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Review Article

THE PRESENT STATUS OF COCONUT BREEDING IN INDIA

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ABSTRACT

The progress in the research work done on collection, conservation and evaluation of coconut germplasm and in selection and hybridisation for the improvement of the palm in the different research centres in India since 1970 is reviewed. Limitations met with in coconut breeding are enumerated.

INTRODUCTION

Improvement of perennial crops in general and coconut in particular by breeding is very complicated and time consuming. The long juvenile period, the long interval between generations, heterozygous nature of the palm, the long period of experimentation required to obtain results and the large area required for a statistical layout of the experiment are mainly responsible for the slow progress in coconut breeding work. In spite of these limitations, considerable progress has been achieved in India where organised coconut breeding work was started for the first time in the world as early as 1916. It was at the erstwhile Central Coconut Research Station, Kasaragod [now the Central Plantation Crops Research Institute (CPCRI)] and its research centres now under the Kerala Agricultural University that several items of breeding work on the improvement of the coconut palm were initiated. H. C. Sampson in his book *The Coconut Palm* published in 1923 had referred to the earliest breeding work on coconut (Sampson, 1923). A more extensive coverage is found in the book *The Coconut – A Monograph* by J. S. Patel published in 1938 (Patel, 1938). References to later works have been made in detail in the publications *The Coconut Palm – A Monograph* (Menon and Pandalai, 1958) and *Hand Book on Coconut Palm* (Thampan, 1981).

The highlights of research on coconut carried out in the country have been brought out in *Six Decades of Coconut Research in India* (Anonymous, 1976b) and *Sixty Years of Coconut Research* (Anonymous, 1976c) published on the occasion of the Diamond Jubilee Celebration of Coconut Research. Bavappa and Nampoothiri (1974) and Bavappa and Sukumaran (1976) reviewed

the work on breeding in coconut and suggested future lines of work in the light of information gathered in the past. Iyer et al., (1978) described the *limitations encountered in coconut breeding* methodologies adopted and suggested some lines of approaches. In this paper a review on the status of coconut breeding work in India since 1970 has been presented.

I. COLLECTION, CONSERVATION AND EVALUATION OF COCONUT GERMPLASM

For evolving a purposeful breeding programme in coconut, germplasm collection of 62 exotic and 32 indigenous cultivars is being maintained at CPCRI, Kasaragod. Recently a further introduction of 2500 nuts of 20 Talls and 4 Dwarfs from Solomon Islands, Fiji, American Samoa, Tonga, French Polynesia and Papua New Guinea has been made to widen the genetic base (Rao and Koshy, 1982). In the Co-ordinating Centres like Pilicode (Kerala), Veppankulam (Tamil Nadu), Arsikere (Karnataka), Ambajipet (Andhra Pradesh) and Ratnagiri (Maharashtra) also, similar germplasm collections are being maintained, to study their performance under different agroclimatic regions. Observational trials of promising cultivars have been laid out in Mahuva (Gujarat), Kalyani (West Bengal), Cuttack (Orissa) and Coimbatore (Tamil Nadu). All these cultivars are being evaluated for their yield of nuts and copra and other morphological and yield characters and compared with the local Tall cultivar.

The evaluation trials have indicated Philippines Ordinary, Philippines Laguna, Strait Settlements Green (Malaysia), Java (Indonesia) and Fiji Talls among the earlier introductions and San Ramon (Philippines), Borneo (Indonesia), Guam types I and III, Nigerian Tall and Zanzibar Tall from the later introductions are superior to others. Among the indigenous cultivars, Laccadive Ordinary, Laccadive Micro, Kappadam, Andaman Ordinary and Andaman Giant have high yield potential (Anonymous, 1981b). Studies on the yield performance of eight germplasm introductions have indicated that copra outturn is high in San Ramon because of its high kernel content per nut, though the yield of nuts is low. In cultivars Zanzibar, Guam and West Coast Tall, the yield of nuts and copra outturn are high (Satyabalan and Pillai, 1977). An assessment of the yield performance of 12 cultivars introduced during 1955–'56 has indicated that Zanzibar Tall, Solomon Islands Tall, Guam Tall types I, II and III have yielded more than 90 nuts per palm per annum whereas Zanzibar Tall, San Ramon (Philippines) and Guam Tall types I and III yielded more than 20 kg of copra per palm per annum (Satyabalan, Rao and Pillai, 1979). Jacob and Krishnamoorthy (1981) surveyed the Lakshadweep islands for available Laccadive Micro palms, the population of which has been on the decline due to introgression resulting in the intermediate types between Laccadive Ordinary and Laccadive Micro. For conservation of indigenous cultivars *inter se* pollination has been carried out in Laccadive Micro palms in Androth and Kavaratti islands in the Lakshadweep islands, in Andaman cultivars in Andaman islands and in Gangabondam palms in a farmer's

