IC DIVERGENCE IN COCONUT

BY

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Genetic divergence in coconut" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Vellanikkara,
6.9.1982.

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CERTIFICATE

Certified that this thesis is a record of research work done independently by Mr. P.C.Balakrishnan under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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We, the undersigned members of the Advisory Committee of Mr.P.C.Balakrishnan, a candidate for the degree of Master of Science in Agriculture with major in Plant Breeding, agree that the thesis entitled "Genetic Divergence in Coconut" may be submitted by Mr.P.C.Balakrishnan, in partial fulfilment of the requirements for the degree.

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Introduction

INTRODUCTION

Coconut is one of the important perennial cash crops of the tropics. It is cultivated in about 7.5 million hectares in the world and is mostly confined to South East Asian countries.

Among the coconut producing countries of the world, India occupies third place after Philippines and Indonesia in both acreage and total annual production of nuts. As per the 1978-79 statistics, India accounts for 1.125 million hectares under coconut with an annual production of 6,122 million nuts. Among the various Indian States, Kerala ranks first in acreage and production. It has, according to 1977-78 statistics, 699.1 thousand hectares under coconut with an annual production of 3366.5 million nuts.

During the last two decades or more integrated efforts were made both in the field of research and development with a view to modernising coconut culture and thereby increasing coconut production. However, it is surprising to note that inspite of the best efforts made available, productivity of palms has not only decreased, but there has been a steady decline in per hectare yield in the country in general and in Kerala in

particular. Not only per hectare productivity is low but the per palm production is the lowest in Kerala. According to the latest estimate, the palm productivity in Kerala is only 33 nuts as against 41 nuts in Tamil Nadu, 44 nuts in Lakshadeep and 57 nuts in Karnataka. There has been various reasons pointed out for the steady decline in productivity of coconut in the State. It is, therefore, imperative that every attempt should be concentrated to improve the present state of affairs.

Coconut is a cross pollinated crop in which exploitation of hybrid vigour has been attempted. One of the earlier attempts in this direction appears to be that of Patel (1937) who used palms from the two major groups of coconut cultivars viz., Tall and Dwarf ones in his hybridization programme. This is perhaps based on the assumption that palms belonging to the two groups will genetically be more diverse than those belonging to one and the same group, since it has been well accepted that maximum exploitation of hybrid vigour is possible by crossing genetically distant parents. Right from that time onwards successful hybrid combinations have been produced, both in T x D and also in D x T combinations.

The present thinking among coconut breeders is that there exists sufficient amount of genetic variability even within one group of coconut, say Tall, and there

exists great scope for selection even within the Tall palms (Bavappa, 1973).

As a preliminary step in this direction it is desirable to investigate the nature and degree of divergence in a population of palms of the Tall group, since information from such a study is useful for an understanding of the course of evolution of that group and also for classifying the population into sub units on the basis of this diversity. Such studies utilizing multivariate analysis have been successfully completed in several groups of crops. Besides its use in taxonomic problems, such a study helps in closing parents for achieving specific breeding objectives. Now it is well established that exploitation of hybrid vigour and success in getting desirable segregants in any breeding programme depends to a large measure on the degree of genetic divergence between the parents chosen.

With this back ground in view, the present study was taken up with the following objectives.

1. To estimate the variability in the important economic characters in the coconut germplasm available at the Regional Agricultural Research Station, Pilicode.

2. To estimate the genetic divergence among the cultivars and to group them into clusters according to the magnitudes of genetic distances using Mahalonobis D^2 statistic.

Review of Literature

REVIEW OF LITERATURE

Information available in literature on the genetic divergence of coconut seems to be scanty. However, a review incorporating the published work on coconut is attempted here in order to give an overall picture of the subject. Information available in other related crops has also been drawn as and when the same was felt necessary to project the overall dimension of the present topic.

Origin and classification of coconut

The origin of coconut still continues to be a subject of controversy. One theory states that the palm is believed to have originated from the northern end of Andes from where it was taken to the Pacific by pre-historic investigators (Purseglove, 1968). Based on the second theory of origin, coconut must have originated on the coast of central America from where the nuts might have been carried by the equitorial ocean currents to the Pacific Islands. The third theory, which is the widely accepted one, assigns the origin of the coconut to South Asia or Malayesia or in the Pacific from where it might have accidently reached America.

Palmae one of the most ancient families of angiosperms, comprises of a large group of palms of which the species recorded are distributed in 131 genera (Blatter, 1926). These include the economically important genera like cocos belonging to the tribe cocineae, one of the most important genus from the economic point of view.

One of the early attempts to classify the family Palmae was by Martin in his book "Historia Naturalis Palmarum" published in 1850. Later, various workers have attempted to classify the palmae family. Narayanan and John (1949) divided the varieties into five groups viz., spicata, typica, nana, javanica and androgena. In the later references on coconut palm, two groups viz., Tall and the Dwarf have been recognised based on morphological characters.

Cook (1901) and Patel (1938) indicated that the coconut varieties differed greatly in size, shape, colour and quality of the nut. Cook (1901) indicated that few of the coconut had some varietal peculiarities and varieties were local at first and this differenciation was probably favoured by isolation in accordance with the general tendency among the palms to form series of similar species of limited distribution. This has

been referred to differently by research workers as biotypes, ecotypes, strains, types, races, forms etc. Many such varieties have been reported from the different coconut growing countries of the world.

Haries (1982) classified the coconut cultivars in the world into Niu-Kafa and Niu-via types and pointed out its utility in identifying suitable parents for hybrid production. Tall coconut found both on east and west coast of India, Lakshadeep, Andamans and East and West Africa are predominently Niu-Kafa type. In South-East Asia generally Niu-via type is common. Kappadam of India is somewhat related to Niu-via type.

Genetics

Patel (1938) observed that number of leaves in the crown was positively and significantly correlated to annual yield of nuts and negatively correlated to the age at first flowering. Liyanage and Abeyawardena (1957) presented the correlation between 14 characters within and between parents and their bearing on seed selection was discussed. In addition to the established criteria for selecting seed parents, it was desirable to select palms giving large and heavy nuts, about 4000 cc in volume that sprouted early and produced high percentage of tall vigorous seedlings according to the same authors.

Harland (1957) felt that the nature of genetic variation was of significantly important for the transmission of yield of mother palms to their progenies. Satyabalan (1958) reported that among the introduced cultivars of coconut planted in Pilicode during 1924-25, Laccadive Islands, Cochin China, New Guinea, Philippines, Andamans, Java and Siam appeared to be desirable for multiplication under conditions prevailing on the West Coast of Kerala.

Charels (1959) reported that vigour of the seedlings could be judged at four leaf stage from the girth at the base of the shoot, size, spread and colour of leaves, rapidity of growth and sturdiness of the seedlings. Ninan et al. (1964) compared a few trees of West Coast Tall and Philippines giving the same yield of nuts and indicated that the out turn of copra in the latter was on an average 7 kg more than that in West Coast Tall. This indicated that copra content per nut might be an important factor contributing to yield differences between varieties.

The inbreds of open pollinated progenies of six cultivars were compared with those of the parents at Pilicode by Ratanum and Satyabalan (1964). A few cultivars were found to be promising under local conditions in which Cochin China, Philippines and

New Guinea came up first in mean copra out turn rather than S.S.Green and Fiji. According to Liyanage (1966) there was no correlation between nut characters and breeding value. Leaf production of the young palms within a family, during the first 40 months of their growth was correlated with breeding value of parents (Liyanage, 1967).

Nambiar et al. (1970) reported high heritability in characters like total number of female flowers producted, number and percentage of female flowers set and recommended that large number of spikes with one or two female flowers would help in reducing the instability in yield.

Analysis of crosses between six yield groups involving 540 palms drawn from 108 parents revealed the existance of substantial additive genetic variation for characters influencing yield (Nambiar and Nambiar, 1970). The general combining ability of palms yielding over 100 nuts per year was high for number of bunches, female flowers and for yield, but limited for percentage of fruit set. Progenies from crosses with elite pollen were superior in all the characters selected to those from open pollinated or inbred crosses.

The oil content of copra varied more between varieties than between different environments according

to Romney (1972). The differences between Jamaica Tall and Malayan Dwarf might necessitate grading on the basis of oil content.

Satyabalan et al. (1972) conducted studies on yield variations in high, medium and low yielders of West Coast Tall variety underplanted in an existing coconut garden and raised under average management conditions. They found that palms attained their bearing stage when they were 21 to 30 years old and that the maximum stabilised yield was obtained in the 28th year. The height of the palm and the number of functional leaves in the crown were significantly correlated with yield.

