

Coconut breeding in India - Status and future prospects

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West Coast Tall

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India is one of the first countries in the world to undertake research on coconut breeding, dating back to 1916. A comprehensive review on this aspect was made by Nampoothiri *et al.* (1997) and Parthasarathy *et al.* (1998). Collecting of coconut germplasm in India began in 1924 with introductions from the coconut growing countries. Subsequently, in 1952 intensive germplasm collection and exchange started. These collections were planted at Nileshwar and Kasaragod and formed the basic material for coconut improvement. The Indian Central Coconut Committee set up in 1945 initiated intensive research activities from 1947. During the same period, the Kayangulam Research station was established for controlling the coconut root (wilt) disease. From 1947 onwards many research institutes/stations were established for research on coconut. In Kerala, Kumarakom Coconut Research Station and Coconut Research Station, Balaramapuram were established in the early fifties. Regional Coconut Research Stations were established at Veppankulam in Tamil Nadu, Arsikere in Karnataka, Ambajipet in Andhra Pradesh and Ratnagiri in Maharashtra in the fifties. Besides these, other research stations were started in West Bengal

(Mondouri) and Orissa (Konark, presently shifted to Bhubaneswar). These research stations cater to the needs of the different agroclimatic regions. The Indian Council of Agricultural Research (ICAR) took over the Central Coconut Research Station at Kasaragod from Indian Central Coconut Committee subsequent to its dissolution in 1966. Seventies saw intense research on coconut by CPCRI and ten coordinating centres under the All India Coordinated Research Project on Palms. These research institutes along with CPCRI have released 12 hybrids, accounting for nearly one-third of the total hybrids released throughout the world. Besides, India has the world's largest collection of coconut germplasm.

Crop Improvement

Crop improvement in coconut through selection and hybridization has been one of the major objectives of coconut research workers. However, genetic improvement in coconut is a tedious and long process because of the long gestation period of the crop, requirement of huge area for experimental planting, resources required for experimentation, low seed multiplication rate and lack of a reproducible clonal propagation technique. Despite these limitations, India was the first country in the

world to exploit and document hybrid vigour in coconut in a cross between West Coast Tall x Chowghat Green Dwarf (Patel, 1937). This discovery was a significant landmark in the history of coconut improvement and paved the way for the successful exploitation of this phenomenon in many of the coconut growing countries. John and Narayana (1943) found that these hybrids (Tall x Dwarf) gave higher yields, combining the nut and copra characters of tall with early bearing of the dwarf parent. The evaluation of the 25 year old T x D planted at Nileswar had shown that they were early bearing, high yielding and attained steady bearing earlier than the tall parent with higher number of functional leaves (Bhaskaran and Leela, 1964).

Germplasm Collection and Evaluation

The earliest exotic introductions were made in 1924 from the Philippines, Malaysia, Fiji, Indonesia, Sri Lanka and Vietnam. The germplasm exchange programme was intensified in 1950. The collection of indigenous coconut germplasm started in 1958 and some of the indigenous types were added to the germplasm repository during this period as well as exotic collections from Pacific and Indian Ocean Islands.

The present coconut germplasm repository at CPCRI, Kasaragod, has 132 exotic and 222 indigenous types (Table 1). The exotic collections from 27 countries comprise 106 tall, 24 dwarfs, one semi-tall and one hybrid. The indigenous

collection comprises 198 tall and 24 dwarfs from different regions including Andaman and Nicobar Islands and the Lakshadweep group of Islands. During 1981, with the financial assistance of IPGRI, 24 accessions (20 tall and 4 dwarfs) were collected from six Pacific Ocean countries consisting of Solomon Islands, Fiji Islands, Tonga Islands, American Samoa, French Polynesia and Papua New Guinea. They have been planted at the World Coconut Germplasm Centre (WCGC), Andamans. Subsequently, from 1997-2002, under ADB Phase I and ADB Phase II, 31 accessions were collected from the Indian Ocean Islands consisting of Mauritius, Madagascar, Seychelles, Maldives, Comoros and Reunion and from the South Asian countries of Sri Lanka and Bangladesh. These exotic collections were made in the form of zygotic embryos. Indigenous germplasm collections were strengthened considerably during the last five years, with financial assistance from NATP under the mission mode project on Sustainable Management of Plant Biodiversity.

Comparative Performance of Cultivars

Among the exotic accessions, Fiji Tall, Philippines Ordinary and Strait Settlement Green have been found to give highest copra yield of 20 kg/palm/year (Table 2). Among the indigenous types, Lakshadweep Ordinary, Andaman Ordinary and Benaulim are superior to the local West Coast Tall.

