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BREEDING FOR HIGH YIELD IN COCONUT

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ABSTRACT

The Indian coconut population comprises enormous variability, accrued over the years of its cultivation in the country. Improvement in yield potential so far achieved in coconut has been through conventional breeding methods like selection and hybridisation. Mother palm selection based on the number of nuts and morphological characters genetically correlated with yield were found to improve the efficiency of selection. The concept of prepotency though proposed by Harland in the fifties did not receive attention from coconut breeders. Exploitation of hybrid vigour involving crosses between tall and dwarf has resulted so far in releasing nine hybrids with not only high yield but also precocity in bearing. Exploitation of prepotency, crosses between tall and dwarf possessing wider genetic diversity, utilising prepotent talls and homogeneous dwarfs in breeding for disease and drought tolerance, quality improvement with respect to oil content and evolving plant types suitable for coconut-based farming systems are the future strategies suggested.

INTRODUCTION

Coconut improvement is a difficult and time-consuming programme mainly because of the long gestation period, large area and resources required for experimentation, low seed multiplication ratio and lack of reproducible clonal propagation technique. Despite these limitations India was the first country in the world to report hybrid vigour in coconut involving a cross between tall and dwarf palms (Patel, 1937). Enormous variability has accrued in the Indian coconut population over the years of cultivation and this is represented in the 40 indigenous accessions among the world's largest germplasm holding of 126 accessions maintained at the Central Plantation Crops Research Institute, Kasaragod.

BREEDING STRATEGIES FOR COCONUT IMPROVEMENT

Cocos nucifera L. is a monotypic genus with a restricted genetic base. Two distinct cultivars identified in nature are *typica* or the Tall and *nana* or the Dwarf. Tall is a cross-pollinated palm population and the dwarf is comparatively having more homogeneous population with varying degrees of self-fertilisation. Improvement in yield potential in coconut so far achieved has been through conventional selection among the Tall population and hybridisation between Tall and Dwarf.

SELECTION

The earliest selection procedure adopted in coconut was upgrading the existing Tall population through the selection of consistently high-yielding individuals and marking these palms for collection of seed-nuts. Selection of mother palm is mainly based on annual yield (number of nuts/palm) and copra content/nut. An examination of the variability in yield of nuts showed that an improvement up to 20 per cent could be achieved by the mother palm selection alone. By convention, an average annual yield of more than 80 nuts/palm/year under rainfed condition is considered necessary for mother palm selection. The yield data of four different populations of West Coast Tall presented in Table 10.1 indicates that the percentage of high yielding palms (80 nuts/palm/year) varies from 5.9 to 16.7.

Table 10.1: Distribution of palms in various yield groups

Location	*No. of palms studied*	*Yield group*	*Percentage of palms in the group*	*Percentage contribution to yield*	*References*
Kasaragod Kerala	1400	Below 40	32.0	17.3	Menon and Pandalai (1958)
		40–80	59.4	66.9	
		Above 80	8.6	15.8	
Kasaragod Kerala	4347	Below 40	31.3	17.2	Jacob Mathew *et al.* (1979)
		40–80	60.3	67.6	
		Above 80	8.4	15.3	
Pilicode Kerala	150	Below 40	29.3		Kannan (1982)
		40–80	54.0		
		Above 80	16.7		
Veppankulam Tamil Nadu	1668	Below 40	66.9	34.1	Venkateswaran *et al.* (1975)
		40–80	27.2	47.4	
		Above 80	5.9	18.5	

Identification of many elite palms with annual yields of 200 nuts and in rare cases over 400 nuts (Table 10.2) by Iyer *et al.* (1979) indicates the gap between the yield realised and the available yield potential. The fact that some of these super palms are root (wilt) tolerant, adds to their importance as potential parental material in the breeding programme.

Mother palm selection aiming at retention of the desired genotypes and elimination of undesirable ones is recognised as an important method in coconut improvement. The process involved identification of potentially high yielders using some of the recognised morphological characters followed by progeny selection. Straight stout trunks with uniform trunk growth, spherical or semi-spherical crown, short and stout bunch stalks, number of leaves and inflorescences, high and consistent yield of nuts, high copra outturn and freedom from pests and diseases are the characters recommended for mother palm selection (Menon and Pandalai, 1958). It is clear that the selection emphasis is naturally for annual production of nuts since the market value still depends on the number of nuts produced.

