RECENT TRENDS IN COCONUT BREEDING

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The breeding system, perennial habit and the time lag involved in the study of progenies constitute the barrier in undertaking cytogenetical and breeding investigations in coconut. Use of conventional methods such as recurrent selection, reciprocal recurrent selection, etc. adopted for seed propagated, cross-fertilized annual crops are extremely difficult to pursue in coconut due to the extensive area that will be required to raise successive generations of the parents and the hybrid progenies and the time and other resources involved in their study. The possibility of using techniques such as mutation breeding is also thus very limited. Consequently coconut palm has been more neglected than any other crop of comparable importance by the breeders. Subsequent to the review made by Gangolly, Satyabalan and Pandalai (1957) and Charles (1961) there has not been any attempt to review the work on breeding in coconut and suggest future lines of work in the light of the information gathered in the recent past. An attempt in this direction has been made in this paper.

Study of existing genetic variability

Although the value of introductions is very well known, no serious attempt either for exchange, comprehensive collection and assessment of genetic variability or even for the exchange of the available planting material has been made. However, out of the limited introductions made from within and outside India, the *Kappadam, Fiji, Philippines ordinary*, and *Laccadive ordinary* have been found to perform well (Satyabalan, 1955; Nampoothiri and Pillai, 1972) The only example of large scale exploitation of introduction is that of *Malayan dwarf* to Jamaica mainly from the point of view of its resistance to Lethal Yellowing (Whitehead, 1968). The pollen exchange programme that is in operation under the auspices of the FAO can partly overcome the lacuna in the germplasm collection, if done intensively. A survey for the collection of germplasm covering mainly the Pacific Islands was attempted by Whitehead (1966).

Exploitation of hybrid vigour

Since the report on hybrid vigour in West Coast Tall×Dwarf green by Patel (1937), crosses involving a number of varieties have been effected in different countries with varying success. The superiority of T×D hybrids has subsequently been confirmed in India by many workers as listed by Satyabalan, Ratnam and Kunjan (1970). The better performance of T×D was reported from Indonesia by Tammes (1955). Hybrid vigour was also reported from Jamaica in crosses involving N'uleka and the local dwarf. From India, superiority of other hybrids involving tall parents such as Laccadive ordinary, Andaman ordinary and West Coast Tall with Gangabondam, Dwarf orange and Dwarf green have also been reported. Existence of hybrid vigour in the hybrids of different tall forms from Andamans and Laccadive islands has also been recorded from India (Anon. 1972).

Menon and Pandalai (1960) reported that the performance of the D×T hybrids produced by the earlier workers was not encouraging. However, their better performance has been reported from Indonesia by Tammes (1955) and from India by Nampoothiri and Pillai (1972). Satyabalan (1956) and Ninan and Satyabalan (1964) reported that the natural crosses of the dwarf orange of Chowghat to be prolific bearers with superior quality of copra. This has been later confirmed by Nampoothiri and Pillai (1972). Natural cross dwarfs have been found to be either D×T hybrids or comparatively rare recombinants of dwarfs. The D×T hybrids have also been shown to be more tolerent (Table 1) to the deadly root wilt disease (Anon. 1972).

Genetical Investigations

As against an earlier beginning in the exploitation of hybrid vigour and genetic diversity, attempts for improving the genetic base as well as to exploit the same through breeding programmes were attempted only during 1960s. Simple correlation involving different characters of the adult palm (Table 2) have been worked out. Heritability and genetic correlations of a few characters also have been reported (Liyanage and Abeywardena, 1957; Lakshmanachar, 1959; Liyanage and Sakai, 1960; Nambiar and Nambiar, 1970; Nambiar, Jacob Mathew and Kamalakaran, 1970; Nambiar, Jacob Mathew and Sumangala Kutty, 1970).

