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Morphometric Diversity of Popular Coconut Cultivars of South Travancore

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Morphological data on fourteen biometrical traits in thirty palms belonging to six popular coconut cultivars of south Travancore, *via*., WCT, Komadan, Laccadive Ordinary, Natural Cross Dwarf, Chowghat Green Dwarf and Chowghat Orange Dwarf were subjected to genetic analysis. High heritability coupled with high genetic advance was observed for weight of unhusked nut, weight of husked nut and number of nuts per palm per year indicating the use of these characters in selection for improvement. All characters showed positive significant correlation with direct effect on yield. Cluster analysis showed the nut characters to be superior in assessing genetic divergence in coconut. The group constellations developed based on D^2 showed that the local cultivar WCT and NCD were clustered together and the well preferred cultivar Komadan got clustered along with Laccadive Ordinary, the variety of Lakshadweep released in Kerala as "Chandrakalpa" for its superiority in performance. Maximum divergence was reported between Komadan and NCD. Komadan was found to be a superior palm on par with laccadive ordinary. Hybridization between Komadan and WCT and between Komadan and Dwarf palms is suggested for yielding superior hybrids.

Key words: Genetic analysis, Coconut, Genetic improvement

The coconut *Cocos nucifera* L. is grown throughout the tropics as a plantation crop yielding several agronomic products that are important to export economies in these regions (Harries,1995). This palm, a monotypic species of the family arecaceae is a cross-pollinated crop with wide variability for most of the morphological traits. The study of variability in genetic stocks of coconut palm is a pre-requisite for any breeding programme. Since yield is the most important criterion for selection, an estimate of inter-relationship of yield with other characters is of immense help in crop improvement programme. Assessment of the nature and extent of variability among the genotypes will be of immense value in identifying superior genotypes and formulating breeding procedures. The analysis of genetic variation or diversity in coconut has been assessed for many years using morphological traits (Meunier *et al*.,1992)

The present study was undertaken to genetically analyse the biometrical traits in prominent six genotypes of Kerala viz. West Coast Tall, the most stable variety, Laccadive Ordinary commonly cultivated in Islands of India, Chowghat Green Dwarf, Chowghat Orange Dwarf (two prominent Dwarf types) and Komadan, a superior coconut cultivar of high demand among the cultivators in south Travancore and NCD a natural cross hybrid obtained from Chowghat Orange Dwarf by open pollination, so as to get a clear picture of the variability of the morphometric traits in these palms and to locate divergent genotypes for genetic improvement through hybridization.

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Materials and Methods

The present study was conducted in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani during the period 2006-2008. The experimental material consisted of thirty palms belonging to six coconut cultivars or varieties *viz.*, Komadan, Laccadive Ordinary, WCT, Chowghat Orange Dwarf, Chowghat Green Dwarf and Natural Cross Dwarf.

Five palms each of Laccadive Ordinary (LO), Komadan and West Coast Tall (WCT), palms of the similar age group and yield group were selected from C, D and E Block respectively of Instructional Farm, College of Agriculture, Vellayani.

Five palms each of Natural Cross Dwarf (NCD), Chowghat Green Dwarf (CGD) and Chowghat Orange Dwarf of the same age were selected from N8 and J Block of Regional Agricultural Research Station, Pilicode.

Morphological characters studied

(1) Plant height (m): Height of the palm was measured from the base of the stem to the crown region using a graduated meter tape.

(2) Number of leaves per palm: Fully opened leaves on the crown were counted.

(3) Number of spikelets per inflorescence: The number of spikelets per inflorescence in each accession was counted and the average worked out.

(4) Number of female flowers/ inflorescence : The number of female flower sockets in each harvested bunch was counted with number of nuts in that particular bunch which gave the number of female flowers in that inflorescence.

(5) Length of bunch stalk (cm): The bunch stalk length of each accession was measured and expressed in centimeters.

(6) Girth of bunch stalk (cm): The bunch stalk girth of each accession was measured and expressed in centimeters.

(7) Number of bunches harvested/year: Number of bunches harvested in each harvest was added together to obtain number of bunches per year. Average of four harvests was recorded.

(8) Number of nuts per bunch: Numbers of nuts per bunch in each harvest added together and mean number of nuts per bunch was obtained.

(9) Number of nuts per palm per year: This was obtained by adding the total number of nuts harvested in each harvest for one year.

(10) Weight of unhusked nut (kg): Unhusked nuts were weighed in a pan balance and mean weight expressed in kilograms.

(11) Weight of husked nut (g): Each husked nut was cleaned, weighed and weight measured in grams.