garden near Ambajipet in Andhra Pradesh (Anonymous, 1981b). An index for evaluation at different stages based on seedling characters at the 12th month (Rao and Mathew, 1981), pre-bearing growth characters, and economic evaluation at the stabilised yield period based on flowering and yield data has been worked out for rapid evaluation of the germplasm material (Rao, Satyabalan and Mathew, 1978). Nampoothiri and Nair (1976) recommended certain coconut cultivars suitable for garden lands.

Among the indigenous cultivars, the performance of Laccadive Ordinary has been found to be good in different Co-ordinating Centres (Anonymous, 1981a, b). It has been accepted for large scale cultivation in Kerala State. At Pilicode, it gave the highest yield of copra per palm per year (15.34kg) among all the indigenous and exotic accessions, followed by Philippines (13.66 kg) and Java (13.25kg). The local West Coast Tall gave an yield of only 10.60 kg of copra (Anonymous, 1981c). In Karnataka, Shanthamalliah et al., (1981) reported that out of 19 accessions (both exotic and indigenous) planted at Arsikere, Philippines, Gangabondam and Laccadive Ordinary were found to be regular and high yielding than others. In Ratnagiri, it has been reported that Laccadive ordinary gave the maximum number of nuts, when compared to others (Anonymous, 1982). In a survey undertaken in *Maidan* parts of Karnataka for coconut germplasm, two cultivars *Chittagangapani* and *Uddagangapani* suitable for tender coconut were identified and their morphological features studied (Shanthamalliah et al., 1981).

In Tamil Nadu, Venkateswaran et al., (1975) made a study of coconut plantations of East Coast Tall and reported that over 40 per cent of the population of 1668 palms had an average annual yield of 20 nuts or less. Thinning from 262 palms per hectare to 160 per hectare resulted in an yield increase of 25 per cent. Peter and Jayaraman (1977) studied a population of East Coast Tall variety and reported on the high degree of variability for all the characters and stressed the need to take into consideration both production of nuts and copra together for selection of mother palms. Louis, Vijayan and Jayaraman (1977) studied variation in tender nut characters in eight coconut varieties and found that a desired volume of water combined with high sugar content were in Semi-Tall Red and Semi-Tall Green. Ramachandran, Muralidharan and Balasubramanian (1977) found the variety *Ayiramkachi* intermediate between Tall and Dwarf in characters. The important character of this variety is high female flower production which can be exploited for breeding work. But the setting percentages in this variety is low. It is an alternate bearer yielding 75 nuts per palm per annum. This variety was originally obtained from a private nursery in Ramanathapuram (Tamil Nadu).

In Orissa a survey of 20,000 selected palms in 600 coconut plantations of coastal districts and data on growth, yield and nut characteristics of 5,128 palms revealed the existence of two varieties - Orissa Tall and Orissa Dwarf with five forms under Tall and two forms under Dwarf (Panda, 1982).

For coconut germplasm collection a sample procedure to be adopted has been described by Mathew, Rao and Satyabalan (1978).