Thampan and Pankajakshan (1973) stated that copra content per nut had higher heritability value of 0.95 as against 0.48 for number of nuts. They, therefore, suggested that the criterion for selection of mother palms might be shifted to total output of copra per year per palm. The standard should be on annual production of not less than 15 kg of copra per palm. It was suggested that in case of West Coast Tall, 32 per cent of the weight of husked nut might be taken as the weight of copra.

Kannan and Nambiar (1974) after a detailed study of six tall types crossed with Gangabondam reported that

Laccadive Ordinary x Gangabondam was superior to all other hybrids in respect of annual leaf production, setting percentage, annual yield of nuts and copra content.

Genetic diversity

The importance of genetic diversity in selection of parents for hybridization has been stressed by many workers. Singh and Gupta (1968) working in upland cotton stated that the progenies derived from a set of diverse crosses exhibited a broad spectrum of variability. They emphasised the importance of genetic diversity of parents in hybrid breeding programme. According to them, the more diverse the parents were, within a reasonable range, the more would be the chance of improving the character in question.

Multivariate analysis by means of Mahalanobis' D^2 statistic was found to be a powerful tool in the hands of plant breeders for quantifying the degree of divergence between biological populations, to understand the trend on evolutionary pattern, to assess the relative contribution of different characters towards total divergence and the associations between genetic divergence and geographic divergence.

Generally ecogeographic diversity has been considered as an index of genetic variability in crop plants.

However, this may not be true for every case as many workers have postulated that geographic diversity need not necessarily be related to genetic diversity. Varieties from widely separated localities are usually included in hybridization programmes presuming genetic diversity and greater likelihood of yielding better segregants. The validity of the presumption depends upon the association between geographic diversity and genetic diversity (Singh and Bain, 1968). Results of Singh and Srivastava (1978) in castor are quite in agreement with the above. Many workers however, have pointed out that genetic diversity need not necessarily be related to geographic diversity (Murthy et al., 1965, Arunachalam and Ram, 1967, Singh and Bain, 1968, Gupta and Singh, 1970, Upadhay and Murthy, 1970). The workers observed that many varieties forming one group were geographically diverse, while varieties obtained from the same region were genotically diverse.

Literature available on this subject in coconut is meagre. The only reported study of genetic divergence using Mahalanobis' D^2 statistics in coconut (Cocos nucifera L.) is that of Bavappa et al. (1973) who studied the genetic divergence in nine F_1 families of West Coast Tall x Dwarf Green Coconut hybrids for 13 vegetative and productive characters. Bulk F_1 populations of the same cross as well as open pollinated progenies of West Coast

Tall were also studied. It was suggested that proper choice among Tall and Dwarf varieties of coconut would be helpful for the efficient exploitation of the hybrids. They found that individual cross combinations of West Coast Tall x Dwarf green differed significantly for all the 13 characters studied and the 9 cross combinations could be grouped into 4 clusters depending on the similarities of their D^2 values. Their study revealed that phenotypic uniformity could involve considerable genetic diversity and the proper choice of palms even among Tall and Dwarf varieties of coconut might be necessary for the efficient exploitation of hybrids.

Bavappa (1974) while studying the yield components in a germplasm collection of Arecanut, observed that there was significant variation between the different cultivars and ecotypes of A. catechu and A. triandra for various characters. George (1976) also studied the genetic diversity in arecanut and grouped it into eight clusters.

Materials and Methods

MATERIALS AND METHODS

The studies reported herein were undertaken at the Regional Agricultural Research Station, Pilicode and in the Department of Agricultural Botany, College of Horticulture, Vellanikkara during the years 1981-82 with the objective of assessing the genetic diversity of coconut cultivars so as to group them based on their genetic distance.

A. Materials

One hundred and twenty palms belonging to twenty four cultivars of exotic and indigenous origin of the Tall group, representing the wide spectrum of variability, maintained in the varietal collection of the Regional Agricultural Research Station, Pilicode, were earmarked for the study. All the selected palms belonged to 1924-'25 plantation and hence were of 57 years old. They have all been receiving uniform management practices as suggested in the Package of Practices for coconut. Details of the palms selected are given in Table 1.

Table 1. Particulars of the palms selected

Sl. No.	Name of the cultivar	Block	Serial No.of palms selected	Origin (Exotic or Indigenous)
1	Omalur	H	1, 2, 3, 5, 9	Indigenous
2	Kodiripadu	H	23, 25, 26, 29, 30	Indigenous
3	Indupali	H	33, 36, 38, 39, 41	Indigenous
4	Godavery	H	43, 44, 45, 49, 51	Indigenous
5	Fiji	H	70, 79, 87, 88, 89	Exotic
6	S.S.Green	H	108,109,122,126,133	Exotic
7	S.S.Apricot	H	118,119,123,132,Fa101	Exotic
8	Laccadive Ordinary	H	151,152,153,155,156	Indigenous
9	Andaman Ordinary	H	159,160,161,162,216	Indigenous
10	Laccadive Small	H	180,181,190,171,193	Indigenous
11	Bombay	H	205,206,207,209,210	Indigenous
12	Mysore	H	202,218,219,220,221	Indigenous
13	Philippines	H	225,234,235,238,242	Exotic
14	West Coast Tall	H	99,128,140,150,172	Indigenous
15	Malrosapuram	G	1, 2, 4, 5, 8	Indigenous
16	Gudiathum	G	13, 16, 17, 18, 19	Indigenous
17	Selam	G	43, 44, 49, 50, 51	Indigenous
18	Pollachi	G	54, 55, 57, 58, 60	Indigenous
19	New Guinea	J	1, 2, 3, 4, 7	Exotic
20	Cochin China	J	10, 13, 14, 20, 21	Exotic
21	Java	J	39, 42, 44, 48, 49	Exotic
22	Andaman Giant	J	35, 36, 37, 38, N.165	Indigenous
23	Baboor	K	13, 15, 55, 64, 65	Indigenous
24	Basanda	K	81, 86, 87, 89, 99	Indigenous

B. Methods

Observations on the following seventeen characters were recorded from all the hundred and twenty palms during the twelve month period of study i.e. from May 1981 to April 1982. A total of four observations was taken at quarterly intervals, as detailed below:

1. Girth of the stem in cm at 1 m from the ground level

The circumfrance of each palm selected was measured in cm at 1 m above the ground level using a measuring tape. Means were then worked out.

2. Number of leaves

The total number of fully opened leaves present on the crown was counted discarding dried and unopened ones. The mean was then calculated.

3. Number of inflorescence

Total number of inflorescence present on the crown, both opened and unopened, was counted and means arrived at.

4. Number of rachis per inflorescence

The number of rachis present within an inflorescence was counted from ten inflorescence at a time and means arrived at.

5. Number of female flowers per rachis

Number of female flowers per rachis was calculated by dividing the total number of female flowers produced in an inflorescence by the number of rachis present.

6. Number of female flowers in an inflorescence

The total number of female flowers in an inflorescence was recorded by counting the total number of scars present in a matured bunch as well as the number of developed nuts. The mean was then calculated.

7. Number of bunches in different stages of development

The total number of bunches in the crown at different stages of maturity was counted from all the palms and mean calculated.

8. Number of nuts per bunch

Number of nuts in a matured bunch was counted and recorded, the maturity being judged by the standard ripening colour of the nuts.

9. Percentage of setting

This was calculated by dividing number of nuts per bunch with the total number of female flowers produced in the same inflorescence, the same being expressed as percentage.

10. Total yield of nuts per year

This was recorded by taking the total nuts harvested from each of the palm during the study period i.e. from May 1981 to April 1982. The mean was then arrived at.

11. Weight of unhusked nut (in kg)

Three nuts at random from each of the selected palm were weighed in a balance and the mean calculated.

12. Weight of husked nut (in kg)

The three nuts used in the above observation were dehusked and their weight recorded and mean arrived at.

13. Weight of meat per nut (in g)

The weight of the meat was calculated by subtracting the shell weight from the weight of dewatered opened nut and was recorded for the same three nuts of the above observation and mean arrived at.

14. Thickness of meat per nut (in mm)

Thickness of meat was measured from each opened nut by using a steel tape at four different places and its mean value was recorded.

15. Size of the embryo(in mm)

This was recorded by measuring the diameter of that coconut eye where embryo was located by using a measuring tape and the mean was calculated.

16. Copra content (in g)

Oven dried copra extracted from each of the three nuts per palm was weighed and recorded in g. The mean value was then calculated.

