

COCONUT BREEDING – PAST ACHIEVEMENTS AND FUTURE STRATEGIES*

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Abstract: Early efforts of coconut breeding in India included collection and conservation of germplasm initiated in 1930s which received further support of FAO/IBPGR during 1980s. The present Indian germplasm holding with 86 exotic and 41 indigenous accessions is one of the world's largest assemblage of the crop. Based on the evaluation of indigenous germplasm accessions, two cultivars viz., Laccadive Ordinary (Chandrakalpa) and Banawali Green Round have been released for cultivation.

Selection of the prepotent West Coast Tall palms based on progeny performance as well as identification of elite palms gave a new thrust to improve traditional cultivars. The most significant impact was made by the advent of hybrid vigour in crosses involving talls and dwarfs. Research in this line during the last four decades made it possible to release three hybrids viz., Chandrasankara (COD x WCT), Chandralaksha (LO x COD) and Lakshaganga (LO x GB) hybrids. These gave much higher yields than the West Coast Tall (up to 83 per cent in terms of nut and up to 103 per cent in terms of copra out-turn). LO x COD and LO x GB were found to perform well under drought conditions also. Non-availability of sufficient planting materials has been the main constraint in realising the full field impact from these released varieties and hybrids. Efforts have been made to overcome this by establishing a chain of seed gardens in the coconut growing states.

Characterization and evaluation of the available germplasm, production of inbred lines followed by hybridization to exploit hybrid vigour to the full extent, exploitation of field tolerance to breed varieties tolerant to root (wilt) disease and Thanjavur wilt and perfecting the technique of developing plantlets through tissue culture for micro-propagation are some of the breeding strategies to achieve the desirable results in coconut breeding.

INTRODUCTION

Though research efforts to improve coconut production and productivity were started in the early part of the century in India, the progress has been slow because of its unique problems such as perennial habit, breeding system, long pre-bearing age, heterozygous nature, the time-lag involved in the study of progenies and the large area required for experimentation. In spite of all these limitations, substantial progress in coconut breeding has been achieved in the country by concerted efforts and organised breeding approaches by the breeders at the erstwhile Central Coconut Research Station, Kasaragod under Madras State

(Now the Central Plantation Crop Research Institute and its research centres, now under the Kerala Agricultural University). An attempt is made in this paper to record the breeding approaches employed and progress achieved so far and to outline future strategies contemplated for their rapid improvement with inbuilt resistance for pests, diseases and drought.

GERMPLASM AND VARIETAL IMPROVEMENT

Systematic research on crop improvement programme in coconut was perhaps started first in India in 1916. The earliest exotic introductions into India were in 1924 from the Philippines,

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Malaysia, Fiji, Indonesia, Sri Lanka and Vietnam) which formed the nucleus population for many of the research programmes. The germplasm exchange programme was further intensified in 1952 and in 1958 survey for collection of indigenous germplasm was started. At present, the Central Plantation Crops Research Institute, Kasaragod is maintaining the world's largest assemblage of germplasm of 41 indigenous and 86 exotic cultivars. The exotic collections from 22 countries of South and South East Asia, Carribean Islands, Indian Ocean, Pacific Ocean islands and African countries comprise of 52 tall, eight dwarfs, one semi-tall and one hybrid. The indigenous collections from eight states and two union territories comprise of 26 tall, eight dwarfs and one semi-tall. Besides, 24 exotic collections (20 tall and four dwarfs) were made from six countries in the Pacific Ocean regions in 1981 under FAO/IBPGR funded expedition. These exotic collections have been planted at the World Coconut Germplasm Centre,

Andamans for quarantine considerations (Rao and Koshy, 1982). Some of these have been initiated for generating seedling material for planting in the main land.

Germplasm collections are also being maintained at Pilicode under the Kerala Agricultural University and four co-ordinating centres in Tamil Nadu (Veppankulam), Karnataka (Arsikere), Andhra Pradesh (Ambajipet) and Maharashtra (Ratnagiri) to assess their regional adaptability. These germplasms are being systematically evaluated for their yield and tolerance to pests and diseases in comparison with the local cultivars.

