GENETIC IMPROVEMENT OF COCONUT PALM

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INTRODUCTION

One of the causes attributed for low productivity of coconut in Sri Lanka, Malaysia, Philippines etc. is poor genetic make up of the planting material besides neglect, non-adoption of improved methods of cultivation, unfavourable factors of environment and senility of the palms and also serious diseases and pests wherever they severely occur. India is no exception since the very same causes are also responsible for the low productivity of coconut in India also. Wherever very high yields have been reported from individual fields these usually appear to be attributable to exceptionally favourable conditions rather than to the planting material. In all these countries it is felt there has been virtually no genetic improvement for yield and the palms grown today with the exception of certain hybrids are virtually the same as the open pollinated unselected palms used in ancient times.

In Kerala where coconut is the main crop, a more or less continuous programme of selection for yield has been in progress ever since coconut improvement work by breeding was started. This should have registered considerable improvemnnt in the production of coconut; but the situation seems to be different as the yield per palm is reported to be only 35 nuts per year indicating that there has been no substantial, genetic improvement in the yield. In the selection methods adopted from early times for the population improvement of the tall coconut palm which is highly heterogenous because of its cross pollinated nature and which can be propagated at present only through seed, criteria for selection of mother palms, selection of seednuts and selection of seedlings have been fixed, which it was hoped will be helpfull in producing quality plantig material which will perform better than the unselected ones. These selection methods have not given the desired results as it has not been possible to breed palms of uniformly high yield in keeping with the improved methods of cultivation recommended for the improvement of the palm. The possible reasons for the failure are considered in this article.

MOTHER PALM SELECTION

There are certain defects in the present methods of mother palm selection which are obvious. The male parent is unknown, the mother palm from which the seednuts are collected itself is heterogenous and it is not known whether the high productivity of the mother palm on the basis of which it is selected may be transmissible or not to the progenies.

Mother palms are selected on the basis of certain standards laid down with a view to eliminate the production of undesirable planting material. These have been described in all available literature on coconut cultivation.

The main basis by which selection of mother palms is made is the yield of nuts. Seednuts obtained from such selected high yielders are utilised for raising seedlings for planting in the field. If all the high yielding mother palms transmit their high yielding character to their progenies the present method of selection should have changed the present coconut situation. It should have considerably improved the coconut production which in turn would have increased the production of allied products like copra, oil etc. But today we are faced with a different situation. Inspite of planting seedlings from the selected high yielders, observations made in India and elsewhere have indicated that even with all agronomical practices being at a reasonably satisfactory level, the greatest part of the yield in a plantation came from a relatively small number of palms (Satyabalan 1982). In Kerala in spite of continued selection of mother palms over generations, the percentage of high yielders in a population is very low (Table 1) which indicates that progenies from all high yielders are not high yielding. In the 19 fields covering 4347 palms the percentage of high yielders yielding above 80 nuts per palm per annum varied from 2 to 17 per cent and accounted for 3.00 to 27.2 per cent of the yield (Satyabalan 1982). Progeny studies conducted on 20 progenies of each of 15 West Coast tall palms from Kuttiadi seednut centre at Nileshwar have indicated that only two families out of fifteen have recorded high yields (Anonymous 1977). The data on classification of seedlings of high yielding palms in Java presented by Van der Elst (1930-31) in his report *The Coconut palm and its products* (private communication from Prof. Cramer 1951) also has indicated that out of 244 seedlings of high yielders planted during 1911-12, only 48 trees gave an yield of 80 nuts and above during 1922-1928 indicating that all of them were not high yielders. These studies indicate that selection of mother palms on the basis of yield of nuts has not given the expected results.