Utilisation of genetic variability in coconut has been handicapped by (i) inadequacy of comprehensive germplasm collection (ii) limited population size in the genetic stocks wherever available and (iii) lack of well laid out experiments for their comparison. The only report of a well laid out trial of germplasm material appear to be that from Jamaica and New Guinea. The absence of such trials has made it impossible not

TABLE 1 : *Field tolerance of coconut varieties/hybrids to the root (wilt) disease*
Detailed Survey—1972

Variety/Hybrid	Age group*	Total no. of palms studied	Disease incidence (per cent)	
			Age group-wise	Average
D × T	1	267	4.1	
	2	493	9.7	9.3
	3	286	13.3	
T × D	1	1526	9.0	
	2	440	12.7	11.4
	3	164	29.9	
D. O.	1	184	16.8	
	2	476	21.6	22.9
	3	213	31.0	
D. G.	1	76	7.9	
	2	151	11.9	10.4
	3	33	9.1	
W. C. T.	1	573	32.8	
	2	896	38.8	37.5
	3	627	39.7	

*1. 4 to 7 years 2. 8 to 15 years 3. Above 15 years

TABLE 2 : *Correlation between adult palm characters and yield*

Characters	Coefficient of correlation
Height of palm and yield of nuts	0.581 to 0.686
No. of leaves and yield of nuts	0.392 to 0.680
Female flower production and yield of nuts	>0.7
Leaf production and mean yield of adult progenies	0.385
Length of stem and yield	0.3459 to 0.5171
Total number of leaves and yield	0.549 to 0.599
Number of leaflets and yield	—0.161
Length of leaflet bearing portion and yield	—0.060
Total length of leaf including petiole and yield	—0.080
Length of petiole and yield	—0.061
Thickness of petiole and yield	0.050
Area of the cross-section of the petiole and yield	0.075
Number of vascular bundles in the petiole and yield	0.093
Girth of petiole and yield	0.090
Weight of husked nut and weight of copra	0.971

only to critically evaluate the germplasm materials but also to use biometrical techniques like D^2 analysis for their efficient use in breeding programmes. A world wide germplasm collection and laying out trials keeping the long range requirements in view are in progress.

It is evident that the hybrid vigour exploitation has been confined only to a few tall and dwarf crosses. In case genetic distance between different varieties was available, effective utilisation of the hybrid vigour would have been easy. This obviously involves formidable commitments on time, space and other physical resources. Considering the practical feasibility, a set of diallel crosses (without reciprocals) involving nine cultivars has been taken up. The parents have been chosen taking into account the natural barriers existing between varieties as well as their geographic isolation. Many more varieties will have to be similarly crossed and the F_1s evaluated. In view of the storage technique now available (Whitehead, 1965) exchange of pollen between countries in any part of the world is now feasible and crossing programmes covering wider genetic resources should be planned for getting quicker results.

Large scale production of hybrids for commercial plantings has not so far been reported from many parts of the world though sporadic reports like that of Dwarf × Tall (Fremond and Lamothe, 1971; Lamothe and Rognon, 1972) are available. In India T×D hybrids had been under production for the past few years using manual labour which consequently sets high limitations on its large scale production. Programmes are now under way to produce very large quantities of hybrid combinations involving the proved parents by alternate planting of the two parents in isolated gardens and emasculating the required parent. The earlier observations that talls among themselves also show hybrid vigour has not been made use of in production programmes. The possibility of producing superior hybrids among tall varieties and among dwarf varieties also deserve detailed investigation.

Data on seedling selection standards are far inadequate to be of any practical use. Identification of prepotent palms using homozygous lines like dwarf (Harland, 1957) was found to be unsound in view of the segregation observed in the dwarfs (Bavappa, Sukumaran and Jacob Mathew, 1972). Prepotent mother palms have, therefore, to be identified based on the performance of open-pollinated progenies. Unlike annuals, the utility of selection criteria based on correlation and heritability studies are of greater significance in perennials. The advantage of phenotypic selection for yield has already been established by Nambiar and Nambiar (1970). They found that there is substantial additive genetic variation available for selection for yield and other associated characters. A total population of 3900 palms in 130 families are under study on the above aspects. This progeny trial will give valuable information on genetic correlations of different vegetative characters and yield components with yield and their heritability. Use of physiological constants such as NAR, chlorophyll content etc. and qualitative characters such as colour are also being simultaneously studied in the populations.