Table 10.2: Characteristics of elite palms

Palm No. and location	*Age of palm in years*	*No. of leaves on crown*	*No. of spathes/year*	**Annual yield of nuts*
Root (wilt) disease free area				
SP-I Chengala (Cannanore Dt.)	40	35	22	200
SP-II Ezhom (Cannanore Dt.)	20	35	20	300
SP-II (a) Attaygoli (Cannanore Dt.)	16	43	24	250
Root (Wilt) disease prevalent area				
SP-III Ernakulam	16	46	24	300
SP-IV Kayangulam	12	43	19	200
SP-V Thazhava	20	35	24	471
SP-VI Krishnapuram	21	40	19	300
SP-VII Kalayoor	20	46	21	250
SP-VIII Champakulam	30	50	21	300

*Average yield for three years (Iyer *et al.*, 1979).

HERITABILITY/CORRELATION STUDIES

Heritability estimates for yield of nuts in coconut varied from 0.48 to 0.63 (Lakshmanachar, 1959; Nambiar *et al.*, 1970; Narasimhayya and Sukumaran, 1978) and its importance in selection based on yield alone is expected to be negligible. Some of the yield attributes such as copra/palm/year and weight per husked nut showed comparatively high heritability values of 0.67 and 0.97 respectively (Liyanage and Sakai, 1960). Usefulness of giving attention to yield related attributes such as number of leaves produced during the first 40 months (Liyanage, 1967), number of female flowers and percentage of nut set (Nambiar and Nambiar, 1970), high initial yield (Satyabalan *et al.*, 1972) and more number of spikes with one female flower (Nambiar and Ravindran, 1974) were indicated to improve the efficiency of mother palm selection.

Yield in coconut being a complex character controlled by a number of components and their interaction, path coefficient and regression analysis were attempted on coconut to identify the characters with direct influence on cumulative and average yield (Sukumaran *et al.*, 1981). Their study showed that number of female flowers at 21 to 24 years, number of functional leaves in the nineteenth year, internodal distance at a fixed mark, total leaf production up to three years after sowing, and time taken for flowering, are the important components which have direct influence on the yield. While these characters can be used to a certain extent, the expected gains are not often realised mainly because of their high phenotypic correlation but low genetic correlation. Nampoothiri *et al.* (1975) therefore suggested giving importance to characters like girth at collar and leaf production in the nursery and spathe production in adult palms since these are generally correlated with yield.

SELECTION OF PREPOTENT PALMS

The concept of prepotency proposed by Harland (1957) was a significant step in mother palm selection. Based on the experience with open-pollinated cocoa progenies and drawing analogy with animal breeding he proposed that prepotent palms transmit to their progenies their high yield probably through the possession of a favourable combination of dominant genes even when they are subjected to random open mating. The concept further assumes that in a highly cross-pollinated and heterogeneous population of tall coconut, a small proportion of elite high yielding palms are maintained in nature, which exhibit a high rate of transmission of the parental traits to their progeny.

Identification of prepotent talls based on progeny performance would normally take several years and hence attempts were made by many workers to select palms at the nursery stage by correlating seedling characters with adult palms. Ninan and Pankajakshan (1961) showed that it is possible to distinguish high yielders which would give superior progenies from those giving inferior progenies on the basis of seedling performance in the nursery. The possibilities of locating prepotent palms on the basis of their progeny performance in the nursery was reported by Ninan *et al.* (1964) based on significant differences in vigour and growth rate of seedlings between families in comparison with variation within families. The report of Satyabalan *et al.* (1975) that seedling characters such as collar girth and leaf production are genetically correlated with the adult palm yield was subsequently confirmed by Nampoothiri *et al.* (1975). The possibilities of identifying palms of superior genetic value even at the first month based on collar girth and leaf production of high-yielding families was indicated by Satyabalan and Jacob Mathew (1983). In spite of these reports the concept of prepotency has not been put into practical utility by the coconut breeders perhaps due to the very low percentage of such palms and the time consuming and laborious procedure in the evaluation of performance of open-pollinated progenies.

