Advances in Cytogenetics and Crop Improvement

BREEDING METHODOLOGY AS APLICABLE TO COCONUT IMPROVEMENT

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ABSTRACT

An impact on coconut production and productivity in the coming decades can be realised both by bridging the extension gap by adoption of better management, and the research gap by the use of superior planting material for underplanting as well as new plantings. Among the long term measures, rapid identification of prepotents among high yielders with disease resistance should be pursued vigorously. Simultaneous efforts to perfect the tissue culture and other vegetative propagation methods should be augmented in order to achieve a rapid production breakthrough in the near future.

INTRODUCTION

In contrast to the annuals, the plantation crops, such as, coconut, present certain unique problems to the plant breeder. Their long prebearing age, highly heterozygous outcrossing nature and the long time taken to attain optimum production, constitute serious handicaps for their rapid improvement and for the assessment of available variability in these crops. However, there is also the distinct advantage in that the same genotype can be monitored for several years over different seasons. The lack of a rapid method of clonal propagation in many of these crops, particularly the palms, has greatly hampered the realisation of production breakthroughs.

Although coconut palm comprises only one species *Cocos nucifera* L. with no known wild or domesticated relatives, the present day populations of this wonderful palm present a unique array of variability as a result of their long history of cross-pollination. The distribution of coconut is limited to 23°N and S of the equator and the centre of maximum diversity is believed to be in Melanesia or South East Asia. The various geographical races of this palm fall into two main types : the tall *typica*, which is predominantly cross-pollinating, and the dwarf *nana*, which is predominantly self-pollinating. Considerable variability occurs within each of these broad groups, forming diverse panmictic populations. Coconut is monoecious and the great height of the palm poses added problems in pollen collection and hybridization. The genetic complexity of present day coconut populations is somewhat comparable to that in *Homo sapiens* and defies normal taxonomic methods of classification.

India is the third largest coconut producer in the world, with an average yield of 35 nuts/palm/year. Thus raising the yield of existing populations, and generation of more prolific yielding material is the central problem for our country. Coconut breeding in India is over sixty years old and several approaches have been suggested (Haldane, 1958; Abraham and Ninan, 1968; Davis, 1968; Bavappa and Nampoothiri, 1974) and are in progress mainly at Central Plantation Crops Research Institute, Kasaragod. Some new lines of work have been initiated in the wake of more knowledge resulting from earlier work. As it stands, the gap between the best farmers yield average (111 nuts/palm/year) and the maximum obtained in a research farm (174 nuts/palm/year) is wide enough, and needs immediate steps to bridge it (Swaminathan, 1976). It is apparent that even with this level of production we are not fully exploiting the biological potential of this palm since individual palms capable of yielding over 400 nuts/year have been located in disease affected tracts under rainfed conditions, which clearly calls for a more systematic approach for coconut improvement.

Collection Conservation and Evaluation of Germplasm

Our present collection at the Institute comprises 62 exotic cultivars introduced from 20 countries of South and South East Asia, Pacific, Carribean and Indian Ocean Islands, and African countries. Among these, a few cultivars such as San Ramon, Philippine Ordinary and Fiji have shown promise. Besides, we have 32 indigenous cultivars collected from various parts of India, of which Laccadive Ordinary and Andaman Ordinary have proved superior to local West Coast Tall. All these collections are systematically maintained and perpetuated by *inter-se* mating among similar looking individuals of each cultivar. Efforts are also made each year to strengthen these collections and also to procure from new areas through the agency of the National Bureau of Plant Genetic Resources, New Delhi. This germplasm is under constant evaluation for disease reaction, chiefly root wilt of Kerala, and for yield attributes in multilocational testing under the All India Coordinated Project of ICAR. In addition, these collections are also evaluated as parents in crosses with dwarf cultivars in producing more prolific hybrids.

There is urgent need for conservation of existing germplasm which face the danger of genetic erosion due to rapid introgression. We have noticed evolution of intermediate forms and dilution of existing gene complexes. The Laccadive Micro of Lakshadweep and Ayiramkachi of Tamil Nadu are a case in point, and if immediate steps are not taken to conserve these at source by careful *inter se* matings, we might lose the identity of this material. Steps are being taken to organise a world-wide collection of coconut germplasm with UNDP assistance, and to establish a gene bank in an isolated island in the Andaman Nicobar group. The bulkiness of the coconut seed and the small sample available per tree at a time are some of the limitations in ensuring a satisfactorily representative collection from each geographical zone. For a truly representative collection the ideal method would be to make *inter se* matings at source between similar looking individuals and establish the primary collection. This is going to be a colossal task in a world-wide germplasm collection since the variability in certain areas is enormous within a short distance.