Induction of variability has been attempted through mutagenic agents such as gamma rays. The M_2 population is under study especially for resistance to root (wilt) disease in addition to other quantitative and qualitative characters.

Future approaches

By conventional breeding and genetical experiments quick results cannot be achieved in this crop. It will, therefore, be necessary that different methods are pooled in such a way that the maximum genetic advancement is obtained in the shortest time. The following steps either alone or in combination may prove useful.

Correlations, heritability and selection index studies : Characters having high phenotypic and genotypic correlation with yield are used for selection. All measureable characters (morphological, physiological and biochemical) should be correlated with yield. For those characters which have high phenotypic and genotypic correlation with yield their variability should be studied and appropriate selection norms fixed depending upon the extent of gain one would like to have for the character in question.

While correlation studies are useful for obtaining improvement in yield in the population, in which selection is exercised, improvement in the genetic potential of a given material can be achieved only by selection based on heritable characters having correlation with yield. It will thus be necessary and advantageous to work out the heritability of those characters which have high phenotypic and genotypic correlations with yield and selection made on such characters of high heritability. However, practical considerations of plantation management, such as the extent of rejection of seedlings, and gap filling that may have to be kept up in the field, may also have to be kept in view while fixing the selection standards for different characters.

The selection index technique is designed to determine the heritability of each of the characters considered to contribute to the yield of a single plant progeny and to so combine the estimates of heritability as to provide a single estimate of net worth on which the progenies can be selected. Hence, it may be regarded as the limit of refinement of selection methods. In arecanut, Ramachander and Bavappa (1972) have shown that as against an expected genetic advance of 57.11 from straight selection, the advance was 284.68 where a selection index based on 29 characters was used. They also found that a simpler index using number of leaves and height of the plant alone at the time of transplanting gives a relative improvement of 332 per cent. A selection programme based on selection index can thus pay high dividends.

Improvement of plant type : The tall variety which is the most widely cultivated type all over the world has an average stem height of 12 to 24 meters and a frond coverage of 4 to 6 meters diameter. The number of leaves on the crown is 30 to 40. Since the leaves are arranged in spirals (1/5 phyllotoxy) the angle at which the leaves are oriented has a direct bearing on the overall efficiency of the plant to utilize the sunlight. Observations go to show that there is considerable variability existing for this character, the range being completely rosette crown in which the leaves are arranged close and upright to drooping leaves in two distinct whorls. The association of crown habit with yield will have to be worked out. Similar is the necessity for reducing the overall plant size so that a better harvest index can be obtained. With intensive cropping programmes, it may even be necessary to have plant types bred for specific crop combinations so that the maximum return per unit area, time and input is achieved.

A breeding programme for seed nut production : In arecanut a modified mass pedigree selection programme has been outlined by Bavappa and Ramachander (1968) which takes into consideration various biometrical and breeding concepts in its formulation. In view of the hybrid vigour available for exploitation in coconut attempts to have a mass selection programme alone for any varietal improvement will not be worthwhile. All the same it is necessary that the genetic base of the parents involved is improved even in a hybridisation programme so that the resulting hybrids have a better performance.

While drawing up the breeding programme, the principles taken into consideration are the primary selection of the mother palms based on their performance in the population, selecting the seedlings of the resulting progeny for all characters of heritability and correlation with yield, emasculating the non-selected plants so as to prevent their participation in the natural crossing, and using the S_1 generation of the dwarf parents similarly selected so as to obtain the maximum possible uniformity in the planting material in one generation. The superiority that can be obtained due to the exploitation of prepotency has not been considered in this programme, in view of the fact that no information is available about the genetic nature of the phenomenon. If this is due to additive gene action or dominance, hybrids from such a cross is not likely to show better performance than the prepotent parent itself. The D × T hybrids and the improved talls (T × T) will be available at the end of the first stage, i.e. in about 10 years.