Yield of nuts as basis for selection of mother palms

Mother palms are now mainly selected on the basis of yield of nuts. The high yielding capacity of the mother palms selected may be due to two reasons. It may be due to favourable environment or due to the inherent capacity of palms. Unless selection of mother palms is made on the basis of genetical superiority we cannot expect that the progenies obtained from all high yielders will behave like their mother parents in their performance. In the selection of mother palms it has been reported earlier that palms that respond readily to a greater extent to the changes in environment and manurial practices are not desirable as they indicate a type which is genetically inferior. High yields should not be influenced by any favoured position of the palm in the field and by changes in the weather, manurial or cultural conditions. In a random assortment of trees of different genetic make up in the different fields, it is possible that the better performance of a large majority of trees in a heavy bearing garden may be due to the favourable environment. If selection is made only on yield performance, it is possible that trees which are genetically superior but are growing in very poor environment may be eliminated and others genetically inferior but of good performance due to favourable environment may get selected. To minimise such a type of selection, Pankajakshan, George and Krishna Marar (1963) suggested selecting the best 10 per cent of the high yielders which they felt was more helpful in spotting out genetically superior palms. They have also stated that in the absence of yield data for a large number of years cent per cent efficiency could be obtained even with four years data if the selection was restricted to the best five per cent of the trees.

Heritability of yield of nuts in coconut

Estimates of heritability for yield of nuts worked out by different workers have shown that it is about 0.5 (Lakshmanachar 1959; Liyanage and Sakai 1960; Nambiar and Nambiar 1970). Since the heritability value for yield of nuts is low, scientists have felt that selection of palms on the basis of yield of nuts alone is not likely to give the expected results. The copra output of a coconut palm is found to be far less variable from year to year than the number of nuts. The mean weight of copra per nut and the weight per husked nut have high heritability values of 0.67 and 0.95 respectively (Liyanage and Sakai 1960). Correlation studies on 513 West Coast tall palms have shown a high positive linear correlation between yield of nuts and total outturn of copra as well as copra content per nut and total outturn of copra.

The copra content per nut was not related to the yield of nuts (Anonymous, 1975). Similar studies on the relationship of nut, copra and oil have indicated the necessity for excercising selection pressure towards weight of copra per nut and oil percentage in addition to number of nuts (Bavappa and Sukumaran, 1983). In view of the high heritability value, the weight of copra per nut should be considered along with the yield of nuts for selection of mother palms.

Identification of genetically superior palms among the high yielders

The main basis on which selection of mother palms is made is the yield of nuts. According to Harland (1958) these high yielders which are considered to be genetically superior are of two types. The first type may be hybrids which may have a favourable combination of genes in the heterozygous condition and hence are high yielding. Since they are hybrids their progenies may segregate and exhibit varying performance. The second type may be inherently superior because they possess sufficient dominant yield genes to ensure that their progenies are also high yielding. They are considered to have the best breeding values with capacity to maintain significantly high progeny values. Harland (1958) felt that high yield is not transmitted by a mixed group of progenies from high yielding mother palms exposed to natural crossing and suggested that genetically superior (prepotent) palms among the high yielders should be identified. The concept of prepotency used by the animal breeders for selection of pedigree bulls has been applied to coconut where each tree represents a genotype. It is based on the assumption that a highly cross pollinated and heterogenous palm like coconut is able to maintain in nature a certain proportion of elite and high yielding palms which also exhibit a high rate of transmission of parental characters to their progenies. That explains the presence of a few high yielders in a population of open pollinated progenies of high yielders and that only a few palms among the high yielders yield progenies of high yielding nature. But for the operation of such a mechanism such valuable genotypes would have been lost under random mating during the long life history of the palm. Hence success in the palm selection lies in the identification of prepotent palms among the high yielders selected on the basis of regularity of yield of nuts and copra out

turn. Harland (1958) suggested that prepotent palms among the high yielders should be identified by comparison of a large number of open pollinated progenies. As it takes a long time for a tall palm to attain the yield stage, progeny testing on the basis of yield to identify prepotent palms is not practicable as it is a long duration process.