17. Oil content (in %)

The percentage of oil in the copra of each nut was estimated by Cold Percolation Method of Bhandari (1974).

C. Statistical analysis

The analyses of the data were done in a Micro 2200 Computor of the Department of Statistics, College of Horticulture, Vellanikkara and also in T D C 316 (ECIL) Computor at the Computor Centre, Kerala University, Trivandrum. The data on all the 17 characters recorded, were subjected to statistical analysis for the estimation of variances and genetic divergence using Mahalanobis' D^2 statistic.

The calculation of Mahalanobis' D^2 and the grouping of the varieties into clusters were done following Tocher's method (Rao, 1952).

Results

RESULTS

Results of observations recorded from one hundred and twenty palms belonging to twenty four cultivars of coconut on seventeen economically important characters are presented in the foregoing pages.

Data showing the range of variability for the seventeen different characters among the twenty four coconut cultivars are presented in Table 2. Rankings of the cultivars for the different characters studied are given in Tables 3 to 19. In Table 20, an abstract of analysis of variance for different characters is furnished. The phenotypic, genotypic and environmental variances for the different characters are given in Table 21. Table 22 gives the details of cultivars constituting different clusters. Tables 23 and 24 reveal the average intra and inter cluster D^2 and D values respectively of the six clusters on the basis of the 17 characters considered simultaneously. In Table 25, cluster means for different characters are presented. Rank totals on the basis of D^2 values of 17 characters are furnished in Table 26.

Mean values of the 17 characters of twenty four coconut cultivars are presented in Appendix I. Appendix II shows the error variance covariance matrix of seventeen

characters for the twenty four coconut cultivars. Uncorrelated mean values of twenty four cultivars are presented in Appendix III and in Appendix IV, D^2 values considering all the seventeen characters simultaneously are furnished. In the cluster diagram given in Fig.1, all the six varietal clusters with the genetic distances among them are marked.

General variability

Results of observations on the 24 cultivars of coconut presented in Table 2 reveal the presence of high amount of variability in the material. The results further indicate that the maximum values of the seventeen characteristics have been exhibited by nine cultivars and the minimum by nine others of the 24 studied. There exists a wide gap between the maximum and minimum values with respect to each of the seventeen traits.

Results of detailed observations are presented characterwise below:

Girth of the stem in cm at 1 m from the ground level

The mean value for girth of the stem at 1 m above the ground level of the coconut cultivars under study, varied from 67.80 to 101.50 cm with a general mean

Table 2. Range of variability for different characters among the 24 coconut cultivars

Sl. No.	Characters	Range and the cultivars showing the maximum and minimum values			
		Maximum value	Cultivar	Minimum value	Cultivar
1	Girth of the stem in cm at 1 m from the ground level	101.50	Andaman Giant	67.80	S.S.Apricot
2	Number of leaves	31.45	Andaman Giant	21.45	Selam
3	Number of inflorescence	15.70	Laccadive Small	7.30	Cochin China
4	Number of rachis per inflorescence	33.85	Baboor	26.75	S.S.Apricot
5	Number of female flowers per rachis	1.59	Basanda	0.52	Java
6	Number of female flowers in an inflorescence	49.15	Basanda	16.10	Pollachi
7	Number of bunches in different stages of development	8.95	Andaman Giant	4.05	S.S.Apricot
8	Number of nuts per bunch	13.05	Laccadive Small	3.65	S.S.Apricot
9	Percentage of setting	39.09	Laccadive Small	17.48	Andaman Ordinary
10	Total yield of nuts per year	146.60	Laccadive Small	43.40	S.S.Apricot
11	Weight of unhusked nut (in kg)	1.46	Java	0.63	Laccadive Small
12	Weight of husked nut (in kg)	0.92	Philippines	0.41	Godavery
13	Weight of meat per nut (in g)	423.41	Philippines	155.68	Laccadive Small
14	Thickness of meat (in mm)	12.94	Fiji	10.61	S.S.Apricot
15	Size of the embryo (in mm)	12.05	Andaman Ordinary	8.76	Gudiathum
16	Copra content (in g)	246.47	Philippines	97.05	Laccadive Small
17	Oil content (in %)	69.61	Godavery	65.08	Cochin China

Table 3. Ranking of the cultivars for girth of the stem in cm at 1 m from the ground level

Rank No.	Cultivar	Mean value
1	Andaman Giant	101.50
2	Andaman Ordinary	90.90
3	New Guinea	89.71
4	Java	89.70
5	Cochin China	85.60
6	Bombay	85.00
7	Basanda	83.80
8	Philippines	81.30
9	Fiji	80.20
10	Laccadive Small	79.20
11	Indupali	79.00
12	Malrosapuram	78.70
13	West Coast Tall	78.40
14	Godavery	77.90
15	Kudiathum	77.20
16	Mysore	76.20
17	Omalur	76.00
18	Kodiripadu	76.00
19	Baboor	75.80
20	Selam	75.30
21	Laccadive Ordinary	72.90
22	S.S.Green	68.60
23	Pollachi	68.30
24	S.S.Apricot	67.80
	General Mean	79.79
	C.D. (P = 0.05)	9.42

of 79.79 cm. Andaman Giant recorded the maximum girth (101.50 cm) whereas S.S.Apricot showed the minimum girth (67.80 cm). The differences among the cultivars were highly significant (Tables 3 and 20).

The estimated phenotypic variance (Vp) for this character was 106.51 which could be apportioned into genotypic variance (Vg) and environmental variance (Ve) as 49.82 and 56.69 respectively, indicating marked influence of environmental effect on the characters (Table 21).

Number of leaves

The general mean for this character was 24.77 with a range from 21.45 to 31.45 in the cultivars studied. Among this, Andaman Giant recorded maximum number of leaves on the crown (31.45), while Selam showed the minimum number of leaves (21.45). Significant difference was observed for this character among the cultivars studied.(Tables 4 and 20).

Phenotypic variance (Vp), genotypic variance (Vg) and environmental variance (Ve) for this character among the cultivars were estimated to be 13.43, 3.22 and 10.21 respectively, suggesting the predominating influence of environment in the expression of this character (Table 21).

Table 4. Ranking of the cultivars for number of leaves

Rank No.	Cultivar	Mean value
1	Andaman Giant	31.45
2	Basanda	27.75
3	New Guinea	26.65
4	Mysore	26.55
5	Cochin China	26.40
6	Baboor	26.03
7	S.S.Green	26.00
8	Laccadive Ordinary	25.85
9	Bombay	25.60
10	Laccadive Small	25.45
11	Fiji	25.20
12	Philippines	24.90
13	West Coast Tall	24.85
14	Omalur	24.70
15	S.S.Apricot	24.45
16	Java	24.20
17	Godavery	23.75
18	Kodiripadu	22.65
19	Indupali	22.60
20	Andaman Ordinary	22.45
21	Pollachi	22.10
22	Malrosapuram	21.90
23	Gudiathum	21.60
24	Selam	21.45
	General Mean	24.77
	C.D. (P = 0.05)	4.00

Number of inflorescence

Among the 24 cultivars studied, maximum number of inflorescence was observed in the cultivar Laccadive Small (15.70) and minimum in Cochin China (7.30) with a general mean of 12.74. Differences among the cultivars for this character were found to be significant even at one per cent level (Tables 5 and 20).

The phenotypic, genotypic and environmental variances for this characters were 10.86, 1.90 and 8.96 respectively, thereby showing that environment played a vital role in the expression of this characters (Table 21).

Number of rachis per inflorescence

The range of variability for this character was from 26.75 (S.S.Apricot) to 33.85 (Baboor) with a general mean of 30.15. The differences for this character were not found to be significant (Tables 6 and 20).

The genetic component of the total variance for the character was low compared to environmental component, (Vp = 17.43, Vg = 1.34 and Ve = 16.09) thereby showing that environmental influence played a major part to the differences found among the cultivars for this character (Table 21).