Seven varieties have so far been released, namely, Chandra Kalpa, Pratap, Chowghat Orange Dwarf,

Table 1. Coconut germplasm collection at CPCRI, Kasaragod

Region	Number of Accessions				
	Total	Tall	Semi-Tall	Dwarf	Hybrid
Indigenous	222	198	-	24	-
Kerala	30	28	-	2	-
Tamil Nadu	18	13	-	5	-
Karnataka	14	7	-	7	-
Andhra Pradesh	5	4	-	1	-
Goa	8	8	-	0	-
Gujarat	2	1	-	1	-
Orissa	14	14	-	0	-
West Bengal	12	11	-	1	-
Andaman and Nicobar Islands	69	67	-	2	-
Lakshadweep Islands	36	31	-	5	-
Maharashtra	6	6	-	0	-
Assam	8	8	-	0	-
Exotic	132	106	1	24	1
South East Asia	20	16	1	3	-
Central & South America, Atlantic Region	7	6	-	1	-
African Regions	7	4	-	2	1
Pacific Ocean Is.	45	39	-	6	-
Indian Ocean Is.	38	30	-	8	-
South Asia	15	11	-	4	-

Table 2. Comparative performance of cultivars at CPCRI, Kasaragod

Cultivar	Bearing age (years)	Annual nut yield		g/nut	Annual copra yield	
		Nuts/palm	% increase over WCT		kg/ palm	% increase over WCT
Exotic Type						
Fiji Tall	6	106	32.5	199	21.1	529
Philippines Ordinary (<i>kera chandra</i>)	5	110	37.5	198	21.8	57.9
Strait Settlement Green	6	108	35.0	186	20.0	44.9
Indigenous Type						
Lakshadweep Ordinary (<i>chandra kalpa</i>)	6	100	25.0	176	17.6	27.5
Andaman Ordinary (VPM 3)	6	94	17.5	169	16.0	15.9
Benaulim (<i>pratap</i>)	7	150	87.5	152	22.8	65.2
West Coast Tall	7	80	-	172	13.8	-
Chowghat Orange Dwarf (COD)	4	63	-	-	-	-

Kera Chandra, VPM 3, Kamrupa and ALR 1. Based on the evaluation of promising cultivars at various Research Centres in Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra and Kerala, the cultivar Lakshadweep Ordinary was released for commercial cultivation during 1985 under the name Chandra Kalpa. This cultivar yields 25 per cent more nuts and 27.5 per cent more copra than local tall under Kasaragod conditions. Another cultivar, Banawali Green Round from Ratnagiri (Maharashtra) was selected and released in 1987 by Konkan Krishi Vidya Peeth, Dapoli, for cultivation in Konkan Coast as Pratap. The exotic cultivar Philippines Ordinary was tested under three different agroclimatic regions and found superior with respect to the nut yield and copra yield over the local cultivar. The mean yield is 110 nuts/palm/year, with a copra yield of 20.8 kg/palm/year, thereby showing an increase of 37.5 per cent and 50.7 per cent respectively over West Coast Tall. The increase with respect to nut yield as well as copra yield over the released variety Chandrakalpa was 12.2 per cent and 20.9 per cent,

respectively. This cultivar was recommended for release as a 'National variety' (Chandra Tara) during the XII Workshop of AICRPP, held in 1995. It was released for Andhra Pradesh as Double Century. VPM 3 is a selection from Andaman Ordinary and has been released by Tamil Nadu Agricultural University during 1994. This cultivar has greater tolerance to drought and produces on an average 92 nuts/palm/year, with high copra weight (162 g /nut) with 70 per cent oil content. Assam Tall was released as Kamrupa by the Assam Agricultural University during the AICRPP Workshop in February 1999. This variety recommended for cultivation in Assam produces annually 101 nuts/palm with a copra content of 162g/nut, and 64 per cent oil content. The Aliyarnagar 1 (ALR 1), a selection from the local Arasampatti Tall has been released by Tamil Nadu Agricultural University during the AICRPP Workshop in 2001. This comes to bearing in 4-5 years. The annual yield is 176 nuts/palm with a copra content of 131g/nut. The oil content in the copra is 67 per cent.