SELECTION OF SEEDLINGS

At present seednuts collected from high yielding plams are sown in the nursery for raising seedlings. Careful selection of seedlings based on early germination and different vegetative characters which indicate the vigour of seedlings is made when the seedlings are 9 to 12 months old. The vegetative characters are dark green leaves with signs of early splitting, short and broad leaf stalks, short stem with good girth at the collar and the tendency to produce a large number of roots. Nursery selection at present practised is based on the belief that these seedling growth characters are associated with the future adult palm yield performance. The performance of such selected seedlings has also indicated that seedling selection has not been effective to the desired extent.

It has been reported that early germination is an important factor to be taken into account in the selection of seedlings and such seedlings from early germinated nuts are vigorous in growth and become early bearers and high yielders. Studies on germination and growth of seedlings of high yielders in the nursery have indicated that there is not much difference in the growth characters of the seedlings whether they germinate earlier or later, during July to November, if the seedlings are studied for their growth characters from the time of germination to a fixed period (Satyabalan, 1984) as indicated in Table2. According to Kannan and Narayanan Nambiar(1979)the yield difference between vigorous and intermediate seedlings is not significant and seedling selection though necessary need not be as stringent as is advocated at

present. This leaves one to doubt whether selection of seedlings in West Coast tall is effective at all in improving the yield. This indirectly indicates the importance of mother palm selection and leads to the necessity of identifying genetically superior (prepotent) palms among the high yielding mother palms as suggested by Harland (1958). Attempts have been made to find out whether such prepotent palms can be identified based on progeny growth in the nursery.

Nursery selection of seedlings should be based on the sound correlation between seedling growth characters and its future adult palm performance. Among the growth characters of the seedlings studied, Nampoothiri, Satyabalan and Jaoob Mathew (1975) have reported that seedling characters like collar girth and leaf production are genetically correlated with the yield of adult palms (Table 3). Studies on seedling characters like collar girth and leaf production of high yielders by Ninan and Pankajakshan (1961) had shown that on the basis of seedling performance it was possible to isolate high yielders which yield superior progenies from those showing inferior performance. They recommended a switch-over from mass selection to progeny row breeding to identify high yielders of outstanding breeding merit for use in propagation as well as breeding work. Further observations on growth rate and seedling vigour of progenies of ten selected families by Ninan, Pankajakshan and Abdu (1964) showed that differences in growth rate and vigour of seedlings between families were highly significant in comparison with variation within families, which indicated again the possibility of identifying prepotent palms among the high yielders based on progeny performance in the nursery. Satyabalan, Nampoothiri and Jacob Mathew (1975) studied the seedling growth characters like collar girth and leaf production of open pollinated one year old seedlings of some high yielding palms and their performance as adult palms and reported on the possibility of identifying the probable prepotent palms based on, seedling growth in the nursery. Further observations made by Satyabalan and Jacob Mathew (1983) on growth rate and seedling vigour every month as measured by collar girth and leaf production from the time of germination in 599 open pollinated progeny seedlings of 16 selected high yielding West Coast tall families indicated highly significant differences in growth rate of progenies between families. Correlations of these growth characters from the first to the ninth month from the time of germination with those of the tenth month showed that correlation was high and positive from the fifth month. This has indicated that it may be possible to identify palms of superior genetic value (prepotents) even from the fifth month based on these two growth characters of the progeny. The breeding values of six families worked out for leaf production and collar girth of the progeny during the fifth and tenth month of growth in the nursery and their yield performance in the field showed that prepotent palms, whose progenies would be high yielders, have high breeding values for both these characters. Out of the six high yielding families, the open pollinated progenies of which were planted only family 41/588 is likely to be a prepotent one (Table 4). Further studies on the nursery performance of progeny raised from seednuts harvested during different months and also germinated during different months after planting in the nursery in June have indicated that in the case of palms identified as likely prepotents, the growth of the progenies was more vigorous than those of other palms. All these observations show that only certain palms yield progenies of superior growth characters which are correlated with yield and such palms of of superior genetic value can be identified by comparison of growth characters of the progenies even at the fifth month from the time of germination. The progenies of such palms only can bring about population improvement.