Table 5. Ranking of the cultivars for number of inflorescence

Rank No.	Cultivar	Mean value
1	Laccadive Small	15.70
2	Philippines	15.55
3	Andaman Giant	15.10
4	Bombay	14.95
5	West Coast Tall	14.80
6	Mysore	14.75
7	Fiji	14.60
8	Andaman Ordinary	13.10
9	Selam	13.10
10	Baboor	13.00
11	Laccadive Ordinary	12.95
12	S.S.Green	12.65
13	Java	12.40
14	S.S.Apricot	12.30
15	Omalur	11.95
16	Godavery	11.95
17	New Guinea	11.85
18	Indupali	11.75
19	Kodiripadu	11.70
20	Malrosapuram	11.45
21	Basanda	11.20
22	Pollachi	11.00
23	Gudiathum	10.60
24	Cochin China	7.30
	General Mean	12.74
	C.D. (P = 0.05)	3.74

Table 6. Ranking of the cultivars for number of rachis per inflorescence

Rank No.	Cultivar	Mean value
1	Baboor	33.85
2	S.S.Green	33.65
3	Fiji	32.90
4	Andaman Giant	32.35
5	Laccadive Ordinary	32.05
6	Cochin China	32.05
7	Basanda	31.60
8	Java	31.25
9	Bombay	31.10
10	Mysore	30.95
11	Selam	30.75
12	Malrosapuram	30.40
13	Godavery	30.15
14	New Guinea	30.00
15	West Coast Tall	29.10
16	Pollachi	28.95
17	Gudiathum	28.80
18	Omalur	28.75
19	Laccadive Small	28.70
20	Andaman Ordinary	28.20
21	Philippines	27.30
22	Indupali	27.05
23	Kodiripadu	26.90
24	S.S.Apricot	26.75
	General Mean	30.15
	C.D. (P = 0.05)	5.02

Number of female flowers per rachis

The variation for this character ranged from 0.52 to 1.59 with a general mean of 0.78. Cultivar Basanda showed the maximum and Java the minimum values (Table 7). The varietal differences were found to be significant (Table 20).

The genetic component of the total variance for this character was found to be low (Vp = 0.13, Vg = 0.03, Ve = 0.10), thereby indicating the predominating influence of environment for this character (Table 21).

Number of female flowers in an inflorescence

Among the cultivars studied, Basanda ranked first (49.15) and Pollachi-last (16.10) with a general mean 23.60. The differences between the cultivars were highly significant (Tables 8 and 20).

The genotypic variance was found to be low (25.94) when compared to the environmental variance (93.15) constituting the total phenotypic variance (119.09), thereby suggesting that environment played a major role in the expression of this trait (Table 21).

Number of bunches in different stages of development

This character was found to vary among the

Table 7. Ranking of the cultivars for number of female flowers per rachis

Rank No.	Cultivar	Mean value
1	Basanda	1.59
2	Laccadive Small	1.19
3	Kodiripadu	0.91
4	West Coast Tall	0.87
5	New Guinea	0.87
6	Godavery	0.86
7	Mysore	0.83
8	Philippines	0.82
9	Bombay	0.81
10	Andaman Ordinary	0.81
11	Indupali	0.75
12	S.S.Green	0.74
13	Fiji	0.72
14	Laccadive Ordinary	0.71
15	Selam	0.70
16	S.S.Apricot	0.69
17	Omalur	0.69
18	Andaman Giant	0.68
19	Malrosapuram	0.67
20	Cochin China	0.67
21	Gudiathum	0.61
22	Baboor	0.56
23	Pollachi	0.55
24	Java	0.52
	General Mean	0.78
	C.D. (P = 0.05)	0.40

Table 8. Ranking of the cultivars for number of female flowers in an inflorescence

Rank No.	Cultivar	Mean value
1	Basanda	49.15
2	Laccadive Small	33.50
3	Godavery	26.90
4	New Guinea	25.80
5	Andaman Ordinary	25.65
6	Mysore	25.60
7	S.S.Green	25.35
8	West Coast Tall	25.20
9	Bombay	25.10
10	Fiji	24.10
11	Laccadive Ordinary	23.00
12	Kodiripadu	22.40
13	Andaman Giant	21.85
14	Philippines	21.80
15	Selam	21.50
16	Cochin China	21.40
17	Omalur	20.20
18	Malrosapuram	20.15
19	Indupali	20.15
20	Baboor	19.05
21	S.S.Apricot	18.55
22	Gudiathum	17.60
23	Java	16.45
24	Pollachi	16.10
	General Mean	23.60
	C.D. (P = 0.05)	12.07

cultivars studied, from 8.95 (Andaman Giant) to 4.05 (Cochin China) with a general mean of 7.16, and the varietal differences for this character were significant (Tables 9 and 20).

The character was found to be highly influenced by environmental conditions as indicated by the values of Vp = 4.27, Vg = 0.55 and Ve = 3.72 respectively (Table 21).

Number of nuts per bunch

This is a character which directly influences the yield of a palm. The mean number of nuts per bunch was found to vary from 3.65 to 13.05 with a general mean of 6.34. The highest mean value was recorded (13.05) by the cultivar Laccadive Small and lowest (3.65) by S.S.Apricot. The differences among the cultivars were highly significant (Tables 10 and 20).

Here also the environment influence was seen to be more to total variability as suggested by the values Vp = 10.10, Vg = 2.85 and Ve = 7.25 (Table 21).

Percentage of setting

The mean values of the character were found to vary much among the cultivars studied. The highest

Table 9. Ranking of the cultivars for number of bunches in different stages of development

Rank No.	Cultivar	Mean value
1	Andaman Giant	8.95
2	West Coast Tall	8.75
3	Laccadive Small	8.70
4	Fiji	8.65
5	Philippines	8.35
6	Bombay	8.05
7	New Guinea	7.80
8	Mysore	7.35
9	S.S.Green	7.30
10	Andaman Ordinary	7.25
11	Omalur	7.20
12	Baboor	7.20
13	Laccadive Ordinary	7.10
14	Basanda	7.05
15	Selam	7.00
16	Godavery	6.90
17	Malrosapuram	6.75
18	Java	6.75
19	S.S.Apricot	6.65
20	Indupali	6.50
21	Kodiripadu	6.15
22	Pollachi	6.10
23	Gudiathum	5.20
24	Cochin China	4.05
	General Mean	7.16
	C.D.(P = 0.05)	2.42

Table 10. Ranking of the cultivars for number of nuts per bunch

Rank No.	Cultivar	Mean value
1	Laccadive Small	13.05
2	Basanda	11.60
3	New Guinea	7.30
4	Fiji	7.25
5	Godavery	7.05
6	Laccadive Ordinary	6.80
7	Baboor	6.75
8	West Coast Tall	6.55
9	Andaman Giant	6.45
10	S.S.Green	6.35
11	Omalur	6.05
12	Malrosapuram	5.85
13	Kodiripadu	5.75
14	Gudiathum	5.60
15	Selam	5.55
16	Pollachi	5.55
17	Bombay	5.50
18	Cochin China	5.40
19	Java	5.40
20	Indupali	5.15
21	Philippines	4.85
22	Mysore	4.60
23	Andaman Ordinary	4.20
24	S.S.Apricot	3.65
	General Mean	6.34
	C.D. (P = 0.05)	3.37

setting percentage was recorded by Laccadive Small (39.09) and lowest by Andaman Ordinary (17.48) with a general mean of 28.08. The differences among the cultivars were not significant (Tables 11 and 20).

The major part of variation for this character was found to be environmental. (Vp = 95.35, Vg = 5.23, Ve = 90.12) (Table 21).

Total yield of nuts per year

The differences for this ultimate economic character were found to vary widely among the cultivars studied with a range of variation from 146.60 nuts (Laccadive Small) to 43.40 nuts (S.S.Apricot) with a general mean of 83.52. The varietal differences were highly significant (Tables 12 and 20).

Major part of variation for this character was found to be due to environment though genetic component was also found to contribute to some extent. This has been indicated by the values of Vp = 1230.70, Vg = 338.28 and Ve = 892.42 (Table 21).

Weight of unhusked nut (in kg)

The mean weight of the unhusked nut among the cultivars was found to be variable ranging from 0.63 kg

Table 11. Ranking of the cultivars for percentage of setting

Rank No.	Cultivar	Mean value
1	Laccadive Small	39.09
2	Basanda	33.78
3	Pollachi	33.60
4	Baboor	33.40
5	Malrosapuram	32.06
6	Gudiathum	31.91
7	Java	30.96
8	Andaman Giant	30.25
9	Laccadive Ordinary	29.54
10	West Coast Tall	29.05
11	New Guinea	28.89
12	Godavery	28.69
13	Fiji	28.56
14	S.S.Green	27.74
15	Omalur	26.59
16	Kodiripadu	26.43
17	Selam	25.54
18	Indupali	24.87
19	Cochin China	24.80
20	Bombay	24.25
21	Philippines	24.13
22	S.S.Apricot	22.38
23	Mysore	19.91
24	Andaman Ordinary	17.48
	General Mean	28.08
	C.D. (P = 0.05)	11.88

Table 12. Ranking of the cultivars for total yield of nuts per year

Rank No.	Cultivar	Mean value
1	Laccadive Small	146.60
2	Basanda	123.20
3	New Guinea	110.00
4	Godavery	102.80
5	Baboor	101.20
6	Fiji	94.80
7	Gudiathum	93.80
8	Laccadive Ordinary	92.00
9	West Coast Tall	89.40
10	Bombay	84.20
11	Cochin China	84.00
12	Andaman Giant	80.40
13	S.S.Green	78.20
14	Indupali	77.60
15	Omalur	77.40
16	Mysore	75.60
17	Malrosapuram	75.40
18	Kodiripadu	73.60
19	Pollachi	73.20
20	Selam	70.60
21	Java	64.60
22	Philippines	58.80
23	Andaman Ordinary	45.80
24	S.S.Apricot	43.40
	General Mean	83.52
	C.D. (P = 0.05)	37.37

(Laccadive Small) to 1.47 kg (Java) with a general mean of 1.02. The differences among the varieties were highly significant (Tables 13 and 20).

