

Genetic Improvement of Coconut (*Cocos nucifera* L.) in Tamil Nadu

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Abstract

The genetic improvement of coconut (*Cocos nucifera* L.) was initiated in Tamil Nadu during 1958 at Coconut Research Station, Veppankulam. Collection and evaluation of coconut germplasm has resulted in the identification of promising coconut cultivars suited for Tamil Nadu. Hybridization involving local cultivar, East Coast Tall with other dwarf varieties has resulted in the development of three Tall x Dwarf hybrids viz., VHC 1, VHC 2 and VHC 3 with high nut, copra and oil yields. Promising tolerant types were identified by screening germplasm for pests and diseases. Breeding work is in progress for developing varieties resistant/tolerant to pests and diseases.

Introduction

Coconut is a high value commercial crop grown in an area of 1.84 million hectares in India with annual production of 12597 million nuts. Tamil Nadu with an area of 3.24 lakhs hectares holds the third position in the country with an annual production of 3158 million nuts. Though India is in the fore front in coconut production in the world, the per palm productivity is as low as 40 nuts per palm per year. Ironically, there are several elite disease free palms showing unusually high yield of over 470 nuts per palm per year (Iyer *et al.*, 1979). Varietal improvement is one of the basic steps towards achieving higher productivity. Organised research efforts for the improvement of coconut were initiated in the early part of 19th century but the progress was very slow till 1960. 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 after the establishment of Central Coconut Research Station at Kasaragod as early as 1916. Breeding work on the improvement of coconut palm was initiated in Tamil Nadu at Coconut Research Station, Veppankulam during 1958. It was further strengthened by the establishment of another research station at Aliyarnagar under Tamil Nadu Agricultural University during 1982. These two research stations also serve as sub centres under All India Co-ordinated Research Project on Palms since 1972 and 1986 respectively. The systematic research carried out during the last three decades in crop improvement has resulted in the identification of superior genotypes and hybrids in coconut. In this paper a review on the genetic improvement of coconut palm through different breeding methods in Tamil Nadu has been presented.

Collection, Conservation and Evaluation of Coconut Germplasm

Collection, conservation and evaluation of germplasm of coconut is one of the pre requisites for the crop improvement programme. The most significant contribution in the early part of coconut research in Tamil Nadu was the introduction of both exotic and indigenous germplasm accessions at Coconut Research Station, Veppankulam during 1958 from Central

Plantation Crop Research Institute, Kasaragod. The germplasm collection was further intensified during 1984 with the addition of 10 more accessions from CPCRI, Kasaragod. The systematic survey and collection of indigenous germplasm in different parts of Tamil Nadu during 1988 resulted in further enrichment of coconut gene pool. At present, the station is maintaining a total assemblage of 48 coconut germplasm consisting of 24 indigenous and 24 exotic collections.

Coconut germplasm collection was started in 1988 at Coconut Research Station, Aliyarnagar in Coimbatore district and so far 42 accessions comprising 22 exotic and 20 indigenous collections have been made and were studied for their morphological reproductive and yield attributes and evaluated for their adaptability to western and north western regions of Tamil Nadu.

The performance of twenty eight coconut genotypes planted during 1958 at Coconut Research Station, Veppankulam for their nut, copra and oil yield in their stable yielding period of twenty seven years was analysed. The result indicated that among the genotypes, West Coast Tall recorded the highest cumulative mean nut yield (136.9) followed by Spicata (130.8), Laccadive Micro (123.7), Malaysian Green Dwarf (96.7) and Andaman Ordinary (92.6). However, the copra and oil yield/palm and copra and oil yield/ha was the highest in Andaman Giant followed by Andaman Ordinary, Kappadam, WCT, Cochin China, Siam and FMS. Genotypes with high nut yield

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and copra content recorded significantly higher copra and oil yield, while the genotypes though with significantly higher nut yield but with low copra content recorded lesser copra and oil yield. Based on the superior performance of Andaman Ordinary at Veppankulam, the variety was released as VPM 3 by the Tamil Nadu Agricultural University in 1994 for cultivation in Tamil Nadu.

