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Diversity of coconut accessions for fruit components

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Abstract

Using Mahalanobis' generalized distance, 70 accessions of field conserved coconut germplasm maintained at Central Plantation Crops Research Institute, Kasaragod were classified for fruit characteristics. In the dendrogram showing hierarchical clustering, the largest group consisted of 47 accessions. Amalgamation of clusters in this group was at shorter distance. Classification of the accessions into distinct groups was also attempted. The pattern of amalgamation observed in the dendrogram was taken as the guideline for deciding the 'cut-off' points in the partition method which resulted in twenty seven clusters. The cluster size varied between 1 to 7: there were two clusters each of sizes 7 and 5; five clusters of size 4; eight clusters of size 2 and the remaining 12 were singletons. It was noticed that the popular cultivars known across the world (West Coast Tall, Tiptur Tall (both from India), West African Tall, Philippines Ordinary Tall and Sri Lanka Tall) have many fruit characters in common. In other words, in most of the coconut growing countries, the cultivators considered the fruit type of these cultivars as the ideal. The three dwarfs of Malaysian origin appeared in the same cluster. However, the dwarfs did not exclusively form a cluster, except for the one consisting of Surinam Brown Dwarf and Chowghat Green Dwarf. The accessions that are distinct apart are all of Tall type. The accessions from the Pacific Ocean and South-East Asian regions were spread throughout the dendrogram, confirming that these regions offered maximum variability. The indigenous collections also exhibited enormous variability. The correlation among the fruit characters was attributed to three causative factors, the first one related to weight measurements, second is for nut-constituents and third for the husk. The important characters that cause divergence as obtained from the canonical analysis were, weight of fruit, length of fruit, volume of cavity, weight of shell and per cent husk to fruit weight.

Key words: Coconut accessions, fruit component analysis, biodiversity

Coconut germplasm collection and conservation programme in India was initiated during 1924. In the first two and a half decades, priority was given to collection of exotic accessions. Work on survey and collection of indigenous accessions was started in the year 1952. During 1981, the International Board of Plant Genetic Resources provided financial assistance to Central Plantation Crops Research Institute to undertake a survey and collection of coconut germplasm in the six Pacific Ocean Islands (Rao and Koshy, 1982). The first attempt to classify the accessions in India was made by Narayana and John (1949). Rao and Mathew (1982) developed an index for characterization of germplasm at the nursery stage which will enable the germplasm collector to assess the population status in the collecting site, and based on which a decision on appropriateness of sampling size may be made. Whitehead (1966), demonstrated that population characteristics and variability in coconut can be assessed by fruit component analysis. Harries (1978) while reviewing the evolution, dissemination and classification of coconut, has proposed the use of fruit component analysis as a rational approach for classification of coconut cultivars. This classification system together with time taken for germination, was adopted by Rao and Pillai (1984) to assess the degree of introgression in 40 accessions. Ratnambal *et al.* (1995) prepared a catalogue in which 48 accessions were described for vegetative, reproductive, fruit and biochemical characteristics. In the present study, an attempt is made to classify 70 accessions based on fruit components. The Mahalanobis' generalized distance statistic was used for the classification.

Material And Methods

Population: The accessions were grown in the field gene bank at CPCRI, Kasaragod, Kerala, India, at an altitude of 10.7 m above MSL (12° 30' N latitude and 70° 00' E longitude). The soil type is red sandy loam (pH 5.3). The palms were grown under rainfed condition (average annual rainfall is 3175.5 mm with 113 rainy days/year). The average minimum and maximum temperature at Kasaragod ranges between 20 to 25°C and 28 to 33.5°C respectively. The palms received recommended fertilizer application and plant protection measures. The name and abbreviation of the accessions are given in Table 1 and their geographical distribution in Table 2.