Selection of Mother Palms and Prepotents

For bringing about the population improvement as outlined above, the first step naturally is the identification of high yielders and, in particular, the prepotent palms. It was suggested (Harland. 1957) that the concept of prepotency used by animal breeders for selection of pedigree bulls (Lush, 1949) can be usefully extended to coconut where each tree represents a gene complex. A prepotent palm would be one where the gene combinations tend to cohere and do not recombine, thus resulting in the '*enbloc*' transmission of parental characters to the progeny even under random mating leading to some sort of functional homozygosity (Clausen and Hiesey, 1958; Müntzing, 1963). It has been noticed that such prepotent palms occur in a population to the extent of one percent. Earlier studies (Satyabalan and Mathew, 1976) have shown that it is possible to identify such palms on the basis of nursery characters of their progenies, such as, collar girth, leaf number, leaf splitting etc., which are highly correlated with the yield of the adult palnts raised from them. A prepotent palm would be one which gives over 80-90% of progeny resembling the mother in its yield and other attributes. The next question is to use the juvenile characters of the seedling progeny to predict the prepotency of the mother palm without having to wait for yield of the progeny. Such an exercise was done using two characters namely, leaf number and collar girth and selecting for high mean and low variance in the top 30% of the population. This analysis also gave an indication that prepotents occur to the tune of one per cent in a population ; this study is being continued. An important consideration in these studies is to calculate the age of seedlings from the date of sprouting and not of sowing of seed. Since earlier studies have shown that the juvenile scoring at 5 month old seedling is highly correlated with that of 10-month old seedlings with the yield of the adult palm raised from them (Table 1), it would now become possible to identify prepotent mother palms rapidly for use in breeding, as well as in replanting and underplanting programmes.

Table 1. Nursery score of progeny from six high yielding parents at three stages of growth (Each figure is an average of at least 20 seedlings).

Mother palm No.	Total no. of leaves emerged			Girth at collar (cm)		
	First month	Fifth month	Tenth month	First month	Fifth month	Tenth month
VII/27	0.8	4.0	7.1	5.2	9.1	13.8
VIII/112	0.4	3.6	6.3	4.7	8.5	12.6
*O.C.19	1.1	4.7	7.4	5.5	10.0	14.8
O.C.6	0.3	3.4	6.3	4.9	8.4	12.4
VIII/23	0.2	3.6	6.5	4.6	8.7	13.3
*41-588	0.4	4.3	7.4	5.1	9.6	14.4

*Prepotent palms

3. Upgrading of Existing Plantations

While it is important to conserve coconut germplasm and constantly enrich our collection, the limited scope available for area expansion calls for immediate steps to upgrade the existing gardens both by better management as well as careful choice of superior material for underplanting and a systematic culling of unproductive palms. An alternative approach has been suggested for increasing productivity per unit area through 'vertical expansion' by 'multi-level cropping' (Swaminathan, 1977). With the shrinking of agricultural land and the expanding population this approach has become all the more relevant. It is hence important to identify materials where per palm productivity is high and attainment of stability of production is rapid. It has been generally noticed that high yielders occur to the extent of 8 to 10% in a coconut population. By about 20 years after planting, most palms would have yielded for 12 to 14 years and their production potential can be assessed by taking the cumulative yield for 10 to 12 years. Cumulative yield of 8 years exhibits a high correlation with that attained after stabilisation (Rao, *et al.*, 1978). Similar observations were also made by Liyanage and Abeywardane (1957). Thus by a careful choice of material, particularly from progenies of prepotent palms, for a progressive and phased underplanting, it would become possible to gradually replace all the poor yielders in 35-40 years. Since all the palms will not reach senility at one time, the phased programme of underplanting will ensure maintenance of a high level of production in the garden.