EXPLOITATION OF HYBRID VIGOUR

Ever since the report of heterosis in Tall × Dwarf hybrids by Patel (1937), various hybrids involving Tall and Dwarf have been evaluated for their increased productivity. In the immediate years following the discovery of hybrid vigour in coconut, the emphasis was on the production of Tall × Dwarf hybrids. These hybrids were precocious and high yielding compared to the local cultivar West Coast Tall, under irrigation and good management. Among the different dwarfs, Chowghat Orange Dwarf and Gangabondam were preferable as pollen parents over Chowghat Green Dwarf (Satyabalan *et al.,* 1970). Emphasis for specific combinations involving selected individual dwarfs and talls was stressed as the field performance of hybrids derived from different combinations were found to vary due to differential combining ability of individual palms.

So far nine hybrids have been recommended for release for large-scale cultivation to various parts of the country. The details are given in Table 10.3. It could be seen that the cross-combinations between Talls and Dwarfs are not only high yielding but also precocious. The yields of hybrids in terms of nut production were much higher (95 or more nuts/palm/year) compared to around 80 nuts produced by the Tall cultivar.

Table 10.3: Performance of released coconut hybrids

Hybrids	*Nut yield/ palm/year*	*Copra yield*		*Copra yield/ ha (t)*	*Oil content (%)*	*State for which recommended*
		Mean/ nut (g)	*Mean/ palm (kg)*			
Chandrasankara (COD × WCT)	116	215	25	4.4	68	Kerala Karnataka Tamil Nadu
Kerasankara (WCT × COD)	108	187	21	3.5	68	Kerala Karnataka
Chandralaksha (LO × COD)	109	195	21	3.7	69	Kerala Karnataka
Lakshaganga (LO × GB)	108	195	21	3.7	70	Kerala
Anandaganga (AO × GB)	95	216	21	3.6	68	Kerala
Keraganga (WCT × GB)	100	201	21	3.5	69	Kerala
VHC-1 (ECT × DG)	98	135	13	2.3	70	Tamil Nadu
VHC-2 (ECT × MYD)	107	152	16	2.9	69	Tamil Nadu
ECT × GB	140	150	21	3.7	68	Andhra Pradesh
WCT	80	176	14	2.5	68	Control

The difference in copra yield is more marked in Chowghat Orange Dwarf × West Coast Tall hybrid giving as much as 25 kg per palm per year in comparison with 14 kg from West Coast Tall. However judicious selection of parental lines and cultivars within the talls and dwarfs seems necessary since combination-wise differences are noticeable.

SEED DEMAND VERSUS SUPPLY

It is of interest to examine the extent of availability of improved/released hybrids *vis-a-vis* its requirements. The current annual demand for coconut seedlings in the country is estimated at 15 million. The production of hybrids is to the tune of only one million and that of Talls is 2.2 million (Table 10.4). Thus there is a wide gap between demand and supply. This situation is being exploited by private nurseries which supply poor quality seedlings. It is, therefore, necessary to increase hybrid production capability of the existing 24 seed gardens covering an area of 1,258 ha and additional seed gardens need to be established in the major coconut growing states. These seed gardens should be planted with parental materials to produce hybrids recommended for the respective states.

Table 10.4: Production of planting materials (in millions)

Agency	*Present production (1991)*			
	Talls	*Dwarfs*	*T x D*	*D x T*
1. Dept. of Agric. Kerala	1.26	—	0.09	0.01
2. C.S.F., Aralam	0.04	—	0.007	0.01
3. Dept. of Agric. Tamil Nadu	0.70	—	0.35	0.35
4. Dept. of Agric. Lakshadweep	0.06	—	0.05	0.05
5. C.P.C.R.I., Kerala	0.11	0.02	0.003	0.01
TOTAL	2.17	0.02	0.50	0.43

FUTURE BREEDING STRATEGIES FOR YIELD IMPROVEMENT

From the foregoing review, it is evident that, if adequate planning is made to adopt viable strategies and their implementation, higher yield levels are attainable through use of quality planting material. Future strategies for increasing the productivity in coconut are indicated below:

1) *Prepotency*

Since the possibility of selecting prepotents has been adequately demonstrated, it now remains to identify and multiply a large number of such palms which could be directly used to improve the local talls and also as parents in breeding programmes.