Tender coconut water is one of the finest soft drinks in the world. Louis *et al.* (1977) studied the variation in tender nut characters in eight coconut varieties and found that a desired volume of water combined with high sugar content were in Malaysian Orange Dwarf and Malaysian Green Dwarf. Screening of forty genotypes in coconut for tender nut water revealed that volume of tender nut water was maximum in San Ramon in the tall and Gangabondam of dwarf variety. Among the varieties, Zanzibar and West Coast Tall in the tall and Chowghat Orange Dwarf and Malaysian Orange Dwarf in dwarf were found to be superior in tender water. The superiority of COD and MOD for the tendernut water was also reported by Dhamodharan, *et al.*, 1993 and Ratnambal, 1999.

Ramachandran *et al.* (1977) found the variety Ayiramkachi intermediate between Tall and Dwarf in characters. The important characters of this variety

is high female flower production which can be exploited for breeding work. But the setting percentage in this variety is low. It is alternate bearer yielding 75 nuts per palm per annum. This variety was originally obtained from a private nursery in Ramanathapuram in Tamil Nadu.

Fifteen accessions of coconut planted during 1988 at Coconut Research Station, Aliyarnagar were evaluated for nut yield (Anon, 2000). Malaysian Green Dwarf recorded the highest annual nut yield (164.1) followed by Arasampatti Tall (161.3), East Coast Tall (137), St. Vincent (136.4) and MOD (101.8). The promising genotype, Arasampatti Tall with high nut and copra yield and relative tolerance to drought was released as ALR(CN) 1 by the Tamil Nadu Agricultural University during 2002 for cultivation in Tamil Nadu.

Selection

The initial programmes on crop improvement focussed on standardization of selection procedures for mother palms and perfecting seedling selection criteria. The desirability traits for selection of mother palms included high and consistent yield of nuts, high copra outturn, straight stout trunk with spherical or hemispherical crown, more number of leaves, inflorescence and flowers as well as freedom from disease and pests. The

characters considered for seedling selection included the seedlings vigorous indicated by girth at collar, height, number of leaves and early splitting of leaves besides early germination.

Venkateswaran *et al.* (1975) made a study on the coconut plantations of East Coast Tall at Veppankulam 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 (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 spathe 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.

Harland (1957) advocated the identification of genetically superior (prepotent) palms among the high yielders as he felt that only such palms possess sufficient dominant genes to ensure that their progenies are also high yielders and suggested that such prepotent high yielders could be identified from a comparative study of sufficiently large number of progenies from open pollinated mothers. Progeny testing has been recommended as the most reliable method of detecting prepotent palms by several workers. Satyabalan *et al.* (1975) from their studies on growth characters of one year old seedlings of some palms and their performance as adult palms showed the possibility of identifying prepotent palms based on their progeny growth in the nursery. Further studies by Satyabalan and Jacob Mathew (1983)

Table 1. Performance of promising coconut genotypes at veppankulam

Genotypes	Cumulative nut yield for 27 years	Mean nut yield/palm/year	Copra yield		Oil yield	
			Copra yield/kg/palm	Copra yield/kg/ha	Oil yield/kg/palm	Oil yield/kg/ha
Andaman Ordinary	2500.4	92.6	18.5	3.3	12.3	2.2
Andaman Giant	2192.5	81.2	20.7	3.7	13.3	2.4
Cochin China	2138.6	79.2	15.8	2.8	10.4	1.9
FMS	2344.1	86.8	13.7	2.4	9.2	1.6
Kappadam	2223.0	82.3	18.5	3.3	11.8	2.1
Laccadive Micro	3340.2	123.7	12.7	2.3	9.1	1.6
Siam	1857.8	68.8	15.3	2.7	10.1	1.8
West Coast Tall	3697.2	136.9	17.3	3.1	11.7	2.1
East Coast Tall (Check)	2384.8	88.3	11.0	2.0	7.3	1.3
Overall mean	2147.10	79.51	11.19	1.98	7.41	1.32

Table 2. Coconut varieties and hybrids released by TNAU.

Variety/ Hybrid	Origin	Year of release	Annual nut yield/ palm	Copra content g/nut	Oil content of copra %	Special attributes
VHC 1	ECTX CGD	1982	115	142	69.0	Early flowering
VHC 2	ECT X MYD	1988	142	146	70.0	Early flowering reduced bunch buckling and leaf drooping
VPM 3	Selection from Andaman Ordinary	1994	92	176	70.0	Drought tolerant
VHC 3	ECT X MOD	2000	156	162	70.2	Early flowering reduced leaf drooping
ALR (CN)1	Selection from Arasam patti local	2002	126	131	66.5	Resistant to BSR, Moderately resistant to stem bleeding, leaf spot and bud rot.

indicated that it is possible to identify prepotent palms based on collar girth and leaf production of the progeny even at the fifth month from the time of germination in the nursery.