(12) Husk/nut ratio: The difference in weight of unhusked nut and husked nut divided by weight of unhusked nut gave the husk/ nut ratio.

(13) Fruit polar perimeter (cm): The length of the nut from one pole to other was measured by setsquare blocking of the nut and measuring the distance using a meter scale gave the polar diameter of the fruit in centimeter.

(14) Fruit equatorial perimeter (cm): The breadth of the nut at the middle portion measured by setsquare blocking of the nut and measuring the distance using a meter scale gave the equatorial diameter of the nut in centimeter.

Statistical Analysis of growth and yield components

The analysis of variance was carried out for various characters. Phenotypic and genotypic coefficients of variation (PCV and GCV) and the correlation coefficients (phenotypic, genotypic and environmental) were worked out based on the formulae given by Singh and Chaudhary (1997). The path analysis was done by the method developed by Wright (1954) to study the cause and effect relationship among a system of variables which helped to measure the direct influence along each separate path in such a system and to find the degree to which the variation of a given effect was determined by each particular cause. Genetic divergence was studied using Mahalanobis D^2 Statistic. The genotypes were clustered by Tocher's method. Dendrogram constructed with D^2 totals using NTSYS software.

Results and Discussion

Coconut is a robust palm, with tall, slender and thick stem and massive crown with large number of leaves bearing bunches of nuts in their axis. Variability exists among different cultivars of coconut on a number of morphological traits. Data on 14 morphological traits were recorded on thirty palms belonging to six genotypes.

The magnitude of variation as represented by range, phenotypic coefficient of variation and genotypic coefficient of variation, was moderately high for all the characters studied(Table 1).Many workers have reported that the coconut cultivars could be characterized and classified successfully based on leaf, stem, inflorescence and nut characters (Manju and Gopimony,2001 and Jayalekshmy and Sree Rangasamy, 2002(a))

For all the nut characters except husk/nut ratio Komadan recorded the highest value and for yield it was on par with Laccadive Ordinary which recorded the maximum. Superiority of Komadan for yield and related characters were reported previously by Shylaraj *et al.* (1991). In this study Lacadive Ordinary, showed significant superiority over the WCT which is the local cultivar of this area. Lacadive Ordinary commonly cultivated in the Islands of India, has already been released for Kerala in the name of "Chandrakalpa". The cultivar NCD showed similarity to Komadan only for plant height, number of nuts per bunch and fruit shape characters. For all the rest of the characters Komadan showed significant variation from corresponding traits of NCD.

The genotypic coefficient of variation is a measure of genetic variability facilitating successful isolation of desirable types. Coefficients of variation both genotypic and phenotypic were high for all the characters. Sindhumole and Ibrahim (2000) had reported that economic characters had high coefficients of variation than vegetative and reproductive characters but in this study such a trend was not seen. Genotypic coefficient of variation together with heritability estimates can give the best picture of the amount of advance to be expected from selection. The heritability estimates were high for most of the characters studied. High heritability coupled with high genetic advance was observed

Table 1. Mean values of different characters for the genotypes studied

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14
WCT	17.72	27.80	28.60	28.20	33.80	11.40	11.20	10.60	1090	464	0.625	52.00	47.30	89.4
LO	7.44	42.20	53.20	28.80	55.40	19.30	9.00	16.80	860	474	0.446	53.5.	42.40	119.6
Komadan	12.17	32.00	36.00	28.40	580	22.00	11.20	11.60	1251	541	0.588	58.10	47.80	118.6
NCD	12.94	28.40	35.40	23.20	29.80	10.00	9.00	10.20	933	485	0.507	56.70	45.40	95.6
CGD	4.80	26.80	26.20	27.20	35.48	8.20	6.20	9.20	552	248	0.461	51.10	39.70	59.6
COD	4.10	26.80	32.40	17.60	25.94	9.17	6.80	7.80	730	506	0.300	45.90	43.10	54.8
Mean	9.86	30.67	35.30	25.57	36.71	13.35	8.90	11.03	902.77	453.00	0.49	52.88	44.28	89.60
SE	0.389	1.93	1.63	2.32	4.12	1.46	1.05	2.23	3943.0	567.08	0.01	6.85	6.33	86.78
CD	0.812	1.82	1.67	1.99	2.65	1.58	1.34	1.95	81.97	31.09	0.09	3.42	3.29	12.16
F value	372.42	92.10	279.81	41.94	327.81	116.24	21.24	21.62	79.17	95.51	14.33	13.85	7.68	44.80
GCV(%)	53.82	19.35	27.04	17.03	44.72	43.41	23.16	27.50	27.50	22.86	22.83	7.93	6.57	30.77
PCV(%)	54.18	19.88	27.28	18.04	45.06	44.34	25.87	30.66	28.37	23.45	26.77	9.35	8.69	32.48
Hertability(%)	98.00	95.00	98.00	89.00	98.00	96.00	80.00	80.00	94.00	95.00	73.00	72.00	57.00	90.00
GA (%)	11.01	11.90	19.49	8.47	33.56	11.68	3.80	5.61	495.86	207.85	0.20	7.33	4.53	53.81