Based on the organoleptic test of tendernut water in 46 cultivars, 12

cultivars were selected for a detailed biochemical analysis like total sugars, reducing sugars, amino acids, sodium and potassium contents (Damodharan *et al.*, 1991). In view of the superior quality of tendernut water, Chowghat Orange Dwarf was recommended for release in 1991. The quantity of tendernut water in this cultivar ranges from 300 to 400 ml/nut. The mean total sugar is 7.1 g/100 ml with 2000 ppm of potassium and 20 ppm of sodium. The annual average nut yield is 63 nuts/palm.

Exploitation of Hybrid Vigour

Ever since the report of heterosis in Tall x Dwarf hybrids by Patel (1937), various inter-varietal hybrids involving tall and dwarfs have been evaluated. In the immediate years following the discovery of hybrid vigour in coconut, the emphasis was on the production of Tall x Dwarf hybrids. These hybrids were precocious and high yielding compared to local cultivar West Coast Tall under irrigation and good management. Subsequently, Tall x Tall hybrids are also being evaluated.

More than 90 cross combinations using different Tall and Dwarf like

Chowghat Orange Dwarf, Gangabondam and Chowghat Green Dwarf were evaluated over the years at CPCRI and various centres under the All India Coordinated Research Project on Palms. In view of the high yield performance, the hybrids, COD x WCT, LCT x COD and WCT x COD were recommended for release in various years starting from 1985 under the name Chandra Sankara, Chandra Laksha and Kera Sankara, respectively. Subsequently, the Kerala Agricultural University (KAU) and Tamil Nadu Agricultural University (TNAU) evaluated and released eight more hybrids viz., Laksha Ganga (LCT x GBGD), Ananda Ganga (ADOT x GBGD), Kera Ganga (WCT x GBGD), Kera Sree (WCT x MYD) and Kera Sowbhagya (WCT x SSAT) from KAU and VHC-1 (ECT x MGD), VHC-2 (ECT x MYD) and VHC-3

(ECT x MOD) from TNAU. The Andhra Pradesh Agricultural University has released a hybrid, Godavari Ganga (ECT x GBGD). Comparative performance of these



COD

hybrids indicates their superiority over local tall in terms of nut production and copra yield. The nut

yield of the hybrids ranges from 95 to 140 nuts/palm/year as compared to 80 nuts/palm/year in the case of WCT (Table 3).

Performance of Released Varieties and Hybrids at AICRPP Centre

Comparative performance of some of the released varieties and hybrids is provided below (Table 4).

Varieties:

Laccadive Ordinary: This variety shows superior performance at different locations. It recorded an annual yield of 130, 98 and 81 nuts/palm/year at Veppankulam, Aliyarnagar and Mondouri centres, respectively. But in Ratnagiri centre having coastal alluvium soil, LCT produced 146 nuts/palm/year. The lowest yield (45 nuts/palm/year) was recorded in Konark.

Philippines Ordinary: PHOT

Table 3. Performance of released hybrids

Hybrids	Annual nut yield/palm	Annual copra yield			Oil content (%)	State for which recommended
		g/nut	kg/palm	t/ha		
Chandra Sankara (COD x WCT)	116	215	25	4.4	68	Kerala, Karnataka Tamilnadu
Kera Sankara (WCT x COD)	108	187	21	3.5	68	Kerala Karnataka
Chandra Laksha (LCT x COD)	109	195	21	3.7	69	Kerala Karnataka
Laksha Ganga (LCT x GBGD)	108	195	21	3.7	70	Kerala
Ananda Ganga (ADOT x GBGD)	95	216	21	3.6	68	Kerala
Kera Ganga (WCT x GBGD)	100	201	21	3.5	69	Kerala
Kera Sree (WCT x MYD)	112	216	24	4.2	66	Kerala
Kera Sowbhagya (WCT x SSAT)	130	195	25	4.3	65	Kerala
VHC-1 (ECT x MGD)	98	135	13	2.3	70	Tamil Nadu
VHC-2 (ECT x MYD)	107	152	16	2.9	69	Tamil Nadu
VHC-3(ECT x MOD)	156	161.5	25.2	3.5	64.5	Tamil Nadu
Godhavari Ganga (ECT x GBGD)	140	150	21	3.7	68	Andhra Pradesh
WCT (Control)	80	176	14	2.5	68	

showed good performance at Veppankulam, Aliyarnagar and Ratnagiri centres and yielded 107, 110 and 105 nuts/palm/year respectively.

Pratap: This variety is unique to the Konkan region and yields 143 nuts/palm/year.

Chowghat Orange Dwarf: This tender nut variety was released in 1991. Its performance at Veppankulam center, with a three year yield average is 66 nuts/palm/year.