The total phenotypic variance for this character was seen to be equally shared by genotypic and environmental components as indicated by the values of Vp = 0.08, Vg = 0.04 and Ve = 0.04 (Table 21).

Weight of husked nut (in kg)

The cultivars were found to vary widely for this character. The maximum value of 0.92 kg was recorded by Philippines and the minimum of 0.28 by Laccadive Small. The general mean for this character was seen to be 0.55. The differences for this character were highly significant also (Tables 14 and 20).

The total phenotypic variance for this character was seen to be equally shared by both environmental and genotypic components as indicated by the values of Vp = 0.04, Vg = 0.02 and Ve = 0.02 (Table 21).

Weight of meat per nut

Weight of meat per nut among the cultivars studied was found to vary widely. The maximum amount of meat was noted in Philippines (423.41 g) and the

Table 13. Ranking of the cultivars for weight of unhusked nut (in kg)

Rank No.	Cultivar	Mean value
1	Java	1.47
2	New Guinea	1.43
3	Philippines	1.40
4	Andaman Ordinary	1.36
5	Cochin China	1.30
6	Andaman Giant	1.26
7	Basanda	1.11
8	Pollachi	1.10
9	Baboor	1.05
10	Selam	0.96
11	Bombay	0.94
12	Indupali	0.94
13	Omalur	0.93
14	S.S.Apricot	0.92
15	Fiji	0.92
16	S.S.Green	0.92
17	Laccadive Ordinary	0.90
18	Mysore	0.90
19	Kodiripadu	0.88
20	Malrosapuram	0.86
21	West Coast Tall	0.84
22	Gudiathum	0.82
23	Godavery	0.75
24	Laccadive Small	0.63
	General Mean	1.02
	C.D. (P = 0.05)	0.26

Table 14. Ranking of the cultivars for weight of husked nut (in kg)

Rank No.	Cultivar	Mean value
1	Philippines	0.92
2	Java	0.87
3	New Guinea	0.86
4	Cochin China	0.82
5	Andaman Giant	0.64
6	Andaman Ordinary	0.61
7	Basanda	0.56
8	Pollachi	0.55
9	Baboor	0.55
10	Bombay	0.54
11	S.S.Apricot	0.53
12	Fiji	0.53
13	Selam	0.52
14	Omalur	0.51
15	S.S.Green	0.51
16	Mysore	0.46
17	Indupali	0.45
18	Laccadive Ordinary	0.45
19	West Coast Tall	0.44
20	Malrosapuram	0.44
21	Kodiripadu	0.42
22	Gudiathum	0.42
23	Godavery	0.41
24	Laccadive Small	0.28
	General Mean	0.55
	C.D. (P = 0.05)	0.14

minimum in Laccadive Small (155.68 g) with a general mean of 286.22 g. The differences seen among cultivars were found to be highly significant (Tables 15 and 20).

The genetic component for this character was found to be high comparatively as compared to the environmental component. This has been indicated by the values of Vp = 6724.64, Vg = 3829.31 and Ve = 2895.93(Table 21).

Thickness of meat

The variability for thickness of meat among the 24 cultivars studied ranged from 10.61 mm (S.S.Apricot) to 12.94 mm (Fiji), with a general mean of 11.96 mm. The differences among the cultivars for this character were found to be significant (Tables 16 and 20).

The character was seen to be subjected to high influence. The total phenotypic variance Vp was found to be 0.60 with the environmental component Ve being 0.40 genetic component, Vg = 0.20 thereby indicating the preponderance of environment in the expression of this trait (Table 21).

Size of the embryo

Variation for this character was found to be significant. The range of variability was seen to be

Table 15. Ranking of the cultivars for weight of meat per nut (in g)

Rank No.	Cultivar	Mean value
1	Philippines	423.41
2	New Guinea	416.41
3	Cochin China	413.36
4	Java	381.25
5	Andaman Giant	310.21
6	Fiji	309.30
7	Andaman Ordinary	305.33
8	Pollachi	292.85
9	Basanda	291.13
10	Omalur	289.94
11	Baboor	285.69
12	Bombay	283.99
13	S.S.Apricot	276.98
14	Selem	271.79
15	S.S.Green	260.95
16	Indupali	256.94
17	Mysore	255.12
18	Malrosapuram	251.16
19	West Coast Tall	239.41
20	Laccadive Ordinary	237.09
21	Kodiripadu	233.41
22	Godavery	215.88
23	Gudiathum	212.00
24	Laccadive Small	155.68
	General Mean	286.22
	C.D. (P = 0.05)	67.31

Table 16. Ranking of the cultivars for thickness of meat (in mm)

Rank No.	Cultivar	Mean value
1	Fiji	12.94
2	Omalur	12.72
3	Pollachi	12.63
4	Laccadive Small	12.34
5	Bombay	12.34
6	Indupali	12.28
7	Mysore	12.26
8	Malrosapuram	12.26
9	Selam	12.21
10	West Coast Tall	12.09
11	Baboor	12.04
12	Andaman Ordinary	12.03
13	Godavery	12.02
14	Cochin China	11.99
15	New Guinea	11.96
16	Laccadive Ordinary	11.89
17	Andaman Giant	11.81
18	Philippines	11.64
19	Basanda	11.59
20	Kodiripadu	11.59
21	Java	11.55
22	Gudiathum	11.35
23	S.S.Green	10.99
24	S.S.Apricot	10.61
	General Mean	11.96
	C.D. (P = 0.05)	0.79

from 8.77 mm (Gudiathum) to 12.05 mm (Andaman Ordinary) with a general mean of 10.26 mm (Tables 17 and 20).

Environmental variance was found to be the major source of variation for embryo size as indicated by the values of Vp = 2.38, Vg = 0.57 and Ve = 1.81 (Table 21).

Copra content

Wide range of variation was observed for this character, the maximum being 246.47 g (Philippines) and the minimum 97.06 (Laccadive Small). The varietal differences for this character were highly significant also. The general mean for the character was found to be 166.92 (Tables 18 and 20).

The total phenotypic variance for this character (Vp = 2114.41), was mostly contributed by genetic component (Vg = 1187.04) while environmental variance was found to be only 927.37 (Table 21).

Oil content

The varietal differences for this characters were highly significant and the mean values ranged from 63.16 (S.S.Apricot) to 69.61 (Godavery) with an overall mean of 67.84 percentage (Tables 19 and 20).

Table 17. Ranking of the cultivars for size of the embryo (in mm)

Rank No.	Cultivar	Mean value
1	Andaman Ordinary	12.05
2	Philippines	11.76
3	Mysore	11.68
4	Andaman Giant	11.45
5	Selam	11.30
6	Pollachi	11.30
7	Basanda	10.54
8	New Guinea	10.51
9	Cochin China	10.51
10	S.S.Apricot	10.50
11	Laccadive Ordinary	10.46
12	Bombay	10.40
13	West Coast Tall	10.17
14	Baboor	9.87
15	S.S.Green	9.87
16	Java	9.86
17	Indupali	9.82
18	Malrosapuram	9.62
19	Omalur	9.57
20	Kodiripadu	9.47
21	Fiji	9.07
22	Laccadive Small	8.83
23	Godavery	8.82
24	Gudiathum	8.77
	General Mean	10.26
	C.D. (P = 0.05)	1.68

Table 18. Ranking of the cultivars for copra content (in g)

Rank No.	Cultivar	Mean value
1	Philippines	246.47
2	Java	236.26
3	Cochin China	234.71
4	New Guinea	231.98
5	Andaman Giant	189.26
6	Fiji	187.32
7	Andaman Ordinary	177.58
8	Pollachi	176.32
9	Basanda	172.93
10	Omalur	172.45
11	Bombay	168.24
12	Selam	116.59
13	Malrosapuram	154.50
14	Baboor	154.48
15	S.S.Apricot	153.95
16	S.S.Green	150.37
17	West Coast Tall	148.45
18	Mysore	148.17
19	Laccadive Ordinary	146.45
20	Indupali	146.42
21	Gudiathum	137.87
22	Kodiripadu	137.36
23	Godavery	128.87
24	Laccadive Small	97.06
	General Mean	166.92
	C.D. (P = 0.05)	38.10

Phenotypic and genotypic variances for this character were 5.29 and 1.74 respectively and with an environmental variance of 3.55, thereby suggesting high influence of environment for this character (Table 21).