Table 1. Name of accessions and country/province of collection

Accession name	Abbreviation
ANDAMAN ORDINARY TALL	ADOT
ANDAMAN GIANT TALL	AGT
AYIRAMKACHI TALL	AYRT
BENAULIM TALL	BENT
BLANCHISSEUSE TALL	BLIT
BORNEO TALL	BONT
BRITISH SOLOMON ISLAND TALL	BSIT
CALANGUTE TALL	CALT
COCHIN CHINA TALL	CCNT
CHOWGHAT GREEN DWARF	CGD
CHOWGHAT GREEN DWARF PATTUKOTTAI	CGD01
CHOWGHAT ORANGE DWARF	COD
CAMEROON RED DWARF	CRD
EAST AFRICAN TALL KENYA	EAT32
EAST AFRICAN TALL ZANZIBAR	EAT33
FIJIAN TALL	FJT
GANGABONDAM GREEN DWARF	GBGD
GANGAPANI TALL	GPNT
GONTHEMBILI TALL	GTBT
GUAM TALL TYPE I	GUAT
GUAM TALL TYPE II	GUBT
JAMAICA TALL	JMT
JAVA TALL	JVT
KARKAR TALL	KKT
KAPPADAM TALL	KPDT
KENTHALI ORANGE DWARF	KTOD
KONGTHIEN YONG TALL	KTYT
KLAPAWANGI TALL	KWGT
LAGUNA TALL	LAGT
LACCADIVE ORDINARY TALL	LCT
LIFOU TALL	LFT
LACCADIVE MICRO TALL	LMT
MALAYAN GREEN DWARF	MGD
MALAYAN TALL	MLT
MALAYAN TALL FMS	MLT01
MALAYAN RED DWARF	MRD
MARKHAM VALLEY TALL	MVT
MALAYAN YELLOW DWARF	MYD
NADORA TALL	NDRT
NEW GUINEA TALL	NGAT
NIGERIAN GREEN DWARF	NIGD
NIGERIAN TALL	NIT
NIU LEKA DWARF	NLAD
NU FELLA TALL	NUFT
NU GILI TALL	UGT
NU QUAWEN TALL	NUQT
NU WEHNUG TALL	NWHT
PHILIPPINES DAILING TALL	PDLT
PHILIPPINES ORDINARY TALL	PHOT
PHILIPPINES LONO TALL	PLNT
PANAMA TALL	PNT
PANAMA TALL(JAMAICA SANBLAS)	PNT03
PHILIPPINES PALAWAN TALL	PPWT
RANGOON KOBBARI TALL	RKBT
KING COCONUT	RTB04
ROTUMAN TALL	RTMT
SEYCHELLES TALL	SCT
SAKHI GOPAL TALL	SKGT
SRI LANKA TALL	SLT
SAN RAMON TALL	SNRT
MALAYAN SS APRICOT TALL	SSAT
MALAYAN SS GREEN TALL	SSGT
STANDARD KUDAT TALL	STKT
SURINAM BROWN DWARF	SUBD
SURINAM TALL	SUT
TIPTUR TALL	TPT
VERIKOBBARI TALL	VKBT
WEST AFRICAN TALL	WAT
INDIAN WEST COAST TALL	WCT
INDIAN WEST COAST TALL SPICATA	WCT01

Table 2. Distribution of accession based on region/country of collection

A. EXOTIC ACCESSIONS

Region	*Country*	*Accessions*
SOUTH-EAST ASIA	MALAYSIA	KWGT, MGD, MLT, MLT01, MRD, MYD, SSAT, SSGT
	INDONESIA	BONT, JVT
	PHILIPPINES	LAGT, PDLT, PHOT, PLNT, PPWT, SNRT
	VIETNAM	CCNT
PACIFIC OCEAN ISLANDS	SOLOMON ISLANDS	BSIT
	FIJI	FJT, NLAD, RTMT
	GUAM	GUAT, GUBT
	PAPUA NEW	KKT, MVT, NGAT
	GUINEA	NEW CALEDONIA NUFT, NUGT, NUQT, NWHT
	LIFOU ISLANDS	LFT

CENTRAL AND SOUTH AMERICA & ATLANTIC REGIONS	JAMAICA	JMT, PNT, PNT03
	SURINAM	SUBD , SUT
	TRINIDAD TOBAGO	BLIT
AFRICAN REGION	TANZANIA	EAT33
	NIGERIA	EAT32, NIGD, NIT
	IVORY COAST	CRD, WAT
INDIAN OCEAN ISLANDS	SRI LANKA	GTBT, RTB04, SLT
	SEYCHELLES	SCT
B. INDIGENOUS ACCESSIONS		
	State	
	KERALA	CGD, CGD01, COD, KPDT, WCT, WCT01
	KARNATAKA	KTOD, TPT
	TAMIL NADU	AYRT
	ANDHRA PRADESH	GBGD,GPNT, RKBT, VKBT
	ORISSA	SKGT
	GOA	BENT, CALT, NDRT
	LAKSHADWEEP	LCT, LMT
	ANDAMAN & NICOBAR Is.	ADOT, AGT

Fruit characters: The fully mature nuts (12 months old) were harvested during the summer months (March-April). Four nuts each from 6 to 10 palms of more than 25 years age were collected to characterize the fruit components of accessions (Mathew *et al.*, 1978). Thirteen measurements of the fruit components and three derived values were considered for the study (Table 3).