II. SELECTION

With regard to the improvement of the local cultivar West Coast Tall, criteria for selection of mother palms, seednuts and seedling established by research workers have proved helpful in producing quality planting material. Heritability estimates worked out for different yield groups of coconut have indicated that the estimates were higher for number of female flowers, yield of nuts and percentage set (Nambiar and Nambiar, 1970). Studies on the pattern of genetic variation for reproductive characters and its impact on yield potential have shown that selection of genotypes with low variance of distribution of female flowers and more number of spikes with one female flower tend to reduce instability in production and increase productivity (Nambiar, Mathew and Sumangalakutty, 1970; Nambiar and Ravindran, 1974). Path coefficient analysis for yield of nuts during stabilised period of yield showed that the major contributing characters which influenced yield directly or indirectly were average number of female flowers, number of functioning leaves at 19 years and internodal distance at fixed mark. These characters influenced yield indicating their value in selection (Sukumaran, Narasimhayya and Kumar, 1981). Louis (1981) studied the phenotypic and genotypic variability in 25 varieties and hybrids and found number of leaves per year, number of leaves on the crown, number of spathes per year, number of female flowers per palm, setting percentage and number of nuts to have high genetic advance and recommended consideration of these characters for exercising selection. The performance of under-planted palms studied indicated that they reach full bearing very late. The studies indicated that the yield potential of the palms could be gauged from their initial yields and the height of the palm and number of functioning leaves were significantly correlated with yield (Satyabalan, Mathew and Radhakrishnan, 1972). Studies on phenotypic and genotypic correlations of four seedling and four adult palm characters with yield in coconut indicated that number of leaves and collar girth of seedlings are positively correlated with yield (Nampoothiri, Satyabalan and Mathew, 1975). High yielding progenies were obtained from palms yielding more than 80 nuts per annum selected at random. Seedling selection though necessary need not be as stringent as is advocated at present since the yield difference between vigorous and intermediate seedlings is not significant (Kannan and Nambiar, 1979).

According to Satyabalan (1982), the percentage of high yielders (palms yielding 80 nuts and above per palm per year) in a population is low when compared to medium yielders (those yielding between 40 and 80 nuts) and poor yielders (those yielding less than 40 nuts). It was also indicated that all high yielders do not give high yielding progenies.

Based on the suggestion made by Harland (1957) studies have been made

to identify prepotent palms based on progeny performance in the nursery. Earlier studies made by Ninan and Pankajakshan (1961) and Ninan, Pankajakshan and Abdu (1964) indicated that on the basis of seedling performance it is possible to isolate high yielders which yield superior progenies as the differences in growth rate and vigour of seedlings between families were highly significant in comparison with variation within families. Satyabalan, Nampoothiri and Mathew (1975) reported on the possibility of identifying prepotent palms based on certain seedling characters in the nursery. The possibility of identifying palms of superior genetic value, based on the growth characters (collar girth and leaf production) of progenies recorded from fifth month after germination was indicated by Satyabalan and Mathew (1976). Further, they also observed that the seedlings raised from the nuts of prepotent palms, were more vigorous than those of other palms irrespective of the months of harvest and germination. More than 80 per cent of the progenies of two prepotent palms identified out of 16, had collar girth and leaf production above the general mean of that of 559 seedlings studied. Prepotency studies in West Coast Tall conducted at Nileshwar (Kerala) on 20 progenies each of 15 palms from Kuttiadi area (Kerala) indicated that only two families have high yield (Anonymous, 1977), showing thereby that progenies of all high yielders need not be high yielding.

Correlation studies carried out on 513 West Coast Tall palms comprising low (yielding below 40 nuts per palm per year), medium (between 40–80 nuts) and high yielders (above 80 nuts) showed a high positive correlation between the total yield of copra, and the yield of nut and copra content per nut in all the yield groups. The relationship was linear and high even when the above three groups were combined. The copra content per nut was not related to the yield of nuts (Anonymous, 1975). In West Coast Tall, the mean yield of nuts was significantly and positively correlated with both annual outturn of copra and oil, whereas with mean copra content per nut it was negative and significant. The oil percentage in copra was not significantly related to yield of nuts. Studies on the relationship between yield of nuts, copra content per nut, total yield of copra and yield of oil per palm in West Coast Tall showed that the mean copra content per nut although negatively correlated with yield, did not affect the annual outturn of copra per palm, the threshold value being 162.6 nuts. Similar relationship was found to exist for yield of nuts and annual outturn of oil also indicating the necessity for exercising selection pressure towards weight of copra per nut and oil percentage in addition to number of nuts (Bavappa and Sukumaran, 1976).