2) *Crosses involving wider genetic diversity*

Most of the results so far obtained are through hybrids between local talls and dwarfs, the genetic diversity of which is narrow. We should make use of the available materials introduced from various countries and crosses between Talls and Dwarfs possessing as much wider diversity as possible which should be evaluated. Rennel Tall, for example, has been reported to be a good combiner in many of the countries. It will be rewarding to try cross-combinations involving Rennel Tall and Indian Dwarfs. Selfing of talls and testing the individual combining ability with Dwarfs could improve the efficiency.

3) *Tall x Tall crosses*

Although there are reports of high yielding Tall × Tall crosses elsewhere, the performance report of these hybrids in India has not been encouraging. It is likely that by a judicious choice of the parental talls better yielding Tall × Tall hybrids could be evolved.

4) *Homogeneous dwarfs*

In spite of the reported self-pollination in dwarfs variability is observed in the progenies of pure populations of dwarfs. It will be of advantage to employ more homogeneous dwarfs, which can be easily identified through simple field experimentation in crossing programmes.

5) *Breeding for disease and drought tolerance*

Breeding for adaptive traits like tolerance to diseases which has no control measure should receive priority attention.

Root (wilt) disease prevalent in Kerala is caused by MLOs and there is no specific control measure available. Though none of the varieties/hybrids tested so far is tolerant to the disease individual high yielding field tolerant palms have been identified in 'hot spot' areas. Selfed and *inter se* progenies of these field tolerant palms are now under field testing, and evolving a tolerant variety is the only hope to combat the disease.

Similar work is also to be taken up to locate tolerance to Thatipaka disease caused by mycoplasma like organisms.

More emphasis is required on breeding for drought tolerance since coconut is by and large grown under rainfed conditions and more and more non-traditional areas are being brought under this crop. Some of the comparatively tolerant hybrids, namely, Laccadive Ordinary (LO) × Chowghat Orange Dwarf (COD); LO × Gangabondam (GB); and West Coast Tall (WCT) × GB as well as WCT, Andaman Ordinary and FMS Tall are found to be more tolerant to stress (Rajagopal *et al.*, 1990). These materials could be advantageously used in breeding programmes to evolve stress-tolerant varieties.

6) *Quality improvement*

Though the variability in oil content is narrow, cultivars like Laccadive Ordinary are known to have an oil content of 72 per cent. Efforts have not been made for purposeful improvement in oil content perhaps because the market value is mostly dependent on the number of nuts. It is also necessary to breed for a low saturated : unsaturated oil ratio in view of the dietary consciousness of vegetable oil users.

7) *Establishment of seed gardens to meet the demand*

At present the country is not in a position to meet the increased demand for quality planting material. At the time of establishment of existing seed gardens, the various hybrids now recommended for cultivation were not released. The existing seed gardens will have to be redesigned to produce recommended hybrids and new seed gardens are to be established to meet the demands for hybrids.

8) *Comprehensive breeding strategy*

Though a breeding strategy was suggested by Bavappa and Nampoothiri (1974) most of the trials undertaken were on an *ad hoc* basis relating to one specific problem or the other. It is therefore felt necessary to adopt a comprehensive breeding strategy utilising all the available information and existing genotype resources, notwithstanding the large number of years required for the same.

9) *Breeding for genotypes suited for multiple cropping system*

With the declining trend of monoculture systems and adaptation of multiple cropping, there is anticipated demand for cultivars/hybrids suited to such situations. Continued work on ideotypes for various coconut-based farming systems will be required in the near future.

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DISCUSSION

Rupa Wickramaratne: Do you have location specific varieties for yield?

M.K. Nair: Yes. The varieties recommended for Kerala are West Coast Tall, WCT × COD, COD × WCT, LO × COD, LO × GB, AO × GB and WCT × GB. Laccadive Ordinary is recommended for the states of Kerala, Tamil Nadu, Andhra Pradesh and Maharashtra. Banawali Green Round is recommended for Maharashtra. For Tamil Nadu, two hybrids VHC-1 and VHC-2 are recommended.

A. Muralidharan: The variety Kappadam fulfils all the three essential criteria for mother palm selection. Why is it not finding a place in the breeding programmes?

M.K. Nair: CPCRI is using Kappadam as a parent in the current breeding programme.