The present methods of selection of mother palms and seedlings do not seem to have helped to effect population improvement in coconut. In the case of a highly cross pollinated crop which can be propagated only by seed, identification and propagation of genetically superior palms is difficult, slow and time consuming. But this seems to be the only method of selection to breed palms of uniformly high yield.

HYBRIDISATION

By hybridisation it has been possible to produce Tall female x dwarf male hybrids which are found to be early bearing and high yielding. It has however been observed that there is considerable variation in the yield of hybrids derived from different matings and that some combinations can be very promising while others may be of only average merit. For the production of promising hybrids both male and female parents have to be selected based on their combining ability. A survey made on the performance of the TallxDwarf hybrids in the farmer's fields in different locations has shown that 1) they performed well only under very favourable environmental and management conditions 2) palm to palm variation in the hybrids was very pronounced 3) alternate bearing, bunch buckling, leaf drooping and immature nut fall were more widespread and 4) in diseased tracts decline in yield in the hybrids was more rapid than in the Talls and Dwarf x Tall hybrids (Anonymous, 1979). In spite of the promising nature of the Tall x Dwarf hybrids, there are some limitations with regard to their production, selection and performance. Both male and female parents have to be selected based on their combining ability. In the absence of colour difference the hybrids are to be selected in the nursery based on their growth characters which may not clearly indicate the true hybrid. Full expression of the yield potential is observed only under favourable management conditions. The production of a large number of hybrids involves considerable labour and expenditure as each female flower has to be hand pollinated which is time consuming (Satyabalan, 1983).

In view of the limitations regarding production and identification of Tall x Dwarf hybrids and the demerits associated with them, production of Dwarf female x Tall male hybrids has been favoured now. These hybrids are found to be superior to Tall x Dwarf hybrids in their performance. They can be easily identified in the nursery by colour difference and vigour of the seedlings. For mass production of Dwarf x Tall hybrid nuts under controlled conditions isolated seed gardens are being establised wherein alternate rows of selected talls and dwarfs are planted and after flowering the dwarf palms are to be emasculated and left to be pollinated with tall pollen. In most of the countries including India such seed gardens have been laid out for the production of Dwarf x Tall hybrid nuts. How far these efforts will be successful is yet to be seen. Studies have shown that all dwarf palms pollinated with tall pollen will not yield all hybrids. There is cosiderable variation among the palms of the Dwarf variety whether they are Chowghat Dwarf or Malayan Dwarf or any other dwarf. The results of selfing of dwarf palms suggest that the dwarf coconuts are not homozygous to the extent now believed to be (Ninan and Satyabalan, 1964). There is considerable variation among the palms of the tall variety. Therefore the percentage of hybrids obtained and the performance of the hybrids obtained from each combination will be different. The percentage of hybrids and the performance of the hybrids are likely to vary depending on the combining ability of the parents. In a promising hybrid both the yield of nuts and the copra content per nut should be high resulting in high copra out turn when compared to the local cultivar. As mentioned earlier, there is a relationship between the number of nuts produced by a palm and the copra out turn of the palm. To produce a promising hybrid, parent palms among the population of dwarfs and talls available in a country should be selected based on the combining ability for making crosses. If such parental combinations are not identified, the hybrids produced will yield either large sized nuts having a high copra content per nut but low in number or it will yield a large number of small sized nuts having a low copra content per nut with the result that it will not be a promising one as it will not be superior to the local cultivar in total copra out turn (Satyabalan, 1982).

CONCLUSION

It has not been possible to effe[ct] population improvement in coco[nut] by the present methods o[f] selection of mother palms an[d] seedlings. The identification an[d] production of genetically superio[r] (prepotent) palms among th[e] high yielders seems to be th[e] only method to breed palms o[f] uniformly high yield. Similarl[y] production of promising hybrid is also equally difficult as parent[s] have to be identified for optimum parental combination. Coconu[t] breeding is time consuming an[d] is a work of generations. It is not easy to produce geneticall[y] superior planting material fo[r] population improvement in a short time in a perennial crop like coconut. But based on the results and indications obtained from the studies made so far it may be possible to chalk out a breeding programme for the production of genetically superior planting material which may bring about population improvement in future plantations.