X1 Plant height (m), X2 Number of leaves/palm, X3 Number of spikelets/inflorescence, X4 Number of female flowers/inflorescence
X5 Length of bunch stalk(cm), X6 Girth of bunch stalk(cm), X7 Number of bunches harvested/year/palm, X9 Weight of unhusked nut (kg)
X10 Weight of husked nut (g), X11 Husk/nut ratio, X12 Fruit polar perimeter (cm), X13 Fruit equatorial perimeter (cm)
WCT : West Coast Tall, NCD : Natural Cross Dwarf,CGD : Chowghat Green Dwarf,COD :Chowghat Orange Dwarf,
LO : Laccadive Ordinary,SE : Standard error,CD : Critical Difference GCV: Genotypic coefficient of variation PCV: Phenotypic coefficient of Variation GA : Genetic Advance.

for weight of unhusked nut, weight of husked nut and number of nuts per palm per year. The result indicated that these characters were highly heritable and hence were less affected by the environment. The coconut breeder, therefore, may take his selection on the basis of phenotypic expression of these characters in the individual palms. Heritability in conjunction with genetic advance would give a more reliable index of selection value. Hence, selection based on phenotypic performance would result in considerable genetic gain of these traits. Ganesamoorthy *et al.* (2002) had reported high genetic advance for copra yield, dehusked nut weight, nut yield and whole nut weight. This suggests that selection for all the characters chosen have good role in yield improvement in coconut.

Genotypic correlation between 14 variables were estimated and presented in Table 2. The correlation between variables provided an idea of the degree of association existing among the different parameters measured. All the significant correlations existing between the characters studied were positive. All the characters studied, except plant height, had positive correlation with yield at 1 per cent level of significance. In this study yield had significant positive correlation with both vegetative and

Table 2. Genotypic correlation between different characters

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14
X1	1.000	-0.079	-0.124	0.425	0.276	0.195	0.896**	0.115	0.796**	0.388	0.899**	0.583 **	0.900**	0.498*
X2		1.0000	0.961**	0.491*	0.789**	0.754**	0.260	0.996**	0.191	0.271	0.012	0.327	-0.078	0.764**
X3			1.0000	0.238	0.735**	0.667**	0.187	0.918**	0.161	0.419	-0.154	0.282	-0.051	0.712**
X4				1.0000	0.509**	0.561**	0.553**	0.670**	0.381	-0. 216	0.783**	0.646 **	0.168	0.650**
X5					1.0000	0.984**	0.699**	0.793**	0.715**	0.639**	0.360	0.609**	0.523*	0.924**
X6						1.0000	0.635**	0.748**	0.672**	0.531*	0.369	0.627**	0.450*	0.887**
X7							1.0000	0.385	0.981**	0.630 **	0.867**	0.690**	0.994**	0.796**
X8								1.0000	0.282	0.226	0.217	0.447*	0.007	0.841**
X9									1.0000	0.744**	0.749**	0.683**	1.017	0.750**
X10										1.0000	0.092	0.258	0.792**	0.540**
X11											1.0000	0.765**	0.750**	0.583**
X12												1.0000	0.512*	0.835**
X13													1.0000	0.575**
X14														1.0000

*Significant at 5 per cent level **Significant at 1 per cent level
X1 Plant height (m), X2 Number of leaves/palm, X3 Number of spikelets/inflorescence, X4 Number of female flowers/inflorescence
X5 Length of bunch stalk(cm), X6 Girth of bunch stalk(cm), X7 Number of bunches harvested/year/palm, X9 Weight of unhusked nut (kg)
X10 Weight of husked nut (g), X11 Husk/nut ratio, X12 Fruit polar perimeter (cm), X13 Fruit equatorial perimeter (cm)
X14 Number of nuts per palm per year.

reproductive characters. Sindhumole and Ibrahim (2001) also reported that nut yield was significantly correlated with vegetative and reproductive characters. High positive correlation was recorded for number of leaves per palm and number of spikelets per inflorescence, length and girth of bunch stalk, plant height and number of bunches, number of nuts per bunch and number of leaves per palm and weight of unhusked nut and number of bunches per year.