Analysis of yield attributes like inflorescence production, female flower production and setting percentage in different yield groups indicated that high yielders produce regular bunches, leading to high female flower production, resulting in high yield, whereas in low yielders, production of bunches, female flowers and setting percentage were poor. Correlation studies also showed

positive significant correlation for number of bunches, female flowers and setting percentage with yield (Anonymous, 1976a). Iyer, Rao and Govindankutty (1979) made a systematic survey to locate palms with remarkably high yield potential and identified 19 such elite palms. These elite palms which are reported to have annual yield ranging from 200 to over 600 nuts apparently under little or no management are being studied for their different characters like canopy, leaf production, rate of leaf senescence, bunch production, female flower production, setting percentage etc. for working out a model for an ideal plant type in coconut (Iyer et al., 1981).

III. TISSUE CULTURE

Another recent approach for multiplication of elite palms or prepotent palms is through tissue culture. The approaches being considered for the rapid propagation of elite coconut palms from floral primordia and root and stem cultures are described by Iyer and Shetti (1981). D'souza (1980) has reported on the hypocotyl budding in cultured coconut embryos.

IV. POLLINATION BIOLOGY AND POLLEN STUDIES

Studies on pollination biology of coconut by Kumar and Sukumaran (1981) have shown that maximum rate of pollen tube growth was in Laccadive cultivars and that eight insect species visit coconut crown mainly between 10 AM to 12 noon, under Kasaragod condition. They developed formulae to quantify intensity of floral phase overlapping. Nampoothiri (1970) based on the observations in 12 cultivars reported significant and negative correlation of sterility with pollen germination. The flowers at the distal end of the inflorescence were the least sterile and those at the proximal end were most sterile. Proportion of male flowers at distal, middle and proximal position was constant from tree to tree in Tall, Laccadive and Philippine but in Dwarf the ratio of male flowers was variable from tree to tree.

Studies on variation in pollen characteristics of eight coconut cultivars indicated some variation in both pollen germination and pollen tube growth and this was attributed to different nutritional and environmental requirements of the cultivars for pollen germination. However, there was no relationship between the two characteristics (Shamsuddin and Nampoodiri, 1979).

V. HYBRIDISATION

1. Tall × Dwarf hybrids

The most significant contribution in coconut breeding in this country has been the production of hybrid coconut between West Coast Tall and Chowghat Dwarf and its reciprocal cross initiated in the thirties. These hybrids, when raised under favourable conditions and with proper management have been found to bear earlier and yield more number of nuts and higher copra outturn than the local cultivar West Coast Tall. Further studies have indicated that there is considerable variation in the yield of progenies derived from different crosses and that some combinations can be very promising while others may be of average merit. Among the different types of Dwarf tried, Chowghat Dwarf Orange and

Gangabondam were found to be perferable as pollen parents than Chowghat Dwarf Green (Satyabalan, Ratnam and Kunjan, 1970). Bavappa, Sukumaran and Mathew (1973) based on their studies of West Coast Tall × Chowghat Dwarf Green have suggested that with proper choice among the Tall and Dwarf varieties, efficient exploitation of hybrid vigour could be effected.

Trials laid out at different Co-ordinating Centres have also indicated the superiority of the hybrids under good management conditions. In a comparative study of the performance of four different dwarf types as pollen parent at Nileshwar, Krishnan and Nambiar (1972) found Lakshadweep Dwarf to be the best followed by Gangabondam. This indicated the possibility of geographically different dwarfs giving rise to progenies of differential heterosis in coconut. The performance of hybrid seedlings of crosses involving three Tall, four Dwarf and four Semi-Tall varieties at Veppankulam has indicated that the local Dwarf Green was the best of the dwarf parents and Semi-Tall Yellow was the best of the intermediate types for crossing with tall palms for producing vigorous hybrids (Ramachandran et al., 1974). The performance of West Coast Tall × Chowghat Dwarf Orange hybrid palms from Nileshwar planted at Veppankulam was consistently satisfactory. They came to bearing earlier and recorded 40.8 per cent higher mean yield of nuts and 102.4 per cent more copra per palm than East Coast Tall (Ramachandran et al., 1975). The Tall × Dwarf hybrids were superior in performance at Ambajipet, Veppankulam Coimbatore, Ratnagiri and Mahuva (Anonymous, 1981a, 1981b, 1982). At Arsikere, Tall × Dwarf hybrids gave significantly higher yield of 170 nuts per palm per year over other germplasm collection (Shanthamalliah et al., 1981).