The extent of prepotency in East Coast Tall variety of coconut was studied by Ramanathan in 1989 at Veppankulam and observed that in a random selection of five per cent of mother palms which were open pollinated, sixty per cent of the palms chosen were found to have the ability to transmit the yield potential resulting in progenies with yield increase ranging from 41.5 per cent to 95.8 per cent over the parental yield. One among the ten mother palms chosen for the study was found to be the best prepotent palm as six out of 15 palms in its progeny gave outstanding yield performance.

Correlation studies with 30 cultivars by Ramanathan (1984) revealed that stem height, number of functional leaves, number of leaflets, total number of leaves, girth of stem at base, length of leaf and girth of stem at crown were found to be positively and significantly correlated with yield. Metroglyph analysis was done in a group of 23 genotypes of coconut (Raveendran *et al.*, 1987). The varieties came under two groups were recognised when the classification was made on the nut characters. The exotic cultivars, in general, had relatively higher expression for morphological and nut characters. The possibility of obtaining heterotypic hybrids from divergent parental combinations was also indicated.

Hybridization

Ever since heterosis or hybrid vigour was discovered in maize by Shull (1910) and East (1908), there have been successful attempts to exploit this phenomenon in various other crops including coconut.

Systematic work on hybridization in India was started in 1930's between West Coast Tall (WCT) as a female parent and Chowghat Green Dwarf (CGD) as the

male parent. This is considered to be one of the notable achievements in coconut breeding as Patel (1937) who studied the performance of these Tall x Dwarf (T X D) hybrids reported for the first time the manifestation of hybrid vigour in coconut. This important finding paved the way for the subsequent successful exploitation of this phenomenon in many coconut growing countries of the world. The hybrids germinated early and were very vigorous characterized by increased height, collar girth and more number of leaves compared to the progeny of female parent. The superiority of T X D hybrids has subsequently been confirmed by many workers (Satyabalan *et al.*, 1970, Bavappa *et al.*, 1973 and Kannan and Nambiar, 1974).

Evaluation trials laid out at Coconut Research Station, Veppankulam to assess the performance of West Coast Tall x Chowghat Orange Dwarf hybrid palms from Nileshtar revealed that the performance of the hybrid was consistent and 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).

Heterosis breeding at Coconut Research Station, Veppankulam was initiated during 1968 and first set of hybridization was done utilizing three tall varieties, four dwarf varieties and four semi tall varieties in both direct and reciprocal crosses. Ramachandran *et al.* (1974) in their study on the two year old seedlings of these hybrids reported that among the Tall x Dwarf hybrids, Cochin China x Dwarf Green was the most vigorous followed by Dwarf Green x East Coast Tall. Dwarf Green was the best among the dwarf parents which produced the most vigorous hybrids. Semi tall yellow can also be employed as one of the parents in place of dwarf types, as it gave equally good hybrid seedlings when crossed with tall types.

The release of the first hybrid coconut VHC 1 developed at Veppankulam by the Tamil Nadu Agricultural University in 1982 was the landmark in the history of coconut breeding in Tamil Nadu. A cross between East Coast Tall X Dwarf Green was found to be the most promising with a mean nut yield of 115 nuts/palm/year and 21,648 nuts/ha.



The mean copra yield of 3537 kg/ha and 2211 kg/ha of oil recorded by the hybrid was found to be significantly higher than the East Coast Tall variety (Ramanathan *et al.*, 1984).