To study the direct and indirect effects of 14 characters considered for the estimation of the genotypic correlation coefficient, path coefficient analysis was done and presented in Table 3.Eight characters *viz.,* plant height, number of spikelets/ inflorescence, number of female flowers/ inflorescence, length of bunch stalk, number of nuts per bunch , weight of unhusked nut, weight of husked nut and fruit polar perimeter showed positive correlation and positive direct effect. Five characters viz., number of leaves per palm, girth of bunch stalk, number of bunches harvested per year, husk/nut ratio and fruit equatorial perimeter showed negative direct effect. Path coefficient analysis revealed that eight characters *viz.*, plant height, number of spikelets/inflorescence, number of female flowers/ inflorescence, length of bunch stalk, number of nuts per bunch, weight of unhusked nut, weight of husked nut and fruit polar perimeter showed positive correlation and positive direct effect on yield. So according to this study the selection strategy for yield may be based on the above characters. The residual effect was low(0.12), showing that the variables selected explain eighty-eight percentage of variability in yield.

Table 3. Path coefficient analysis

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	Correlation with yield
X1	0.538	0.025	-0.023	0.060	0.187	-0.003	-0.322	0.031	0.088	0.051	-0.118	0.178	-0.195	0.498*
X2	-0.042	-0.317	0.181	0.069	0.536	-0.013	-0.093	0.271	0.021	0.036	0.001	0.100	-0.017	0.764**
X3	-0.066	-0.305	0.188	0.033	0.499	-0.011	-0.067	0.249	0.017	0.055	0.020	0.086	0.011	0.712**
X4	0.228	-0.156	0.044	0.142	0.345	-0.009	-0.199	0.182	0.042	-0.028	-0.103	0.197	-0.036	0.650**
X5	0.148	-0.250	0.138	0.072	0.679	-0.017	-0.251	0.215	0.079	0.084	-0.047	0.186	-0.113	0.924**
X6	0.104	-0.239	0.125	0.079	0.668	-0.017	-0.228	0.203	0.074	0.070	-0.048	0.192	-0.097	0.887**
X7	0.482	-0.082	0.035	0.078	0.474	-0.011	-0.360	0.104	0.108	0.083	-0.114	0.211	-0.216	0.796**
X8	-0.062	-0.316	0.173	0.095	0.538	-0.013	-0.138	0.272	0.031	0.029	-0.028	0.137	-0.001	0.841**
X9	0.428	-0.060	0.030	0.054	0.485	-0.011	-0.353	0.076	0.110	0.098	-0.098	0.209	-0.221	0.750**
X10	0.208	-0.086	0.079	-0.030	0.433	-0.009	-0.227	0.061	0.082	0.132	-0.012	0.078	-0.172	0.540**
X11	0.484	-0.003	-0.029	0.111	0.244	-0.006	-0.312	0.059	0.083	0.012	-0.131	0.234	-0.163	0.583**
X12	0.313	-0.103	0.053	0.092	0.413	-0.010	-0.248	0.121	0.075	0.034	-0.100	0.306	-0.111	0.835**
X13	0.4849	0.024	-0.009	0.023	0.355	-0.007	-0.357	0.002	0.112	0.105	-0.098	0.156	-0.217	0.575**

RESIDUAL EFFECT= .1242985 Bold letters are the direct effects Off diagonal values are indirect effects

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

X1 Plant height (m), X2 Number of leaves/palm, X3 Number of spikelets/inflorescence, X4 Number of female flowers/inflorescence

X5 Length of bunch stalk(cm), X6 Girth of bunch stalk(cm), X7 Number of bunches harvested/year/palm, X9 Weight of unhusked nut (kg) X10 Weight of husked nut (g), X11 Husk/nut ratio, X12 Fruit polar perimeter (cm), X13 Fruit equatorial perimeter (cm)

Table 4. D^2 values for the six coconut genotypes

	1	2	3	4	5	6
1	0.000	678.965	414.763	83.280	1111.296	796.684
2		0.000	183.415	464.478	752.583	490.262
3			0.000	391.704	1325.870	861.637
4				0.000	663.825	339.776
5					0.000	193.177
6						0.000

Bold figures indicate the lowest and highest D2 totals

1. West Coast Tall (WCT) 2. Laccadive Ordinary (LO)
3. Komadan 4. Natural Cross Dwarf (NCD)
5. Chawghat Green Dwarf (CGD) 6. Chawghat Orange Dwarf (COD

Genetic divergence of the six coconut genotypes based on eight morphological traits was worked out using D^2 analysis. The D^2 values for the six genotypes are given in Table 5. The most divergent pair was Komadan and CGD with D^2 value of 1325.87. The least value was between the pair WCT and NCD (83.28).