Genetic divergence among the cultivars

The twenty four indigenous and exotic cultivars included in the study fell into 6 clusters, each one having different number of cultivars (Table 22). Clusters I and II comprised of six cultivars each whereas clusters III and IV were equally having four each and the cluster V included three and cluster VI - only one, the same being formed on the basis of D^2 values furnished in Appendix IV.

The intra and inter cluster D^2 and D values of the six clusters worked out, have been presented in Tables 23 and 24 respectively. From the Table it could be observed that the intra cluster D^2 values were the least within each cluster in comparison to inter cluster D^2 values of that cluster with other clusters.

The average intra cluster distances in the six clusters ranged from 0.00 (Cluster VI) to 5.90 (Cluster V). The other clusters possessing values in between the two extremes (Table 24).

Table 19. Ranking of the cultivars for oil content (in %)

Rank No.	Cultivar	Mean value
1	Godavery	69.61
2	Malrosapuram	69.61
3	Pollachi	69.10
4	Baboor	69.06
5	Gudiathum	68.93
6	Omalur	68.92
7	Selam	68.83
8	Basanda	68.70
9	Laccadive Ordinary	68.62
10	Mysore	68.40
11	Laccadive Small	68.37
12	West Coast Tall	68.19
13	Indupali	68.15
14	Andaman Ordinary	68.00
15	Bombay	67.92
16	Kodiripadu	67.88
17	S.S.Green	67.82
18	Andaman Giant	67.41
19	Fiji	67.28
20	Philippines	66.98
21	Java	66.78
22	New Guinea	65.30
23	Cochin China	65.08
24	S.S.Apricot	63.16
	General Mean	67.84
	C.D. (P = 0.05)	2.36

Table 20. Abstract of Analysis of Variance for the different characters

Sl. No.	Characters	Mean square values		F value for cultivars	C.D.	
		Cultivars (d.f.= 23)	Error (d.f.= 92)		P = 0.05	P = 0.01
1	Girth of the stem at 1 m from the ground level	305.78	56.68	5.39**	9.42	12.52
2	Number of leaves	26.30	10.21	2.58**	4.00	5.31
3	Number of inflorescence	18.45	8.96	2.06**	3.74	4.97
4	Number of rachis per inflorescence	22.79	16.09	1.42	5.02	6.67
5	Number of female flowers per rachis	0.24	0.10	2.39**	0.40	0.53
6	Number of female flowers in an inflorescence	222.86	93.14	2.39**	12.07	16.05
7	Number of bunches in different stages of development	6.48	3.73	1.74*	2.42	3.21
8	Number of nuts per bunch	21.48	7.25	2.96**	3.37	4.48
9	Percentage of setting	116.29	90.12	1.29	11.88	15.78
10	Total yield of nut per year	2583.81	892.42	2.90**	37.37	49.67
11	Weight of unhusked nut (in kg)	0.26	0.04	6.26**	0.26	0.34
12	Weight of husked nut (in kg)	0.13	0.01	10.88**	0.14	0.18
13	Weight of meat per nut (in g)	22041.88	2895.34	7.61**	67.31	89.47
14	Thickness of meat (in mm)	1.39	0.40	3.48**	0.79	1.05
15	Size of the embryo (in mm)	4.66	1.81	2.57**	1.68	2.24
16	Copra content (in g)	6862.56	927.37	7.40**	38.10	50.63
17	Oil content (in %)	12.25	3.55	3.45**	2.36	3.13

* Significant at 5 per cent level
** Significant at 1 per cent level

Table 21. Phenotypic, genotypic and environmental variances for the different characters

Sl. No.	Characters	Phenotypic variance (Vp)	Genotypic variance (Vg)	Environmental variance (Ve)
1	Girth of the stem at 1 m from the ground level	106.51	49.82	56.69
2	Number of leaves	13.43	3.22	10.21
3	Number of inflorescence	10.86	1.90	8.96
4	Number of rachis per inflorescence	17.43	1.34	16.09
5	Number of female flowers per rachis	0.13	0.03	0.10
6	Number of female flowers in an inflorescence	119.09	25.94	93.15
7	Number of bunches in different stages of development	4.27	0.55	3.72
8	Number of nuts per bunch	10.10	2.85	7.25
9	Percentage of setting	95.35	5.23	90.12
10	Total yield of nuts per year	1230.70	338.28	892.42
11	Weight of unhusked nut (in kg)	0.08	0.04	0.04
12	Weight of husked nut (in kg)	0.04	0.02	0.02
13	Weight of meat per nut (in g)	6724.64	3829.31	2895.33
14	Thickness of meat per nut (in mm)	0.60	0.20	0.40
15	Size of the embryo (in mm)	2.38	0.57	1.81
16	Copra content (in g)	2114.41	1187.04	927.37
17	Oil content (in %)	5.29	1.74	3.55

Table 22. Details of cultivars constituting different clusters

Cluster Number	Cultivars included		Total No.
	Number	Name	
I	3	Indupali	6
	14	West Coast Tall	
	4	Godavery	
	8	Laccadive Ordinary	
	11	Bombay	
	12	Mysore	
II	1	Omalur	6
	5	Fiji	
	15	Malrosapuram	
	17	Selam	
	18	Pollachi	
	23	Baboor	
III	2	Kodiripadu	4
	7	S.S.Apricot	
	6	S.S.Green	
	16	Gudiathum	
IV	13	Philippines	4
	21	Java	
	19	New Guinea	
	20	Cochin China	
V	9	Andaman Ordinary	3
	22	Andaman Giant	
	24	Basanda	
VI	10	Laccadive Small	1

Table 23. Average intra and inter cluster D^2 values of 6 clusters of coconut on the basis of 17 characters considered simultaneously

Cluster No.	I	II	III	IV	V	VI
I	7.461	9.417	13.049	35.025	33.414	20.451
II		9.864	17.512	35.395	39.664	27.034
III			20.967	36.165	43.192	32.788
IV				22.693	38.826	68.464
V					34.805	47.085
VI						0.000

Table 24. Average intra and inter cluster D values of 6 clusters of coconut on the basis of 17 characters considered simultaneously

Cluster No.	I	II	III	IV	V	VI
I	2.731	3.079	3.612	5.918	5.781	4.522
II		3.141	4.185	5.949	6.298	5.200
III			4.579	6.014	6.572	5.726
IV				4.764	6.231	8.274
V					5.900	6.862
VI						0.000

Cluster VI was found to show the maximum average inter cluster distances with any other cluster and it was found to be the cluster showing maximum distance in 2 out of the total possible 5 combinations it could make. Cluster I showed the lowest average inter cluster distances (Tables 23 and 24).

Cluster means for the different characters

Girth of the stem in cm at 1 m from the ground level

Maximum mean value for this character was shown by cluster V (92.07) and the minimum by cluster III (72.40) (Table 25).

Number of leaves

Maximum number of leaves was seen in cluster V (27.22) and the minimum number of leaves in cluster II (23.56).

Number of inflorescence

The cluster mean for this character ranged from 11.78 (cluster IV) to 15.70 (cluster VI).

Number of rachis per inflorescence

The cluster means for this character were found to be maximum in cluster II (30.93) and minimum in cluster VI (28.70).

Number of female flowers per rachis

Cluster II had the lowest (0.65) and cluster VI the highest (1.18) mean values for the character.

Number of female flowers in an inflorescence

Cluster VI showed the largest mean value (33.50) and cluster II showed the lowest (20.18).

Number of bunches in different stages of development

The cluster means for this character was found to vary from 6.33 (cluster III) to 8.70 (cluster VI).

Number of nuts per bunch

Maximum cluster mean for the character was seen in cluster VI (13.05) and the minimum in cluster III (4.43).