Among the exotic cultivars Fiji Tall, Fiji Longtonwan from Fiji island, Philippines Ordinary, Philippines Laguna and San Ramon from Philippines and Strait Settlement Green (SS Green) from Malaysia are superior to others. Among the indigenous cultivars Kappadam, Andaman Ordinary and Lakshadweep Or-

Table 1. Performance of promising coconut cultivars at CPCRI, Kasaragod, India

Cultivar	Bearing age (years)	Mean nuts/year/palm		Copra weight			
		No.	(17-20 years) % over WCT	Nut (g)	Palm/year (kg)	% over WCT	
						Nut	Palm/year
<i>Exotic</i>							
Fiji Tall	6	106	30.86	199.1	21.1	48.59	65.2
Fiji Longtonwan	8	104	22.12	210.5	22.0	54.92	66.0
Philippines Ordinary	5	108	33.33	196.1	21.1	48.59	66.0
Philippines Laguna	6	88	8.64	258.9	22.7	59.86	66.5
SS Green	6	108	33.33	186.1	20.1	41.55	67.0
San Ramon	6	64	—	349.6	22.4	57.75	68.0
<i>Indigenous</i>							
Kappadam	6	90	11.11	283.50	25.5	79.58	67.0
Andaman Ordinary	5	94	16.05	160.2	15.1	6.34	66.0
Laccadive Ordinary	6	98	20.99	176.3	17.3	21.83	72.0
West Coast Tall	7	81	—	176.0	14.2	—	68.0

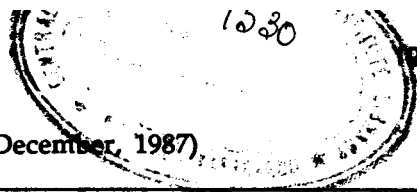


Table 2. Comparative performance of hybrids (December, 1987)

Hybrid	n	Cumulative yield of nuts up to 21st year		1984 yield of nuts (18th-21st year)		Copra out-turn	
		Mean/tree	% over WCT	Mean/tree	% over WCT	Mean/tree (kg)	% over WCT
COD x WCT (Chandrasankara)	11	1200	42	99.8	36	20.8	52
WCT x COD	11	1019	21	88.4	20	17.5	28
WCT x GB	13	822	-2	65.7	-11	12.4	-10
LO x COD (Chandralaksha)	11	1016	21	99.3	35	19.4	42
LO x GB (Lakshaganga)	10	1089	28	101.5	38	19.8	45
WCT	18	840	-	73.5	-	13.7	-

dinary have higher yield potential than the local West Coast Tall. The performance of promising cultivars of exotic and indigenous origin is given in Table 1. Based on the overall performance in the four co-ordinating centres in Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra and at CPCRI Kasaragod, Lakshadweep Ordinary has been recommended for release under the name 'Chandrakalpa'. This cultivar gave 25 per cent more yield in terms of nuts and 33 per cent more copra yield at stabilized bearing period (Anon., 1985).

Recently Benawali Green Round with a mean number of nuts of 151 and copra out-turn of 22.8 kg has also been released. Characterisation of varieties has been a problem faced by the breeder. To overcome this Pillai *et al.* (1986) has developed a descriptor using important traits like stem characters, breeding behaviour and nut characters)

Evaluation of coconut germplasm is a long drawn process due to its long juvenile phase and also time taken for stabilisation of yield. For evaluating at the nursery stage, seedling characters such as the sprouting period of seed-

nuts, number of leaves, girth at collar and seedling height are generally used (Satyabalan and Mathew, 1976). Most of these characters have correlation with the adult palm bearing. An index was developed by Rao and Mathew (1981) using mean and CV of these characters for evaluation and characterisation of coconut germplasm at the nursery stage. The number of days taken for germination has negative and significant correlation with yield and mean values for this character were ranked in ascending order and characters with positive correlation were ranked in descending order. The graph with mean on X axis and CV on Y axis has been arbitrarily divided into four sectors, taking the mid-values on both axes. The cultivars in sector 1 are with high mean values for characters scored and low variability. Their low CV indicated relative homozygosity. Sector 4 accounts for cultivars with low mean value and high variability indicating highly heterozygous nature of these cultivars. Those cultivars falling in group 1 can be considered as promising. Usually the performance of a cultivar is evaluated against the local material only after stabilization of yield which may take

15-20 years after planting. However, Rao *et al.* (1978) found that it is possible to evaluate the germplasm accession at an early stage as the cumulative yield of the first eight years had high correlation ($R^2 = 0.95$) with the stabilized yield.