In the second stage of the programme the progenies of the selected talls will be allowed to open-pollinate among themselves. In the dwarf parent further homozygosity may be brought in by raising S_2 and genetic advance by repeating selection. The F_1 hybrids of D × T from the second stage are likely to be much more uniform and also better than those from the first stage in view of the additional homozygosity that has been brought into the parents as well as the improvement in their genetic base. The above programme can be applied to different tall and dwarf parents as and when information is available on their better performance.

REFERENCES

Anonymous (1972). *Ann. Rep.* Central Plantation Crops Research Institute, Kasaragod, 1971.

Bavappa, K. V. A. and Ramachander, P. R. (1968). Selection in arecanut palm. *Trop. Agric.* **123** : 25-35.

Bavappa, K. V. A., Sukumaran, C. K. and Jacob Mathew (1972). A study of the F_1 hybrids of Tall × Dwarf Coconut and its bearing on the genetics of dwarfness. *Proc. Natl. Symp. on Plantation Crops, Trivandrum.*

Charles, A. E. (1961). Selection and breeding of the coconut palm. *Trop. Agric., Trin.*, **38** : 283-297.

Fremond, Y. and Lamothe, M. (1971). The coconut improvement block at Port-Bouet. *Oleagineux,* **26** : 71-82.

Gangolly, S. R., Satyabalan, K. and Pandalai, K. M. (1957). Coconut breeding, a review. *Indian Coc. J.*, **10** : 32-48.

Harland, S. C. (1957). The improvement of the coconut palm by breeding and selection. *Ceylon Coc. Res. Inst. Bull.* **15.**

Lakshmanachar, M. S. (1959). A preliminary note on the heritability of yield in the coconuts. *Indian Coc. J.*, **12** : 65-68.

Lamothe, M. and Rognon, F. (1972). The production of hybrid coconut seed by controlled natural pollination. *Oleagineux,* **27** : 483-488.

Liyanage, D. V. and Abeywardena, V. (1957). Correlation between seed nut, seedling and adult palm characters in coconut. *Bull.* **16** : *Cocon. Res. Inst. Ceylon.*.

Liyanage, D. V. and Sakai, K. I. (1960). Heritabilities of certain yield characters of the Coconut palm. *J. Genetics.*, **57** : 245-252.

Menon, K. P. V. and Pandalai, K. M. (1960). The coconut palm. A Monograph. Indian Central Coconut Committee, 106-107.

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.

Nambiar, M. C., Jacob Mathew and Kamalakaran, A. K. (1970). Seasonal variation in nut production and sex expression in coconut. *Indian J. Genet.*, **30** : 557-564.

Nambiar, M. C., Jacob Mathew and Sumangala Kutty, S. (1970). Inheritance of nut production in coconut. *Indian J. Genet.*, **30** : 599-603.

Nampoothiri, K. U. K. and Pillai, R. V. (1972). Coconut breeding—a review (in Malayalam). *Vigyan Kairali,* **4** : 676-682.

Ninan, C. A. and Satyabalan, K. (1964). A study of natural, self and cross (Dwarf × 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.

Patel, J. S. (1937). Coconut breeding. *Proc. Assoc. Econ. Biol.*, **5** : 1-16.

Ramachander, P. R. and Bavappa, K. V. A. (1972). Selected index in arecanut. *Indian J. Genet.* **32** : 73-76.

Satyabalan, K. (1955). Plant introduction for the improvement of crops with special reference to coconut. *Indian. Coc. J.*, **8** : 113-117.

Satyabalan, K. (1956). A note on the performance of the Natural Cross Dwarf, (female) × Tall (male) in coconut. *Indian Coconut J.*, **1** : 166-173.

Satyabalan, K., Ratnam, T. C. and Kunjan, P. V. (1970). Hybrid vigour in nut and copra characters of coconut hybrids. *Indian J. agric. Sci.*, **40** : 1088-1093.

Tammes, P. L. M. (1955). Review of coconut selection in Indonesia. *Euphytica*, **4** : 17-24.

Whitehead, R. A. (1965). Freeze drying and room-temperature storage of coconut pollen. *Econ. Bot.*, **19** : 267-75.

Whitehead, R. A. (1966). 'Sample survey and collection of coconut germplasm in the Pacific Islands'. Ministry of Overseas Development.