These primers are OPA4, OPA10, OPB1, OPB5, OPC2, OPC5, OPC9 and OPE2.

Proportion of polymorphic bands for each accession as well as for exotic and indigenous accessions was calculated. Genetic diversity was estimated by using Shannon information index.

Eight primer detected 77 polymorphic markers in 81 palms. The number of markers for each primer varied between 7 (OPA 4, OPB 1, OPC 5) to 15 (OPB 5) with an average of 9.6 markers/primer. However, the number of markers present in an accession varied between 46 (COD) to 71 (Kappadam). The proportion of polymorphic bands among tall accessions varied between 22 (GPT) to 71 (KAP) with an average of 49%, whereas among the dwarfs, it varied between 20 (KTD) to 44 (MOD) with an average of 36%.

The average diversity for all the accessions (H_T) was 0.214. The average diversity (H_o) for individual accession 0.057 (KTD) to 0.196 (PHT). The mean within population (H_M) diversity was 1.120. The proportion of total diversity found within population (H_M/H_T) was found to be 0.56. Thus, the proportion of between population diversity was 0.44.

When considering only all tall accessions (13 Nos.) the genetic diversity was 0.125, a little higher than H_T (0.124), whereas the genetic diversity of the dwarf accession was calculated to be 0.118.

The average genetic diversity for indigenous accession was 0.209 which was lower than that of exotic accession (0.225 indicating more variation among exotic collection).

The RAPD data was used to calculate similarly coefficient for 81 palms. Similarity coefficient data was used to construct a dendrogram of genetic relationship by UPGMA method using NTSYS (Ver. 1.7) package.

In dendrogram dwarf accessions formed two main groups (III and IV) whereas tall accessions were clustered in three main groups (I, II, V) which were further subdivided into many subgroups. Gangabondam, an intermediate type was clustered with tall accessions.

Coconut, being an important oil crop with diverse uses, has great scope for research. India, being the host country for the International Coconut Gene Bank, houses about 270 accessions. These accessions have been evaluated for their genetic and molecular variations. Even though, some of the accessions have been used for breeding purposes, research would be intensified for using these conserved germplasm for exploitation of various desirable traits such as high copra content, optimum luric acid content, dwarfness, tolerance to drought, mite attack and root (wilt) disease.

References

Beccari O (1970) The origin and dispersal of *Cocos nucifera Phillp. J. Sci.* **14:** 295-367.

Child R (1974) *Coconuts* 2nd edition, Longman Group Ltd., London, 335p.

Corner EJH (1966) *The Natural History of Palm.* Weidenfeld and Nicolson, London, 393p.

De Candolle A (1886) *Origin of Cultivated Plants.* Hafner Pub. Co. New York, 428p.

Hill AW (1929) The original home and mode of dispersal of the coconut. *Nature* **124:** 133-134, 151-153.

Kaul KN (1951) A palm fruit from Kapurdi. Jodhpur, Rajasthan Desert *Cocos Sahnii* ssp. *Curr. Sci.* **10:** 138

Martius CFP (1850) *Historia Naturalis Palmarum* **3**: 1823-1850

Menon KPV and KM Pandalai (1958) *The Coconut Palm–A Monograph*, Indian Central Coconut Committee, Ernakulam, 384p.

Rosengarten F (1984) *The Book of Edible Nuts.* Walker and Company, New York, 384p.

Swaminathan MS and Nambiar MC (1961) Cytology and origin of the dwarf coconut palm. *Nature* **192:** 85-86.

Vovilov NI (1951) The origin, variation and the breeding of cultivated plants. *Chronica Botanica* **13:** 1366.