SELECTION

This method of improvement was being practised by cultivators for ages through their experience as an art rather than from a scientific angle. Later the technique was given due attention by the coconut breeders. One of the selection programmes contemplated for yield improvement was identification of high yielding mother palms based on seedling and growth characters. Research workers like Lakshmanachar (1959), Liyanage and Sakai (1960), Nambiar *et al.* (1970), Narasimhayya and Sukumaran (1978) have tried to work out the heritability of yield and yield attributes in coconut. For yield, these estimates varied from 0.48 to 0.63 whereas for the yield attributes like number of spathes, female flower production, setting percentage etc., the estimates were still higher indicating the advantages of selection based on these characters. These informations have been used for yield improvement programme by identification of high yielding mother palms based on seedling and growth characters. The prepotency in coconut was suggested by Harland (1957) which presumed that in these palms the gene combination responsible for high yield potential tends to be transmitted *en bloc* to progeny even under random mating. Satyabalan *et al.* (1975) reported that it may be possible to identify palms of superior genetic value (prepotent) based on collar girth and leaf production in the nursery. It is possible to identify these palms even at the fifth month based on these two growth characters of the progeny

(Satyabalan and Mathew, 1976).

(Liyanage and Sakai (1960) worked heritability values for nut weight and copra and reported high heritability values of 0.67 and 0.95 respectively indicating that the yield of copra could be considered as the best selection criterion. Studies on the relationship between yield of nuts, copra content per nut, total yield per palm and yield of oil per palm showed that in WCT, the mean copra content, though negatively correlated with yield, did not affect annual copra out-turn per palm, the threshold value being 162.6 nuts, and that the yield of oil per palm and yield of nuts were significantly and positively correlated indicating the necessity for exercising selection pressure towards copra per nut and oil per cent in addition to number of nuts (Bavappa and Sukumaran, 1976).

HYBRIDIZATION

A new dimension to coconut improvement was added with the discovery of manifestation of hybrid vigour by Patel (1937) in crosses between West Coast Tall and Chowghat Dwarf Green. Subsequently, many workers (John and Narayana, 1949; Rao and Koyamu, 1952; Satyabalan, 1956; Liyanage, 1956 and Bhaskaran and Leela, 1964) confirmed the heterotic effects in the intervarietal and intra-varietal crosses. Till middle 1950s the emphasis was on the production of Tall x Dwarf (T x D) hybrids. These hybrids were precocious and high yielding compared to West Coast Tall only under good management. Satyabalan *et al.* (1970) found that among different dwarfs, Chowghat Orange Dwarf and Gangabondam were preferable as pollen parents compared to Chowghat Green Dwarf. Another finding of significance was the differential field performance of hybrids derived from different cross combinations of tall

and dwarfs due to differential combining ability of the parents. Therefore, emphasis for specific combinations involving selected individual dwarfs and tall was stressed. The off type palms obtained from open pollinated progenies of Orange Dwarf coconuts were found to be superior to West Coast Tall palms in yield of nuts and copra content per nut (Rao and Koyamu, 1955). They were believed to be natural cross hybrids between Chowghat Dwarf Orange (female) and West Coast Tall (male) parents. The hybrid COD x WCT was found to be superior to the tall parent as well as to its reciprocal in yield of nuts and out-turn of copra (Ninan and Satyabalan, 1964).

It has been reported by IRHO that Malayan Dwarf Yellow x West African Tall gives over 95-97% recovery of hybrids MAWA (PB 121). The same could not be realized in COD x WCT hybrid combinations where the hybrid recovery was only about 30% on an average. However, the study by Satyabalan and Rajagopal (1987) has shown that by proper selection of parents on nut characters (dwarf palms having shell content less than 20% of husked weight are to be pollinated with tall palms which have a husk content of less than 50% of fruit weight and more than 150 kg of copra/nut) maximum recovery of hybrids could be obtained.