The clustering of the cultivars was done by Tocher's method based on the D^2 totals. The six cultivars were grouped in to 3 clusters. Cluster II with dwarf palms COD and CGD, cluster I with WCT and NCD and cluster III with Komadan and Laccadive Ordinary. The means of clusters for eight characters chosen for the D^2 analysis is given in Table 5.Cluster II with Komadan and Laccadive

Table 5. Cluster means for different traits

Characters	Cluster I	Cluster II	Cluster III
Plant height (m)	4.45	15.33	9.80
Length of bunch stalk(cm)	21.57	31.80	56.70
Girth of bunch stalk (cm)	8.68	10.70	20.65
Number of nuts per bunch/palm/year	8.50	10.40	14.20
Weight of unhusked nut (kg)	641.00	1011.80	1055.50
Fruit polar perimeter (cm)	48.50	54.35	55.80
Fruit equatorial perimeter (cm)	41.40	46.35	45.35
Number of nuts per palm per year	57.20	92.20	119.10

Ordinary had the highest mean for five characters out of eight chosen for clustering. The present study revealed that the importance of nut characters in assessing the genetic divergence in coconut. Similar results were reported by Jayalekshmy and Sree Rangasamy (2002(b)).

The inter and intra cluster distances of the three clusters are presented in Table 6. The average intra cluster distance for the three clusters ranged from 7.456 (Cluster I) to 10.858 (ClusterIII). The second cluster had an intra cluster distance of 8.8. The inter

Table 6. Average inter and intra cluster distance

Cluster	I	II	III
I(WCT,NCD)	**7.456**	23.115	27.534
II(CGD,COD)		**8.800**	20.856
III(Komadan,L.O)			**10.858**

Bold figure indicate intra cluster distance

cluster distance showed that the Cluster I and Cluster III were the farthest (27.537) and Cluster II and III were the closest (20.856).

The two dwarf palms chosen (Chowghat Green Dwarf and Chowghat Orange Dwarf) were separately clustered. The uniqueness of dwarf palms were reported by many workers (Jayalekshmy and Sree Rangasamy,2002 b, Arunachalam *et al.,* 2005 and Ratnambal *et al.,* 2005). The local cultivar

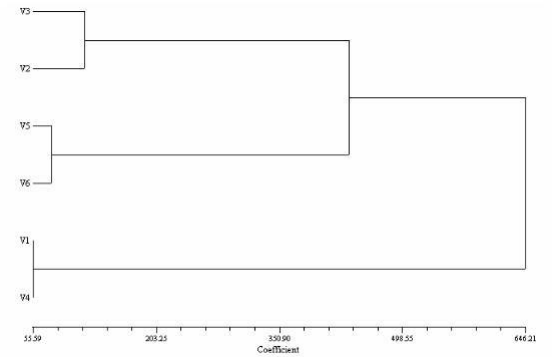

Fig.1. Dendrogram constructed with D^2 values based on morphological traits

V1-West Coast Tall V2-Laccadive Ordinary
V3-Komadan V4-Natural Cross Dwarf
V5-Chowghat Green Dwarf V6-Chowghat Orange Dwarf

WCT and NCD were clustered together and this may be due to the common heritage of NCD and WCT since WCT is the male parent of NCD. The same trend of NCD to cluster with WCT was also reported by (Manju and Gopimony, 1998).

The well preferred cultivar Komadan got clustered along with Laccadive Ordinary the variety of Lakshadweep released in Kerala as "Chandrakalpa" for its superiority in performance. The yield characters, number of nuts/bunch and number of nuts/palm/year were the highest for this group emphasizing the superiority of Komadan. Maximum divergence was reported between Komadan and NCD.

The study of genetic divergence helps to identify divergent parents which can be utilized in hybridization programmes so that maximum heterosis can be obtained. In this study, Komadan and Chandrakalpa were more divergent from WCT and NCD than the dwarfs. So, superior hybrids can be obtained from hybridization between Komadan and WCT or NCD. Eventhough Komadan is a highly preferred variety, it has certain defects as bunch buckling and lack of general resistance. This can be overcome by hybridization with WCT which is reported to be a stable variety. Hybridization between Komadan and the dwarfs can also be attempted as a new combination in the TxD series as the two groups are divergent.

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