Besides the local dwarfs, Gangabondam, a green semi – tall from Andhra Pradesh is also found to be a suitable pollen parent for the production of promising hybrids. The superior performance of Tall × Gangabondam hybrids has been reported from Kasaragod (Kerala), Mahuva and Coimbatore (Anonymous, 1981a). Among the six varieties crossed with Gangabondam as pollen parent, Laccadive Ordinary × Gangabondam hybrid has proved to be the best combination as it is outstanding in respect of annual yield of nuts and copra output. While it gives 20.2 kg of copra per palm per annum, the copra yields are 16.9 kg for Andaman Ordinary × Gangabondam, 15.8 kg for Cochin China × Gangabondam, 15.1 kg for West Coast Tall × Gangabondam, 13.7 kg for Laccadive small × Gangabondam and 9.6 kg for Java × Gangabondam (Kannan and Nambiar, 1974). Studies on the performance of open pollinated progenies of Tall × Dwarf hybrids and their back – crosses at Nileshwar showed that the open pollinated progenies of Tall × Dwarf hybrids yielded more than the back cross progenies. Further studies indicated that rigorous selection in the nursery to weed out segregating dwarfs among the open pollinated progenies of F1 hybrids could help to establish an economically high yielding plantation. However precocity which is usually manifested in the F1 hybrids of T × D

is not found in the open pollinated progenies (Anonymous, 1977).

At Veppankulam a comparative study on the performance of four intervarietal hybrids in coconut namely East Coast Tall × Dwarf Green (Local), East Coast Tall × *Ayiramkachi,* East Coast Tall × Semi-Tall Yellow and Semi-Tall Yellow × East Coast Tall have indicated that East Coast Tall × Dwarf Green is superior to the rest in terms of yield of nuts, weight of whole nut, weight of dehusked nut, weight of kernel and weight of copra. The hybrid East Coast Tall × Semi-Tall Yellow gave higher yield than its reciprocal (Ramanathan, 1981).

In a survey on the performance of coconut varieties and hybrids in Kerala State conducted during 1978–'79 it was noticed that (1) full expression of yield potential of Tall × Dwarf was observed only under very favourable environmental and management conditions, (2) palm to palm variation in Tall × Dwarf was very pronounced, (3) alternate bearing, bunch buckling, leaf drooping and immature nut fall were more widespread in Tall × Dwarf and (4) decline in yield of diseased Tall × Dwarf palms was more rapid than in Dwarf × Tall hybrids and Talls (Anonymous, 1979).

2. *Dwarf × Tall hybrids*

Among the Tall × Dwarf and Dwarf × Tall hybrids, Chowghat Dwarf Orange × West Coast Tall hybrid combination was found to be superior in yield of nuts and copra. Comparative yield data of 16 year old palms of three hybrid combinations and West Coast Tall palms planted in the same plot and raised under rainfed conditions at Kasaragod showed that Chowghat Dwarf Orange × West Coast Tall gives a mean yield of 90 nuts and 16.8 kg of copra per palm per year whereas West Coast Tall × Chowghat Dwarf Orange and West Coast Tall × Gangabondam combinations give a mean yield of 61 and 62 nuts and 11.4 kg and 11.2 kg of copra per palm per year respectively. The West Coast Tall gives only a mean yield of 57 nuts and 9.2 kg of copra per palm per year. Since all these palms are planted in laterite soil and maintained under rainfed conditions with the usual recommended dose of fertilisers, the yield data show that Chowghat Dwarf Orange × West Coast Tall can perform better under such conditions than the other two hybrid combinations and West Coast Tall (Kumar and Satyabalan, unpublished). The yield performance of Dwarf × Tall hybrids obtained from Chowghat Dwarf Orange palms by natural pollination with West Coast Tall, at Kasaragod and other Co-ordinating Centres was reported to be good (Anonymous, 1981a). The survey made on the performance of coconut varieties and hybrids in Kerala also indicated that among the Tall × Dwarf and Dwarf × Tall hybrids, the latter was definitely superior to the former. Under identical conditions Dwarf × Tall gave higher yield than Tall × Dwarf or West Coast Tall. Though pre-bearing period of Dwarf × Tall was slightly more than Tall × Dwarf, tree to tree variation was not as pronounced as in Tall × Dwarf. (Anonymous, 1979).