REFERENCES

Anonymous. 1975. Annual Report for 1974. Central Plantation Crops Research Institute, Kasaragod, India. pp. 177.

Anonymous. 1977. Reports and Papers. Coconut Convention, 9th and 10th Oct., 1975, Directorate of Extension Education, Kerala Agricultural University, Mannuthy, India. pp. 44.

Anonymous. 1979. Survey report on the performance of coconut varieties and hybrids in Kerala. State-Survey organised jointly by Kerala Agriculture Department, Kerala Agricultural University, Directorate of Coconut Development and Central Plantation Crops Research Institute during 1978-'79 (Mimeographed) pp. 38.

Bavappa, K. V. A. and Sukumaran, C. K. 1983. Coconut improvement by selection and breeding–A review of in the light of recent findings. In *Coconut Research & Development* (Ed. N. M. Nayar) Wiley Eastern Ltd. New Delhi. 44-55.

Cramer, P. J. S. 1951. The coconut palm and its products. (Private Communication).

Harland, S.C. 1957. The improvement of coconut palm by breeding and selection. *Bull,* Coconut Research Institute, No. 15. Ceylon.

Jacob Mathew, Bhaskara Rao, E. V. V. and Satyabalan, K. 1978. Sampling procedure for coconut germplasm collection. Paper presented at the National Symposium on Plant and Animal Genetics Research. 28-30 Dec., 1978. IARI. New Delhi, India.

Kannan, K. 1982. West Coast Tall. How to improve its production potential? *Indian Cocon. J.* 12 : 5-8.

Kannan, K. and Narayanan Nambiar, P.K. 1979. Mother palm and seedling selection in coconut. *Agri. Res. J. Kerala.* 17:1-6.

Lakshmanachar, M. S. 1959. A Preliminary note on the heritability of yield in the coconut. *Indian Cocon. J.* 12 : 65-68.

Liyanage, D.V. and Sakai, K.I. 1960. Heritabilities of certain yield characters of coconut palm. *J. Genet.* 57:245-257.

Nambiar, M.C. and Nambiar K.P.P. 1970. Genetic analysis of yield attributes in *Cocos nucifera* L. var. West Coast Tall. *Euphytica* 19:543-551.

Nampoothiri, K.U.K., Satyabalan, K. and Jacob Mathew. 1975. Phenotypic and genotypic correlation of certain characters with yield in coconut. Fourth FAO Tech. Wkg. Party, Cocon. Prod. Prot. and Processg. Kingston, Jamaica (AGP: CNP/75/44).

Ninan, C.A. and Pankajakshan, A.S. 1961. Progeny studies in coconut. 1. Relationship between parent yield and seedling characters of progeny with special reference to open pollinated and hybrid progenies of West Coast Tall and its bearing on the concept of prepotency in coconut. *Indian Cocon. J.* 14:100-109.

Ninan, C.A and Satyabalan, K.1964. A study of natural, self and cross (Dwarf x Tall) progenies of dwarf coconuts of the West Coast of India and its bearing on the genetics of Dwarfs and the putative hybridity of their off-type progenies *Caryologia* 17:77-91.

Ninan, C.A., Pankajakshan, A.S. and Abdu, K.M. 1964. Some observations on growth rate and vigour of coconut seedlings. *Indian Cocon J.* 18:12-17.

Pankajakshan, A. S., George, M. and Krishna Marar, M. M. 1963. A study of some procedures of selecting mother palms in coconuts. *Indian Cocon. J.* 16:47-62.

Satyabalan, K. 1982. Yield capacity and transmitting power of mother palms in coconut. *Indian Cocon. J.* 13 : 5-13.

Satyabalan. K. 1982. Need for selection among the parents in the production of Dwarf x Tall coconut hybrids *The Cocomunity,* Quart. Suppl. APCC/QS/40/82. 1-9.