In view of the superior performance, the VII Workshop of All India Co-ordinated Coconut and Arecanut Improvement Project recommended the release of hybrids COD x WCT (Chandrasankara), LO x COD (Chandralaksha) and LO x GB (Lakshaganga) for cultivation in Kerala. The comparative performance of hybrids is given in Table 2. Hybrids VHC 1 (East Coast Tall x Dwarf Green) and VHC 2 (East Coast Tall x Malayan Yellow Dwarf) were released by the Tamil Nadu

Agricultural University for cultivation in Tamil Nadu during 1981 and 1988 respectively. These two hybrids gave 16.4 and 26.7% more yield over East Coast Tall. Hybrids involving LO x COD and LO x GB showed less fluctuation in yield due to drought compared to COD x WCT.

A total of 87 cross combinations involving promising cultivars were planted in different periods at CPCRI, Kasaragod and are being evaluated for yield and other attributes. These include 21 tall x dwarfs, 10 dwarfs x tall, 51 tall x tall, 4 dwarfs x dwarfs and one three way hybrid.

REFINEMENT OF HYBRIDIZATION TECHNIQUE

Considering the tedium involved in the traditional method of hybridization, refinements have been brought out in the hybridization technique. A simple hybridization technique for the commercial production of coconut hybrids has been standardized. This technique involves emasculation of the male flowers before female flowers come to receptivity, collection of mature male flowers from selected tall parents, extracting the pollen, mixing of pollen with diluents in the ratio of 1:9 and dusting this mixture using a pollen dispenser (Pillai and Rao, 1984).

SEED PRODUCTION

Based on the National Group Discussion on Strategy for Planting Materials held at Kasaragod in January 1988, the annual planting material required in the country has been estimated as 15 million seedlings. This includes seedlings required for new planting to the extent of 30,000 ha per year (four lakh ha already been identified as suitable for coconut cultivation by Coconut Development Board), replant-

ing and under-planting in other areas. Taking into consideration the performance of tall and dwarf, the group also identified parents such as COD, MOD, LO, ECT etc. suitable for hybrid seed production in different states.

For the large scale production of hybrids, hybrid seed gardens have been established in Kerala, Karnataka, Tamil Nadu and Orissa (Pillai and Nayar, 1979). A total of 1.5 million hybrid seedlings are expected to be produced annually from these seed gardens. Earlier, planting of alternate rows of tall and dwarf was recommended. Since only two hybrid combinations are produced in this method, compact block planting of pure dwarf is being preferred. All the palms in this block are emasculated and assisted pollination is carried out using the desired pollen. In this way many desirable hybrid combinations can be obtained.

TISSUE CULTURE

Another recent approach is clonal multiplication through tissue culture. Recently Raju *et al.* (1984) have succeeded in producing clonal plantlets directly from tender leaf segments of WCT and T x D hybrid seedlings through direct somatic embryogenesis. They could obtain from a single leaf explant measuring 5 mm as many as 48 embryoids. However, the response was found to be erratic and repeatability was found to be extremely low. Current efforts are directed towards perfecting this technique and also to use adult palm tissues.

SCREENING FOR DROUGHT TOLERANCE

A method for screening coconut cultivars for their tolerance to drought using sensitive parameters like stomatal resistance, epicuticular wax content, leaf

water potential etc., has been standardized. Out of the genotypes screened, ten have been identified to possess the desired traits to withstand drought (Rajagopal *et al.*, 1988).

FUTURE STRATEGY

Though India has one of the largest and best germplasm accessions, the collections cannot be considered as comprehensive as the total variability represented is very narrow. Screening so far shows that none of the germplasm is resistant/tolerant to root (wilt) disease which is a major production constraint. The fact that coconut belongs to monotype genus also limits the possibility of tapping gene-pools from related sources. In view of this, broadening the genetic base through collections from Melanesia, Micronesia and Indian Ocean islands which are known to have wide variability should receive top priority. Similarly the indigenous collections are not representative of the total variability in the country. Collections from Orissa, West Bengal and North Eastern Region should also receive top priority.