Percentage of setting

The maximum and minimum mean values for the character were shown by cluster VI (39.09) and cluster I (26.05) respectively.

Total yield of nuts per year

The cluster means for this character were found to range from 72.25 nuts (cluster III) to 146.60 nuts (cluster VI).

Weight of unhusked nut (in kg)

The lowest and highest mean values for the character were found to vary from 0.63 kg (cluster VI) to 1.40 kg (cluster IV).

Weight of husked nut (in kg)

Maximum mean weight of husked nut (0.87 kg) was shown by cluster IV and minimum (0.28 kg) by cluster VI.

Weight of meat per nut (in g)

The lowest and highest mean values for this character were shown by cluster VI (155.68 g) and cluster IV (408.61 g) respectively.

Thickness of meat (in mm)

The mean value for this character was found to be maximum in cluster II (12.47) and minimum in cluster III (11.14).

Size of the embryo (in mm)

Cluster mean for size of the embryo was found to be maximum in cluster V (11.35) and a minimum in cluster VI (8.83).

Copra content (in g)

The cluster means for this character of ultimate economic importance were found to range from 97.06 g (cluster VI) to 237.36 g (cluster IV).

Oil content (in %)

The lowest cluster mean (66.04) for the character was shown by cluster IV and the highest (68.80) in cluster II.

The rank totals for the various characters have been presented in Table 26. From the Table it could be observed that number of rachis per inflorescence followed by number of female flowers in an inflorescence was contributing to the maximum towards divergence, whereas weight of husked nut and weight of unhusked nut were having the lowest contribution to divergence.

Table 25. Cluster means for different characters

Sl. No.	Characters	Mean values of cluster number					
		I	II	III	IV	V	VI
1	Girth of the stem in cm at 1 m from the ground level	78.23	75.72	72.40	86.58	92.07	79.20
2	Number of leaves	24.87	23.56	23.68	25.54	27.22	25.45
3	Number of inflorescence	13.53	12.52	11.81	11.78	13.13	15.70
4	Number of rachis per inflorescence	30.07	30.93	29.03	30.15	30.72	28.20
5	Number of female flowers per rachis	0.81	0.65	0.74	0.72	1.03	1.18
6	Number of female flowers in an inflorescence	24.33	20.18	20.98	21.36	32.22	33.50
7	Number of bunches in different stages of development	7.44	7.15	6.33	6.74	7.75	8.70
8	Number of nuts per bunch	5.94	6.17	4.43	5.74	7.42	13.05
9	Percentage of setting	26.05	29.96	27.12	27.20	27.17	39.09
10	Total yield of nuts per year	86.93	82.10	72.25	79.35	83.13	146.60
11	Weight of unhusked nut (in kg)	0.88	0.97	0.89	1.40	1.24	0.63
12	Weight of husked nut (in kg)	0.46	0.52	0.47	0.87	0.60	0.28
13	Weight of meat per nut (in g)	248.12	283.46	245.84	408.61	302.22	155.68
14	Thickness of meat (in mm)	12.15	12.47	11.14	11.79	11.81	12.34
15	Size of the embryo (in mm)	10.22	10.12	9.65	10.66	11.35	8.83
16	Copra content (in g)	147.77	168.62	144.89	237.36	179.92	97.06
17	Oil content (in %)	68.48	68.80	66.95	66.04	67.92	68.37

Table 26. Rank total on the basis of D^2 values of 17 characters of coconut cultivars

Sl. No.	Character	Rank	Rank total
1	Girth of the stem at 1 m from the ground level	14	2098
2	Number of leaves	12	2524
3	Number of inflorescence	6	2683
4	Number of rachis per inflorescence	1	2988
5	Number of female flowers per rachis	9	2566
6	Number of female flowers in an inflorescence	2	2971
7	Number of bunches in different stages of development	7	2655
8	Number of nuts per bunch	11	2545
9	Percentage of setting	5	2689
10	Total yield of nuts per year	8	2595
11	Weight of unhusked nut (in kg)	16	1729
12	Weight of husked nut (in kg)	17	1701
13	Weight of meat per nut (in g)	4	2696
14	Thickness of meat (in mm)	15	1906
15	Size of the embryo (in mm)	13	2439
16	Copra content (in g)	3	2890
17	Oil content (in %)	10	2553

Discussion

DISCUSSION

Results of observations on seventeen economic characters recorded from 120 palms belonging to 24 cultivars of coconut have been presented in the preceding chapter. It now remains to discuss the result as a whole so as to draw valid conclusions on the variability and genetic diversity among the cultivars of coconut.

Variability

Results of varietal evaluation have indicated that there exists a great amount of variability in the material for the expression of all the characters. When stem girth at 1 m from the ground level varied from 101.5 cm to 67.8 cm, the ranges in the other traits like number of leaves were from 31.45 to 21.45, number of inflorescence from 15.70 to 7.30, number of rachis per inflorescence - 38.85 to 26.75, number of female flowers per rachis - 1.59 to 0.52, number of female flower in an inflorescence - 49.15 to 16.10, number of bunches in different stages of development - 8.95 to 4.05, number of nuts per bunch - 13.05 to 3.65, percentage of setting - 39.09 to 17.48, total nut yield per year - 146.60 to 43.40, weight of unhusked nut 1.46 kg

to 0.63 kg, weight of husked nut - 0.92 kg to 0.41 kg, weight of meat per nut - 423.4 g to 155.68 g, thickness of meat - 12.94 mm to 10.61 mm, size of the embryo - 12.05 mm to 8.76 mm, copra content - 246.7 g to 97.05 g and oil content 69.61 to 65.08 per cent respectively (Tables 2 to 19).

Among the seventeen characters for which the 24 cultivars were evaluated in detail, the total phenotypic variance was found to be very high for weight of meat per nut, copra content and total nut yield per year. The total variances for these characters were found to very much exceed the general mean and also to exceed the maximum value among the cultivars. Estimates of heritable (genetic) and non heritable (environmental) components of the total phenotypic variance have also shown that, except in case of weight of meat per nut and copra content, the environmental components were found to exceed the genetic components, thereby indicating the predominating influence of environment in the manifestation of such characters. In the case of traits like weight of meat per nut and copra content, the genetic components of variance were found to exceed the environmental components, thereby suggesting that these traits were least affected by environment.

Comparing the cultivars for the ten palm characteristics studied, the cultivar Andaman Giant was found to top all others in stem girth at 1 m from the ground level, number of leaves and number of bunches in different stages of development. With regard to number of inflorescence, number of nuts per bunch, percentage of setting and total nut yield per year, the cultivar Laccadive Small was found to be on top. When the cultivar Basanda occupied first position in respect of number of female flowers per raohis and also that per inflorescence, it was cultivar Baboor which occupied first place in case of number of rachis per inflorescence. In respect of the seven nut characters studied, the cultivar Philippines occupied first position in respect of weight of husked nut, weight of meat per nut and copra content. When cultivar Java possessed the highest value in respect of the weight of unhusked nut, it was cultivar Fiji for thickness of meat and Andaman Ordinary for embryo size, Godavery and Malrosapuram for oil content. These facts clearly indicated that wide spectrum of variability was present in the material. Hence choice of the 24 cultivars in the present study is fully justifiable.

It was also seen that different cultivars were found to be ranking in different orders for the economically

important palm as well as nut characteristics, thereby suggesting the possibility of selecting different cultivars as donors for effecting improvement in the characteristics through planned hybridization programme.

Genetic divergence among the cultivars

The main objective of the present investigation was to assess the genetic diversity among the 24 coconut cultivars and to group them into clusters based on the genetic distance. On the basis of genetic distances computed with reference to 17 economic characters, the 24 cultivars of coconut belonging to the Tall group could be grouped into six clusters. The distribution of cultivars into various clusters showed no regularity. Cluster I and cluster II contained six cultivars, III and IV - four cultivars each, cluster V - three - and cluster VI - only one. Such irregular pattern of distribution has been reported by Mehndiratta and Singh (1971), Bavappa et al. (1973) in coconut and Chandrika (1979) in cowpea. Twelve out of 24 cultivars were found to comprise just in two clusters in the present study.

It is interesting to note that the seven exotic cultivars included in the present investigation (Fiji,

S.S.Apricot, S.S.Green, Philippines, Java, New Guinea and Cochin China) belonged to three different clusters (II, III and IV). Similarly the 17 indigenous cultivars studied in the present case were found to fall in five different clusters (I, II, III, V and VI). Again the two cultivars, Laccadive Ordinary and Laccadive Small were found to fall in two distinct clusters viz., I and VI, thereby indicating that cultivars of the same region could fall into different clusters. These findings are in agreement with the result of Mehndiratta and Singh (1971), Chandrika (1979) and Jayaprakash et al.(1981).