Table 3. Mean, range and CV of variables included in the study

Abbreviation	Variable	Unit	Mean	Min.	Max.	CV%
FRTWT	Weight of fruit	g	954.8	326.5	2544.0	20.23
FRTLENG	Length of fruit	cm	28.5	19.9	38.7	6.88
FRTBRED	Breadth of fruit	cm	24.4	15.4	35.9	7.81
HSKTHK	Thickness of husk	mm	2.7	1.4	4.3	18.20
HSKWT	Weight of husk	g	359.2	126.2	770.0	26.48
NUTWT	Weight of dehusked nut	g	596.9	187.0	1774.0	21.32
CAVTY	Volume of cavity	ml	203.5	38.7	670.0	26.15
ENDOTHK	Thickness of endosperm	mm	1.3	0.8	1.8	6.68
SHLTHK	Thickness of shell	mm	0.3	0.2	0.46	16.22
ENDOWT	Weight of endosperm	g	317.1	116.5	759.0	18.25
SHLWT	Weight of shell	g	136.7	45.6	285.0	17.28
COPRAWT	Weight of copra	g	179.4	70.4	411.0	17.28
%HSK/FRT	% husk to fruit weight	%	38.2	25.7	61.6	13.00
%SHL/NUT	% shell to nut weight	%	24.1	16.1	31.0	12.84
%WATR/NUT	% water to nut weight	%	21.2	6.9	41.1	25.19
%ENDO/NUT	% endosperm to nut weight	%	54.6	38.0	65.7	8.03

Statistical analysis: The values of the characters were averaged for each palm and multivariate analysis of variance was carried out for testing the differences among accessions. The matrix of distance between the accessions was computed as outlined by Rao (1973). Both hierarchical and non-hierarchical methods of clustering were attempted. The average link method was followed for hierarchical classification as described by Gordon (1981). The canonical analysis was performed to identify the characters contributing the maximum towards the divergence. The redundancy of variables was examined by means of principal component analysis (Kendall *et al.*, 1983). The programming was done in Borland C++ (Muralidharan *et. al.*, 1999). The published subroutines for matrix inversion (Griffiths and Hill, 1985) and extraction of characteristic roots and vectors of a matrix (Press *et al.*, 1992) were utilized.

Results And Discussion

The accessions were found to be significantly different for all the characters individually (F test) and also simultaneously (based on Wilks' lambda and Pillai's trace statistics). The mean, range and coefficient of variation (CV) of the characters are given in Table 3. The cultivar SNRT was found to have maximum values for most of the characters while the minimum values for many of the characters was observed for the indigenous dwarf CGD or CGD01. For characters related to the size of the fruit, LMT has the least values (FRTWT, NUTWT, SHLTHK, ENDOWT and SHLWT).

The correlation between NUTWT with FRTWT, ENDOWT and CAVITY were found to be very high (> 0.9). To summarize the inter-correlation among the characters, factor analysis was attempted. The first two factors explained 65.1% variation, while the last two components accounted only for a negligible part (0.01%). Factor loading of high magnitude in the last factor is indicative of variable redundancy. No such pairs of variables were found in this study. The factor loading of characters in the first four principal factors are shown in Table 4. The first factor is dominant with characters associated with the weight of the fruit and may be termed as the 'weight factor'. The per cent constituents of the nut viz., %ENDO/NUT and %WATER/NUT described the second factor. Percentage husk to fruit weight and weight of husk were the dominant characters of the third factor and may be termed as 'husk factor'. In subsequent factors, any association of two or more characters was not observed. In a study on morphological variations of 41 coconut cultivars of Mexico using 17 fruit characters, Villareal and Pinero (1998) obtained almost identical factor resolution. The correlation matrix resolved into three factors in their study: Corresponding to their second factor, two factors were obtained in the present study. The degree and direction of association between certain important characters were however not in agreement between these two studies. The important discrepancies noticed in this study with reference to Villareal and Pinero (1998) were (i) weak correlation between %HSK/FRT and %ENDO/NUT (ii) significant negative correlation between FRTWT and %ENDO/NUT (-.5) (iii) no significant correlation between FRTWT and %HSK/FRT (iv) weak correlation of ENDOWT and COPRAWT with %HSK/FRT (-.37 and -.36) (v) high positive correlation of ENDOWT and COPRAWT with FRTWT (0.8 and 0.7). In summary, the fruit weight is an important character for the selection and improvement of coconut.