It is necessary to have a sizable population (minimum 10 palms per accession) of the collections maintained preferably at more than one location, their characters described and evaluation records are maintained so that the breeders can utilize them for introgression of any one of the desirable features in the breeding programmes. Maintenance of duplicate set would help in meaningful evaluation and also as a stand-by in case of a disease threat. For the initial evaluation trials, a well laid out statistical design preferably RBD with three replications and six palms/cultivar is desirable. Such preliminary evaluation will help in reducing time lag since the promising ones from these trials can be multiloca-

tionally tested for their adaptability and yield. The co-ordinating centres could be used for such trials.

In Sri Lanka and Indonesia selection of phenotypically superior palms met with some success in realizing higher mean yield in the progenies. Since it is possible to identify prepotent palms based on progeny performance all the traditional cultivars must be screened for prepotency for use in breeding programmes as well as in replanting and underplanting programmes.

INBREEDING

Inbreeding and developing pure lines have not received adequate attention from the breeders. The possibility of developing superior hybrids by inbreeding followed by hybridization needs to be explored. Where inbreeding depression is apparent, introgression with other palms should be attempted to correct the weakness after which a second phase of selection of inbreeding may be attempted.

EXPLOITATION OF HETEROSIS

The experience from Ivory Coast on the performance of MAWA (PB 121) hybrids and also on the performance of different hybrids in other countries clearly shows that it is necessary to select dwarfs and tall based on combining ability of the individual palms within an accession/cultivar before resorting to hybridization. A systematic study of the combining ability of the diverse sources of dwarf germplasm with pollen from prepotent tall must be initiated. The homogeneous dwarfs thus identified must be planted in the elite seed gardens of the country for mass-production of hybrids. Malayan Yellow Dwarf which appears to be much more homogeneous due to its self-pollinating nature may prove to be a good female

parent in crosses with promising tall in realising high recovery of superior performing D x T hybrid seedlings. The high out-turn of copra realised in T x T crosses in Indonesia indicates the possibility of upgrading tall. Efforts must be made to utilize all the promising tall like Laccadive Ordinary, Philippines Ordinary and Andaman Ordinary besides West African Tall and Renell Tall in the production of T x T crosses.

RESISTANCE BREEDING

The role of MLO in the etiology of root (wilt) disease has been conclusively proved. In view of the fact that effective control measures are not likely to emerge against this disease, breeding tolerant/resistant cultivars should be taken up on a war-footing. The first step in this direction must be to screen the *inter se* progenies of the exotic germplasm (Pacific Ocean collections) available at the World Coconut Germplasm Centre, Andamans and also to utilize the 35 tolerant palms identified in the farmers field in disease affected areas in the breeding programme. Survey for more tolerant palms in the endemic areas also must be taken up simultaneously. While breeding resistant varieties, attempts should be made to incorporate preferably polygenic resistance into improved varieties/hybrids. This is of vital importance as improved varieties/hybrids will have to remain resistant tolerant for over 60-80 years. A similar effort must be taken up to breed resistant/tolerant cultivars against Thanjavur wilt, thatipakka and stem bleeding diseases.

TISSUE CULTURE

Efforts are to be directed towards perfecting the production of clonal plantlets directly from seedling leaf tissues to adult palms and also to standardize transfer of plantlets from test tube

to soil through the process of hardening of the root system using hydroponic methods. The next step, should be micropropagation for mass multiplication of high yielding elite palms.

IN VITRO CONSERVATION

Embryo culture technique has been standardized by Assy-Bah *et al.* (1988) and at CPCRI and this can be effectively utilized for germplasm collection specially from exotic sources. To supplement the 'field genebanks' cryopreservation for long term storage in *in vitro* banks also should be explored.

ANTHER CULTURE

Preliminary studies at CPCRI have resulted in multicelled pollen embryoids. Anther culture for the production of haploids and homozygous diploids should be an exciting and rewarding attempt in realising the production of isogenic coconut genotypes. If isogenic dwarf and tall could be obtained, this would assure 100% recovery of hybrids in compatible combinations.

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