Results of D^2 and D values presented in Tables 23 and 24 have indicated that the minimum genetic distance was between cluster I and II and maximum between IV and VI. Rest of the clusters were found to occupy intermediary positions as regard to their genetic distances with other clusters (Fig.1). Thus it is to be concluded that clusters I and II are genetically closser while clusters IV and VI are wider.

Rank totals of D^2 values presented in Table 26 gave interesting informations. Characters like number of female flower in an inflorescence, copra content

in g and weight of meat per nut in g have contributed maximum towards total divergence whereas traits like weight of husked nut in kg weight of unhusked nut in kg, thickness of meat in mm and girth of the stem at 1 m from the ground level have contributed to the minimum to total divergence.

A cluster diagram showing all the six clusters and their inter cluster distances has been furnished in Fig.1. This diagram gives an overall picture of the distribution of the varieties constituting different clusters.

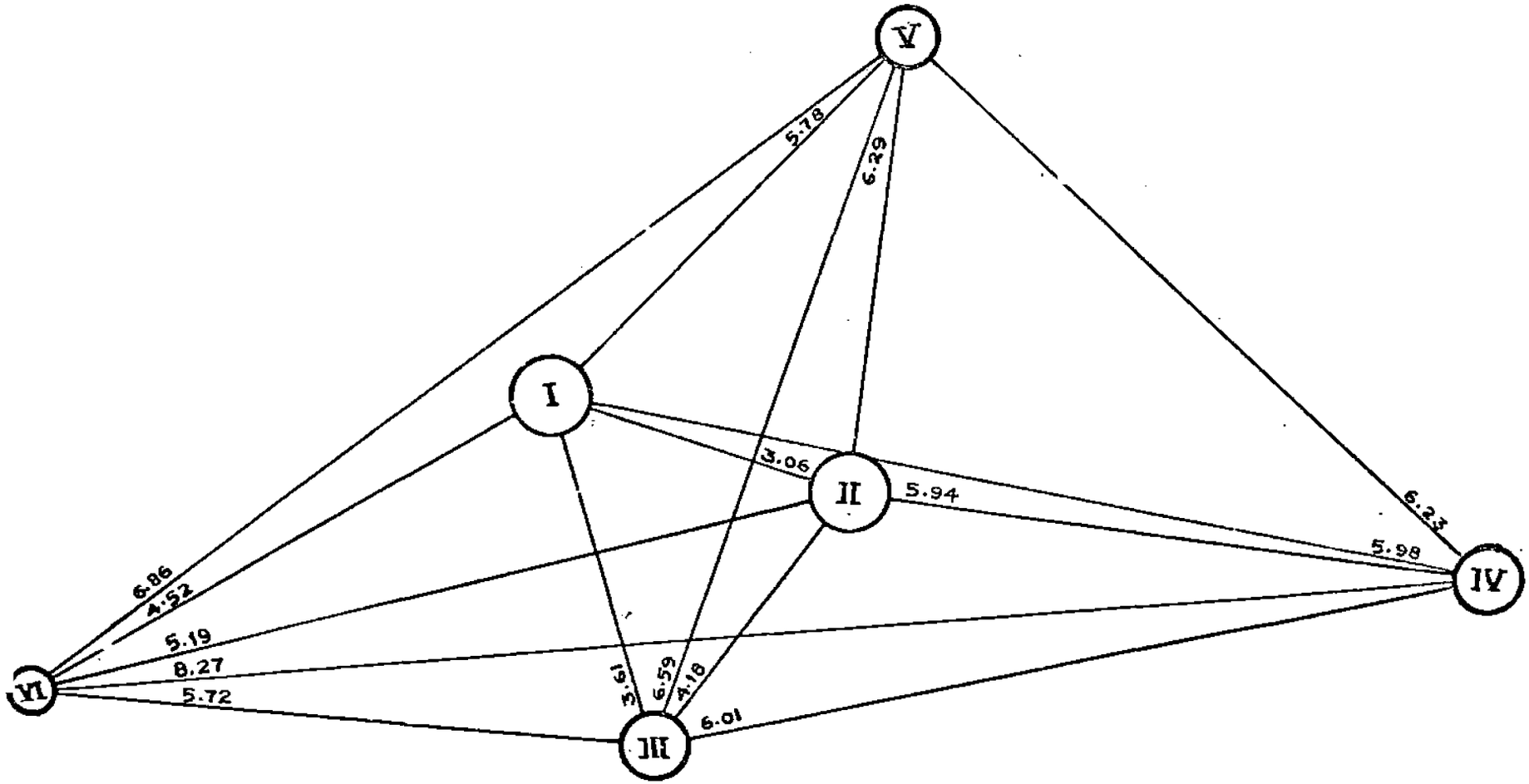

Fig. 1. CLUSTER DIAGRAM SHOWING THE DISTRIBUTION OF CLUSTERS.

Summary

SUMMARY

Genetic studies were undertaken with 24 cultivars of coconut maintained in the germplasm collection of the Regional Agricultural Research Station, Pilicode during 1981-82. It included one hundred and twenty palms of the same age group representing seven exotic and seventeen indigenous cultivars of the Tall group. The studies were mainly directed towards estimating the variability available in the collection, finding out the genetic distances among the cultivars and grouping them into clusters according to their genetic distances following the Mahalanobis D^2 statistic.

The important findings from the evaluation of the cultivars were the following:-

1. The germplasm collection of coconut, maintained at the Regional Agricultural Research Station, Pilicode, was found to contain very high variability for the seventeen characters studied.

2. The genetic component of variation was found to exceed the environmental component in the case of weight of meat per nut (in g) and copra content (in g)

among the seventeen characters studied. Environmental and genetic components were equal for weight of unhusked nut (in kg) and weight of husked nut (in kg). For all the other 13 characters studied, the environmental components exceeded the corresponding genetic components.

3. The cultivar Andaman Giant was identified as the one producing maximum values for number of leaves, girth at 1 m from the ground level and number of bunches in the crown among the 24 cultivars studied.

4. The cultivar Laccadive Small topped in number of inflorescence, number of nuts per bunch, percentage of setting and total yield of nuts per year.

5. The cultivar Baboor produced maximum number of rachis per inflorescence.

6. The cultivar Basanda produced maximum number of female flowers per rachis and also per inflorescence.

7. The cultivar Java and heaviest unhusked nuts among the cultivars studied.

8. The cultivar Philippines possessed maximum values for weight of husked nut (in kg), weight of meat per nut (in g) and copra content (in g).

9. Thickness of meat (in mm) was maximum in the cultivar Fiji.

10. The cultivars Godavery and Malrosapuram had the highest percentage of oil.

11. The 24 cultivars fell into six distinct clusters based on the genetic distances among them.

12. The intra cluster distance was maximum in cluster V and minimum in cluster VI.

13. The inter cluster distance was maximum between cluster IV and VI and minimum between clusters I and II.

14. Cultivars of the same place of origin fell into different clusters while those of diversified origin fell into the same cluster.

15. Among the 17 characters studied, number of rachis per inflorescence and number of female flowers in an inflorescence contributed maximum and weights of husked and unhusked nuts - minimum to total divergence.

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GENETIC DIVERGENCE IN COCONUT

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ABSTRACT OF A THESIS

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ABSTRACT

A study was conducted at the Regional Agricultural Research Station, Pilicode and in the College of Horticulture, Vellanikkara during 1981-82 with the objectives of assessing the extent of variability present in the 24 cultivars of coconut maintained in the germplasm collection at Pilicode and to assess their genetic divergence using Mahalanobis' D^2 statistic. All the 24 cultivars were planted during 1924-'25, and hence were of the same age group and were receiving the same management practices. Observations on 17 economic characters were recorded from 120 palms at the rate of 5 palms per cultivar. Four observations at quarterly intervals were recorded during the 12 month period of study. The data were subjected to relevant statistical analyses and the results were interpreted.

The study revealed that the collection contained very high amount of variability for all the 17 economic characters. A major portion of the observed variability in all the characters except weights of unhusked and husked nuts, weight of meat per nut and copra content

was found to be environmental. Number of rachis per inflorescence and number of female flowers in an inflorescence contributed maximum and weights of husked and unhusked nuts - minimum to total divergence.

Based on the genetic distance worked out, the 24 cultivars of coconut could be grouped into six distinct clusters.

Appendices