Encouraged by the superior performance of T X D hybrids and their reciprocal combinations, different inter and intra varietal crosses involving promising exotic and indigenous varieties were made in all possible combinations *viz.*, Tall x Tall, Tall x Dwarf, Dwarf x Tall and Dwarf x Dwarf at Veppankulam. In addition to these hybrids promising Tall x Dwarf and Dwarf x Tall hybrids produced at different coconut breeding stations were evaluated at Veppankulam under All India Co-ordinated Research Project on Palms. Among these hybrids, WCT X COD, COD x WCT and WCT X MYD were found promising with superior nut and copra yield as compared to East Coast Tall (Anonymous, 2000). Systematic efforts in production and evaluation of coconut hybrids at Veppankulam resulted in the identification of another T X D hybrid between East Coast Tall x Malaysian Yellow Dwarf with a mean annual nut yield of 147 nuts/palm significantly higher than ECT and was released as VHC 2 during 1988 (Ramachandran *et al.*, 1990). The superiority of T X D hybrids in economic attributes such as high growth rate, leaf, spathe and flower production, nut and copra yield was further confirmed by the latest release of VHC 3 hybrid coconut developed at Veppankulam. This hybrid (East Coast Tall x Malaysian Orange Dwarf) recorded an annual nut yield of 156 nuts/palm and copra yield of 25.2 kg/palm and was released by TNAU for cultivation in the state (Natarajan *et al.*, 2001).

Breeding for Resistance/Tolerance to Pests and Diseases

Grey blight or leaf spot disease caused by *Pestalotia palmarum* is of common occurrence in all the coconut

growing areas in the world. Though the pathogen is considered as a weak pathogen causing severe disease only in palms that are deficient in potash, under favourable weather conditions it causes severe damage to the foliage of the palms. Bhaskaran and Ramanathan (1983) screened the coconut varieties and hybrids for their reaction to *P. palmarum* under natural infection and reported none of the varieties or hybrids were immune to this disease. Varieties COD, CGD, Sanblas and Laccadive micro showed relatively less incidence of grey blight suggested utilization of these tolerant types in breeding programme.

Thanjavur wilt of coconut caused by *Ganoderma lucidum* (Leys) Karst. is the major disease of coconut limiting coconut production in Tamil Nadu. Bhaskaran *et al.*, (1992) studied the healthy and diseased palms of different disease severity selected in the hot spot area of Thanjavur district and reported that nut characters are not affected appreciably in mild and moderately diseased palms, however, oil content decreased in these category of palms. Quality of nuts were affected very much in severely diseased palms as observed by reduction in whole nut weight, copra weight and oil content. Screening of large population of East Coast Tall for Thanjavur wilt has resulted in the identification of resistant palms with superior growth, reproductive and nut characters. These resistant palms were utilized in the breeding programme. Hybridization involving ECT, MGD and MYD as ovule parent and wilt resistant ECT as pollen parent was initiated and these hybrids were evaluated for their resistance to wilt at different locations in the hot spot area along with coconut germplasm. Screening of coconut germplasm along with hybrids involving basal stem rot resistant line as one of the parent has indicated ECT X BSR tolerant ECT registered a higher rate of survival (66.7%) and more number of functional leaves (39) as

compared to 40 per cent survival and 35 functional leaves in East Coast Tall (Anonymous, 2000).

The coconut eriophyid mite *Acguerreronis* Keifer is a serious pest of coconut in Tamil Nadu. They pierce the tender tissue of the developing nuts and feed on the sap resulting in scarring of growing nut, deformation, premature nut fall and reduced copra yield. The available coconut germplasm at Veppankulam was screened for natural infestation and resistance by Muthiah and Bhaskaran in 1999. Among the 31 coconut genotypes screened, Laccadive Ordinary, Cochin China, Andam Ordinary and Gangabondam recorded minimum nut damage and suggested for utilization in breeding varieties for mite resistance /tolerance.

Conclusion

In a crop like coconut which has long pre-bearing period and takes long time to attain yield stability, genetic improvement by breeding is slow and time consuming. However, significant progress has been made in introducing promising elite coconut germplasm of exotic and indigenous origin for cultivation in Tamil Nadu. Successful exploitation of hybrid vigour by the scientists of TNAU resulted in the development and release of three high yielding hybrids *viz.* VHC 1, VHC 2 and VHC 3 with high nut and copra yield. Screening of coconut germplasm for important pests and disease *viz.*, leaf blight, basal stem rot and eriophyid mite has resulted in the identification of resistant/tolerant types and are being used in the breeding programme to evolve tolerant varieties.

Acknowledgement

The financial assistance rendered by the Indian Council of Agricultural Research under All India Co-ordinated Research Project on Palms is gratefully acknowledged.

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