However, the production of Chowghat Dwarf Orange × West Coast Tall hybrids has not been successful to the extent desired as the percentage of hybrids

recovered from this cross was about 30 on an average, though the percentage varied from 20 to even 100 in different combinations. From Chowghat Dwarf Orange, hybrid like progenies could be obtained by selfing, open pollination, emasculation and controlled pollination with West Coast Tall. The performance of progenies obtained from Chowghat Dwarf Orange from the above four different methods of pollination indicated that progenies obtained from emasculation and hybridisation with West Coast Tall gave the highest cumulative yield as well as annual yield whereas the mean copra outturn as well as oil content was maximum in progenies from open pollinated and selfed population. Since mean annual yield and cumulative yield were more in progenies obtained from hybridisation than those obtained by selfing Chowghat Dwarf Orange, introduction of fresh variability into the Dwarf seems to be better than manipulating the available variability (Satyabalan and Kumar, 1981).

Based on the data available so far on the performance of hybrids, hybrid seed gardens have been established at Kidu in Karnataka under CPCRI and in different states for the production of large scale hybrid seedlings (Pillai and Nayar, 1979).

In Ivory Coast, Malayan Dwarf Yellow palms are reported to give a high percentage of hybrids when crossed with West African Tall. Investigation to identify the best combiners with Chowghat Dwarf Orange and Malayan Dwarf Yellow and Red has been initiated at Kasaragod so that a high percentage of hybrids is obtained.

3. Other hybrids

At Nileshwar, attempt to combine the high female flower production of Spicata with the high setting percentage of West Coast Tall was not successful (Anonymous, 1977).

Diallel crosses (36 cross combinations) involving eight Talls and one Dwarf have been planted in two replications at Kasaragod to study their performance.

VI. CYTOLOGICAL STUDIES

Studies on the cytological behaviour of inbred and open pollinated progenies of Laccadive, Andaman, Philippines, New Guinea and Cochin China varieties of coconut have indicated that microsporogenesis was comparatively more regular in both inbred and open pollinated progenies of Laccadive variety whereas comparatively higher frequency of chromosome aberrations and higher percentage of pollen sterility were observed in inbred progenies of Philippines and Andaman varieties and in inbred as well as open pollinated progenies of Cochin China and New Guinea. The inbreeding depression observed in the above four varieties and lack of inbreeding depression in Laccadive variety was either due to difference in the intensity of inbreeding and selection between these geographically distinct varieties or due to Laccadive genotype being comparatively less sensitive to inbreeding (Nambiar, Pillai and Kumar, 1970). Studies on the course of microsporogenesis in the progeny of a self pollinated New Guinea palm which produced defective nuts revealed aberrant

meiosis. The sterility in this palm was attributed to inbreeding (Pillai and Kumar, 1972).

A comparison of the somatic chromosome complements of West Coast Tall, Chowghat Dwarf Green and Chowghat Dwarf Orange indicated that the chromosome number in all these varieties was 2n=32 and that there was considerable similarity in karyotype features among these varieties. The karyotype of West Coast Tall was more asymmetric with four submedian and twelve median chromosome and that of the Dwarf Green less asymmetric with one submedian and 15 median chromosomes. Total chromatin was also more in Dwarf Green than in Tall (Pillai, Kumar and Nambiar, 1976; Pillai, Kumar and Ravindran, 1976). Though these observations indicate that the Dwarfs are less specialised than Talls, evidences from morphology, breeding system and meiotic behaviour support the probable evolution of Dwarfs from Talls. Consistent karyological features distinguishing Tall and Dwarf are also seen. In Talls as also in Spicata, a secondary constriction was seen on the long arm of the 6th chromosome. In both Dwarf Green and Dwarf Orange a secondary constriction on the long arm of the 3rd chromosome was invariably present (Ninan and Raveendranath, 1972, 1974 and 1975; Raveendranath and Ninan, 1973). Raveendranath, Nair and Ninan (1975) found no appreciable karyological differences between the Tall and abnormal coconut palm producing bulbils in the place of inflorescences and opined that cryptic structural chromosome change or genetic mutations might be responsible for the appearance of this type of coconut.

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