Exploitation of Hybrid Vigour

A new dimension to coconut improvement was added with the discovery that the hybrids made by Patel (1937) between Tall and Dwarf cultivars showed enormous vigour, enhanced production potential and early bearing tendency. However, this yield (over 170 nuts/palm/year) could be realised only under irrigation and good management. The reciprocal combination of Dwarf×Tall showed an even higher productivity, indicating strong possibility of cytoplasmic influence of the Dwarf parent. Another finding of significance is the differential combining ability of the Dwarf parent when diverse sources of these are crossed with a common source of Tall pollen. In a recent analysis of seedling progenies of such D × T combinations, recovery of heterotic seedlings ranged from 20% to nearly 100% in the different dwarfs used as female. Since a mixture of pollen from high yielding talls was used, it is possible that an element of pollen competition could also have contributed to this differential combining ability of the dwarfs. This is being verified by using pollen in different combinations, especially from prepotent talls. Since the degree of homozygosity varies as much in dwarfs as in the prepotent talls, it is conceivable that by a judicious choice of good combining dwarfs and prepotent talls one can ensure a reasonably high recovery (over 80%) of heterotic hybrid seedlings. This is of vital importance in planning an elite seed garden for mass production of hybrids since correct decision-making in the initial stages will largely determine the continued productivity of such elite seed forms. It has been reported by IRHO (Lamothe and Rognon, 1975) that their MAWAT hybrid (PB 121) combination of Malayan Dwarf Yellow × West African Tall gives over 95-97% recovery of prolific F_1 hybrids whereas our present level of hybrid recovery in Chowghat (CDO) × West Coast Tall (WCT) has not exceeded 30% in general. Therefore, we have initiated a systematic study of the combining ability of diverse sources of dwarf germplasm with pollen from prepotent talls.

Identification of Elite Palms

As already mentioned, individual palms exhibiting very high yield potential have been located even in disease-affected, rainfed tracts. Since we do not have critical data on the limit of biological yield potential in coconut, these un-usually high yielding palms may be taken to represent the upper levels to which our breeding methodology should be gearead. Following a news report of a high yielding palm (over 400 nuts/year) in a village of Quilon District in Kerala, a systematic study of this palm was taken up last year by this Institute. Simultaneously, a survey has been undertaken to locate more palms of this type in different coconut growing states. So far, we have located 17 palms yielding over 200 nuts/year growing in different parts of Kerala, and in Andamans. A common feature of these palms is their proximity to a perennial source of water, high rate of leaf and bunch production, and uniform distribution of female flowers. Besides, the palms growing in the midst of disease-affected gardens are showing no root wilt symptoms and if they turn out to be prepotents also these will form valuable donor parents. Even if they prove to be segregating hybrids, it might be useful starting material for attempting vegetative propagation. Seedling progeny of these palms are being scored for prepotency/hybridity, and the Thazhava palm appears to be a hybrid since it has shown a few yellow seedlings in the progeny.

Vegetative Propagation—Problems and Prospects

Although there are reports of stray palms producing bulbil shoots in place of flowers (Thomas, 1961 ; Davis, 1968), these have not so far been induced to root and establish in soil to produce clonal material. Until this hurdle is overcome, it is hard to say if bulbil propagation to give viable palms producing normal nuts would become a practical proposition. A possible approach would be to attempt bulbil induction by hormonal or other chemical stimulii to temporarily transform the female flowers into vegetative shoots and then induce rooting in them.

Another approach would be an extension of the rooting-box method (Davis, 1968) in order to produce shoots by temporarily suppressing the strong apical dominance of the single vegetative shoot apex of coconut, which may stimulate shoot formation on the trunk along with roots. If this is successful, one can multiply elite palms clonally in a non-destructive manner.

A third approach now being vigorously pursued in coconut is tissue culture propagation. Following the success obtatned in the oil palm, *Elaeis guineensis* Jacq. (Rabechault, Martin and Cas, 1972 ; Jones, 1977), scientists at Wye College, London have made some attempts to culture coconut tissues *in vitro* and have obtained shoot buds from inflorescence region. So far no rooting has been induced, but profuse callusing has been obtained from root meristem cultures (Blake *et*, *al.*, 1975 ; Schwabe, 1976). As a result of these attempts a nutrient medium (Y_3) has been developed (Eeuwens, 1976), containing enhanced levels of potassium and iodine, for the successful growth of coconut tissues.

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