Pratap

Assam Tall: Assam Tall was released as Kamrupa by the Assam Agricultural University during the AICRPP Workshop in February 1999. It yields on an average 106 nuts/palm/year and is suitable to the acidic soils and high rainfall areas of Assam.

West Coast Tall: The performance of WCT in all centers is relatively good, except Konark and Arsikere. The highest yield was recorded in Madukkur series soil type at Veppankulam (159 nuts/palm/year).

Hybrids:

The two released hybrids, Chandra Sankara and Kera Sankara, showed varying performance in the multilocation trials, depending on the edaphic and climatic factors. In Aliyarnagar trial, Chandra Sankara and Kera Sankara gave an annual nut yield of 124 and 134 nuts/palm, respectively. At Veppankulam, the annual yield was 126 and 162 nuts/palm in Chandra Sankara and Kera Sankara, respectively. But in other centres such as Mondouri, annual nut yield was relatively poor with Chandra Sankara yielding 83 nuts/

palm and Kera Sankara producing only 75 nuts/palm. In Kahikuchi, characterized by clay loam soil, the performance was also poor, with Chandra Sankara producing 86 nuts/palm/year and Kera Sankara 66 nuts/palm/year. In Arsikere, the hybrids showed poor performance, with Chandra Sankara performing better with an annual production of 68 nuts/palm as compared to Kera Sankara (36 nuts/palm). At CPCRI, it has been observed that Kera Sankara performs better than Chandra Sankara under rainfed conditions.

Breeding for Specific Traits

Drought Tolerance:

Coconut is being grown under different agro climatic conditions and in varying soil types. However, it has been estimated that an average monthly rainfall of 150 mm is necessary for ideal palm growth and good nut yield and any erratic/low rainfall would adversely affect the yield of the palm and the adverse effects, unlike annuals, would persist for the subsequent 2-3 years. The four Southern States, Andhra Pradesh, Tamil Nadu, Karnataka and

Table 4. Performance of released varieties and hybrids at different centres

Centre	Annual yield (nuts/palm)							
	Mandouri	Konark	Ratnagiri	Veppankulam	Aliyarnagar	Kahikuchi	Ambajipeta	Arsikere
Year of planting	1986	1982	1957	1986	1988	1985	1985	1987
Soil type	Alluvial	Coastal sand	Coastal alluvial	Madukkur series	Red sandy loam	Clay loam	Coastal alluvial	Red sandy Black sandy
Variety/hybrid								
ADOT	71	-	-	101	104	59	56	70
Kamrupa	-	-	-	-	-	106	-	-
Pratap	-	-	143	-	-	-	-	-
LCT	81	45	146	130	98	68	58	56
PHOT	72	38	105	107	110	-	60	57
WCT	64	32	89	159	125	68	59	44
COD x WCT	83	36	-	126	124	86	69	68
WCT x COD	75	37	132	162	134	66	67	36



Kerala where 90 per cent of the coconut is being cultivated, face frequent drought spells. It has been realised that the only way towards increasing coconut production in drought affected areas is through the evaluation of drought tolerant varieties and hybrids.

Studies at CPCRI revealed the possibility of identifying drought tolerant cultivars on the basis of accumulation of epicuticular wax on the leaf surface, low stomatal frequency and leaf water potential, the activity of enzymes like glutamate oxaloacetate transaminase (GOT) and acid phosphatase (Rajagopal *et al.*, 1991; Chempakam *et al.*, 1993). Among the 23 cultivars and hybrids screened for drought tolerance, WCT x WCT, Federated Malay States (FMST), Java Giant, Andaman Giant and LCT x COD were identified as drought tolerant (Rajagopal *et al.*, 1988a). Subsequently, Rajagopal *et al.* (1988b) proved the superiority of the hybrids LCT x COD and LCT x GBGD for drought tolerance. The reduction in yield during drought affected years for LCT x COD and LCT x GBGD was 15 per cent and 44 per cent, respectively, compared to 75 per cent in drought affected COD x WCT hybrid. The identified drought tolerant lines are currently being utilized in the breeding programme at CPCRI, Kasaragod.

Disease Resistance:

The root (wilt) disease of coconut is the most serious problem causing an annual loss of 968 million nuts in eight districts of Kerala (Anon., 1985). The disease is characterized by flaccidity, yellowing and necrosis

of leaflets (Menon and Pandalai, 1958) followed by a progressive decline in the yield. Systematic studies carried out at CPCRI have shown the presence of mycoplasma like organisms (MLOs) in the sieve tube of roots, tender stem, inflorescence and petiole of diseased palms (Solomon *et al.*, 1983).