Table 4. Causative factors of fruit-components

Factor	Factor I	Factor II	Factor III	Factor IV
ENDOWT	**0.945**	0.033	-0.045	0.004
NUTWT	**0.897**	0.339	0.001	0.036
CAVTY	**0.892**	0.195	-0.091	-0.040
COPRAWT	**0.890**	0.036	-0.083	0.058
FRTWT	**0.794**	0.334	0.375	0.147
SHLWT	**0.728**	0.305	0.060	0.050
%ENDO/NUT	-0.178	**-0.954**	-0.089	-0.066
%WATR/NUT	0.332	**0.815**	0.017	0.049
%HSK/FRT	-0.333	-0.039	**0.870**	0.267
HSKWT	0.412	0.231	**0.767**	0.264
FRTLENG	0.373	0.071	0.247	0.271
FRTBRED	0.529	0.172	0.295	0.468
HSKTHK	0.002	0.076	0.355	0.900
ENDOTHK	0.252	-0.065	0.032	0.064
SHLTHK	0.112	0.063	0.104	0.097
%SHL/NUT	-0.374	-0.116	0.106	0.060
% contribution to variability	45.9	19.1	9.9	8.6

The results of canonical analysis showed that the variation explained by the first two, four and six axes was respectively 35%, 57% and 74%. A two dimensional representation of accessions for the first two canonical axes was therefore seems to be inadequate. However, the canonical loadings may be used to assess the relative importance of characters to cause divergence (Muralidharan *et al.*, 1994). In the present study, FRTWT, FRTLENG, CAVITY, SHLWT and %HSK/FRT were found to have high canonical loading in one or other axes irrespective of number of axes considered (Table 5). The usefulness of the character %HSK/FRT for classification of coconut ecotypes was first proposed by Harries (1978). It may be seen that except SHLWT, the dominant characters of canonical factors were also involved in the determination of principal factors of the correlation matrix. N'cho *et al.* (1993) reported that the first three canonical axes explained 68% of variability in a study on 24 morphological characters of tall types of coconut conserved in Ivory Coast and the dominant characters in these axes include HSKTHK, ENDOTHK. These two characters were dominant in the sixth canonical factor extracted in the present study.

Table 5. Canonical factor loadings after rotation (Only six factor-solution is shown)

Factor	One	Two	Three	Four	Five	Six
FRTWT	-0.07	0.22	-0.08	**0.70**	0.09	-0.08
FRTLENG	**0.73**	0.23	-0.03	0.09	-0.16	-0.14
FRTBRED	0.14	-0.11	0.05	0.37	0.08	-0.01
HSKTHK	-0.26	0.19	-0.36	-0.27	0.22	-0.11
HSKWT	0.21	0.06	0.10	0.46	0.15	-0.11
%HSK/FRT	-0.07	**0.71**	0.06	-0.12	-0.08	0.04
NUTWT	0.03	0.03	0.28	-0.15	-0.02	-0.06
CAVTY	0.01	0.03	**0.72**	0.03	0.26	0.07
ENDOTHK	0.28	-0.06	-0.48	-0.04	0.38	0.08
SHLTHK	-0.11	-0.33	-0.01	-0.08	-0.12	0.07
SHLWT	-0.03	0.02	0.07	0.06	**0.79**	0.01
ENDOWT	-0.02	0.02	-0.03	0.05	-0.04	-0.52
COPRAWT	0.44	-0.07	0.02	-0.09	0.09	0.13
%SHL/NUT	0.14	-0.22	-0.04	0.03	-0.09	0.54
%WATR/NUT	0.12	-0.36	0.05	0.02	0.08	-0.33
%ENDO/NUT	-0.05	0.20	-0.02	0.07	0.05	0.48
Percent contribution	20.51	14.55	11.19	10.80	9.84	7.20