Satyabalan, K. 1983. Review Series on Coconut No. 1 Hybridisation - TallxDwarf. Coconut Information Centre, Coconut Research Institute, Lunuwila, Sri Lanka. pp 25.

Satyabalan, K. 1984. Nursery studies in West Coast Tall coconut. 2. Seedling growth and output of quality seedlings in seednuts germinated during different months. 14(12):3-11

Satyabalan, K., Nampoothiri, K. U. K. and Jacob Mathew. 1975 Identification of prepotent West Coast Tall palms based on progeny performance. Fourth FAO Tech. Wkg. Party Cocon. Prod. Prot. and Processg., Kingston, Jamaica. (AGP; CNP/75/45).

Satyabalan, K. and Jacob Mathew. 1983 Identification of prepotent palms in West Coast Tall coconuts based on the early stages of growth of the progeny in the nursery. In *Coconut Research & Development* (Ed. N. M. Nayar) Wiley Eastern Ltd. New Delhi. 15-22.

Table - 1

Distribution of palms according to yield in Kerala

Location	No. of palms studied	Yield group	Percentage of palms in the group	Percentage contribution to total yield	Reference
Kasaragod	1400	40 40-80 80	32.0 59.4 8.6	17.3 66.9 15.8	Menon, K. P. V. and Pandalai, K. M. (1958)
,,	4500	40 41-80 81 & above	33.2 58.2 8.6	17.8 66.2 16.0	Ninan C. A., Pankajakshan, A. S. and Abdu, K. M. (1964)
,,	4347	40 40-80 80	31.3 60.3 8.4	17.2 67.6 15.3	Jacob Mathew, Rao, E. V. V. B. and Satyabalan, K (1978)
Pilicode	150	40 40-80 80	29.3 54.0 16.7	NA	Kannan, K. (1982)
Sasthamkottai	3751	40 41-80 81 & above	56.0 35.7 8.3	NA	Ninan, C. A., Pankajakshan, A. S. and Abdu, K. M. (1964)

Table - 2

Growth characters in seedlings from seednuts sown in the nursery in June and germinated during July to December

Month of germination	Girth at collar (cm) (6th month from the time of germination)	Number of leaves (6th month from the time of germination)	Girth at collar (cm) (12th month from the time of germination)	Number of leaves (12th month from the time of germination)	Number of seedlings studied
July	9.9	6.6	15.1	9.6	94
August	9.8	6.5	14.8	9.3	167
September	9.6	6.5	14.3	9.2	193
October	9.0	6.2	13.4	8.7	242
November	8.7	5.8	13.0	8.2	80
December	8.4	6.0	11.8	8.3	4
	9.3	6.4	14.1	8.9	780

Source : Satyabalan, K. (1984)

Table – 3

Phenotypic and genotypic correlation of certain characters with yield

Characters	Phenotypic correlation	Genotypic correlation
SEEDLING CHARACTERS		
Time taken for germination	+0.0447	+0.170
Number of leaves	+0.2632	+0.528**
Girth at collar	+0.3565*	+0.410*
Height	+0.0173	+0.208

*Significant at P=0.05 **Significant at P=0.01

Source : Nampoothiri *et al* (1975)

Table - 4

Data on the performance of progenies of six palms and their breeding values

			Yield of nuts		Breeding values			
					Leaf Production		Girth at collar	
Sl no.	Parent no.	No. of progenies	Mean	C.V(%)	Fifth month	Tenth month	Fifth month	Tenth month
1	II/177	2	67.0	87.6	1.30	1.58	-0.80	-0.92
2	41/588	3	97.1	5.7	0.90	1.18	1.40	2.28
3	1/55	4	56.9	73.6	0.30	0.18	-1.20	-1.12
4	VIII/55	4	71.4	8.6	0.30	-0.62	-0.40	-0.92
5	X/14	4	76.8	23.1	-0.50	-0.42	0	-0.52
6	VII/1	2	62.8	11.8	-0.50	-0.22	-1.10	-1.72

Source : Satyabalan,K, and Jacob Mathew (1983)

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