The screening of the available coconut germplasm and hybrids has not yielded any resistant type. However surveys of the 'hotspot' areas have identified a few high yielding disease free palms in the midst of heavily diseased palms. Iyer *et al.* (1979) located 162 high yielding apparently healthy WCT palms and 19 CGD palms, which were then subjected to serological and physiological tests. Based on these tests 26 WCT and 19 CGD palms were identified as phenotypically and serologically disease-free and crossed. The first batch of 32 progenies of WCT selfed and 48 progenies of CGD x WCT have been planted in the field. The seedlings of the same combination were evaluated in insect proof cages and *Stephantia typica*, which is proved as a vector transmitting the disease, fed on root (wilt) affected palms were released to transfer the disease to seedlings. The control seedlings developed the disease whereas the CGD x WCT seedlings were disease free. The same combination planted in the open field at CPCRI, Research Station, Kayangulam has shown lesser disease incidence indicating their tolerance to the disease. Subsequent, healthy COD mother palms in hotspots are being used in resistance breeding programme. At present, 81 WCT, 104 CGD and 7 COD palms

which are phenotypically, serologically and physiologically disease-free are being used for controlled pollination to produce quality seedlings with tolerance to the disease.

The other major diseases of coconut are bud rot caused by *Phytophthora palmivora*, stem bleeding disease and Thanjavur wilt/ Ganoderma disease. As these can be controlled by conventional plant protection measures, at present no specific breeding programme has been initiated to develop a resistant genotype for these diseases. However, the available coconut germplasm is being evaluated to identify resistant types for the future breeding programmes.

Insect resistance:

Eriophyid mite has become a major problem in the major coconut growing regions of the country and has drastically reduced the nut yield as well as quality of nuts. As it is very difficult to completely eradicate the pest through conventional plant protection measures, the necessity of having mite resistant varieties assumes greater importance. Therefore the germplasm is being screened to identify resistant types, if any.

In addition, the germplasm is screened for resistance/tolerance to other coconut pests like Rhinoceros beetle, leaf eating caterpillar and root knot nematode.

Tendernut water quality:

The consumption of seven-month old tendernut is becoming increasingly popular as a natural and refreshing drink especially during the

summer months. Therefore, at CPCRI, Kasaragod, a study was initiated to identify a suitable cultivar for tendernut purpose. A total of 46 cultivars were screened through organoleptic tests and biochemical evaluation. The cultivar Chowghat Orange Dwarf (COD) had the maximum amount of total sugars (7g/100ml) and reducing sugars (4.7g/100 ml) coupled with optimum sodium and potassium content (Dhamodaran *et al.*, 1991). Presently, various dwarfs, tall and hybrids are being evaluated for their tender nut water quality. In addition, Dwarf X Dwarf hybrids are under evaluation for their suitability for tender nut purpose.

The concerted efforts in coconut improvement have resulted in the assemblage of a vast germplasm in the National Field Genebank maintained at the Central Plantation Crops Research Institute, Kasaragod. Sub samples of the coconut germplasm are also maintained in the AICRPP centres. In addition, improved varieties and hybrids have been released. However, the performance of some of the improved varieties and hybrids is observed to differ under different agro climatic situations. Therefore, there is a need to breed location specific varieties and this has been addressed to with the development of a research programme for location specific breeding under the AICRPP.

With the removal of trade barriers in the post WTO regime, the prices for copra and coconut are subject to a lot of fluctuations and therefore, diversification and value addition are essential to rescue coconut farmers from poverty. Although coconut palm is known

for multitude of products for various human needs, identification of suitable varieties for specific industry needs is a dire necessity. Mutant forms of coconut palm known as Makapuno/Thayiru Thengai, which have a jelly like endosperm, fetch a premium price and are used in ice-cream and food industries in Philippines. Such accessions need to be identified, conserved and utilized in breeding programme. Screening germplasm for composition of oil and fatty acid profiles is necessary. Coir industry basically utilizes husks a byproduct of coconut. However, identification of accessions with long, stiff fibers could promote the industry as well as benefit the coconut farmer to a great extent. Similarly specific genotypes suitable for production of coconut chips, higher recovery of inflorescence sap, and preparation of shell products need to be identified for utilization in the breeding programmes. At CPCRI, research is underway on some of these aspects.

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