Based on Mahalanobis' generalized distance, the accessions were grouped following both hierarchical and partition methods. The results of hierarchical clustering are depicted in the form of a dendrogram (Fig. 1). Two distinct parts can be distinguished in the dendrogram; one in which amalgamation of cultivars/groups takes place at a close distance while in the other it is more. The first part consisted of 47 cultivars, which may be further partitioned in to 4 clusters. Among these, the cluster with the largest size may again be partitioned in to 8 sub-groups. The distinct clusters obtained from the method of partitioning are shown in Table 6. The pattern of amalgamation observed in the dendrogram was taken as a guideline on deciding the 'cut-off' points in the partition method. The following discussion on the closeness of accessions for fruit components utilizes results of both the types of clustering, and whenever required, the original distances were also taken into account.

In the dendrogram, the four New Caledonia accessions (NUFT, NUGT, NUQT and NWHT) are grouped along with STKT (Indonesia) and VKBT (India).

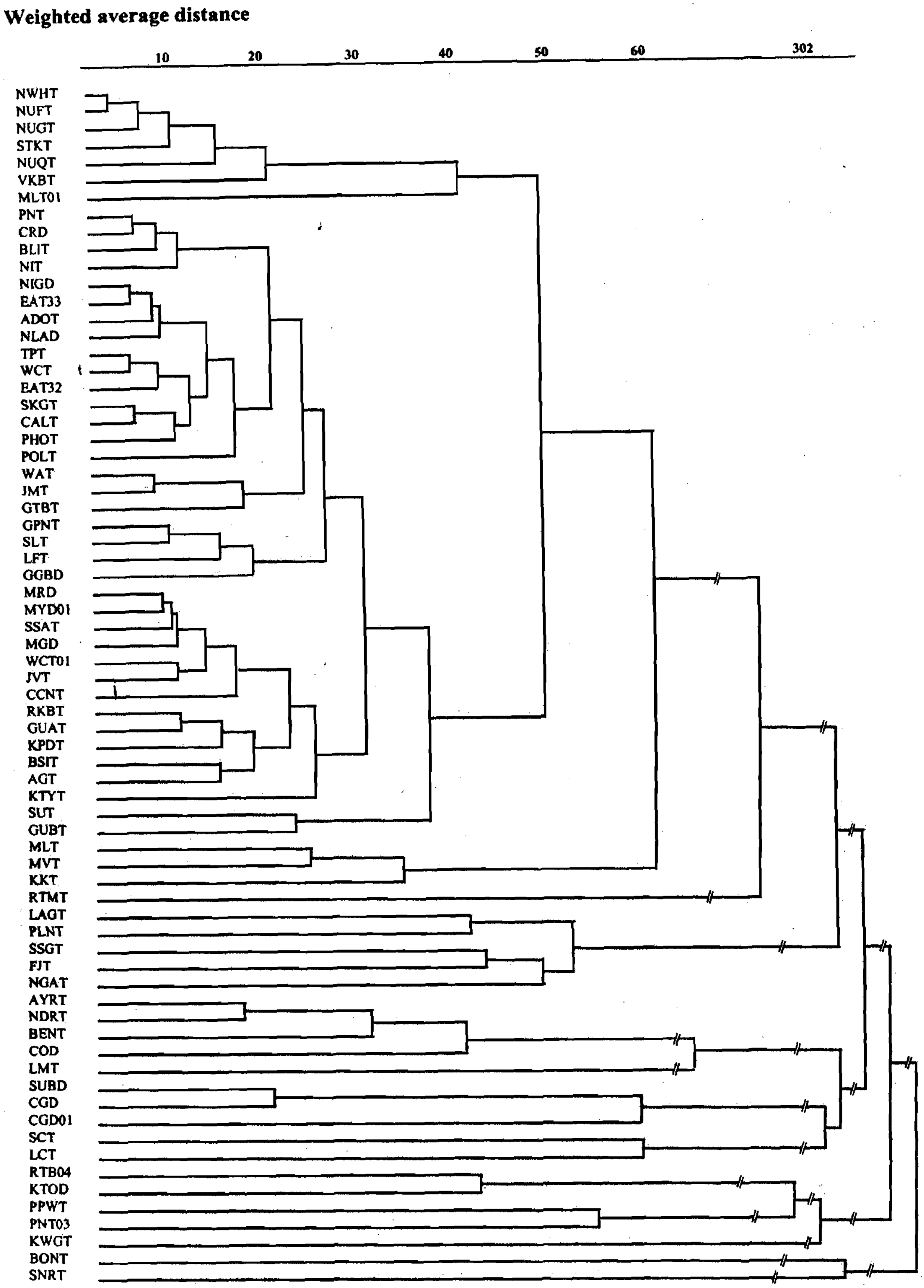

Fig. 1. Dendrogram showing the hierarchical classification (weighted average link method) maintained in the field gene bank at CPCRI, Kasaragod comprising of 70 coconut accessions

These cultivars are characterized by below population average values for all the characters. Among them, NUQT and VKBT have lesser values for HSKTHK, %HSK/FRT and %ENDO/NUT, and were formed as a separate group in the method of partition (Table 4). The dwarf cultivar CRD from the African region was grouped along with three tall cultivars - one from the same region (NIT) and two from the Central- and South-America and Atlantic regions (PNT and BLIT). This group was characterized by the average fruit weight and above average values for nut, shell and copra weights. The cluster consisting of cultivars NIGD, EAT33 (both from African Region), ADOT (Andaman and Nicobar Is.) and NLAD (Fiji Is.) is of special nature. For, two of its members are talls and remaining two are dwarfs; they are also from geographically distant regions. According to Villarreal and Pinero (1998) the dwarfs may have higher %SHL/NUT and %ENDO/NUT. However, in the present study, both NLAD and NIGD were found to have values near to population average for these two characters and hence might have clustered along with the talls. These two dwarfs might have evolved through introgression.

The widely cultivated talls WCT and TPT from adjoining states in India were found to be very close. Either these two cultivars may be one and the same or the cultivators in these regions might have applied selection in same direction. Nearer to these two cultivars was EAT32 from Nigeria. The adjacent cluster was constituted by SKGT, CALT and PHOT. The cultivar from Philippines PDLT formed a single element sub-group. Next to it are the sub-clusters constituted by WAT, JMT and GTBT; and GPNT, SLT, LFT and GBGD. However, the pattern of clustering that emerged from the partition method is slightly different for these cultivars. First of all, the cultivar SKGT (from Orissa in the eastern coast of India) was grouped along with WCT and TPT. Next, the cultivars WAT and JMT were formed as a separate group (their closeness was also evident in the dendrogram). Also, a separate group was obtained for PDLT and GTBT. The remaining members of the aforementioned sub-clusters of the dendrogram formed a separate cluster together with NDRT in the partition method (Table 4). Though GPNT, SLT, LFT and GBGD appeared to be in a single cluster, it was observed that the nearest cultivars of these were not so common. For instance, the nearest cultivars of GBGD were JVT, GPNT, MRD and MGD, and it has an appearance of an intermediate plant type than dwarf. Both GBGD and GPNT are from Andhra Pradesh in India and are extensively cultivated for tendernut purposes. The fruit weight of LFT was found to be more than in the rest of this group. Similarly the mean values of fruit characters of NDRT and AYRT (adjacent cultivars in dendrogram) were observed to be different. The D^2 matrix revealed that cultivars close to NDRT are WCT, PHOT and CALT. Both NDRT and CALT are from Goa State in Western Coast of India characterized by medium sized fruits with low %HSK/FRT.

It is interesting to note that the popular cultivars across the world (WCT, TPT, WAT, PHOT, and SLT) have almost similar fruit characters. In other words, coconut growers all over the world have selected and cultivated palms of ideal fruit type. This observation needs special mention from the viewpoint of coconut breeding as any new hybrid or introduction needs to be qualified to excel the popular talls for fruit characteristics. These results are also in support of the belief in introduction and domestication of coconut in different parts of the world. Some of the tall cultivars in the western and eastern coast of India may be of same origin but evolved to the present form of ecotype in course of continuous selection and cultivation. Also, considering the fact that coconut was introduced in the relatively recent past to Africa (N'cho *et al.*, 1993), some of the African talls might be of Indian origin (Whitehead, 1966). Also note that the practice of exchange of crops between India and Africa by Arabs was in existence for more than 3000 years (Purseglove, 1972).

All the dwarf cultivars and one semi-tall from Malaysia (MRD, MYD, MGD and SSAT) formed a cluster along with WCT01 (India), JVT (Java) and CCNT (Vietnam). These cultivars were nearer to each other except JVT, which is closer to GUAT and PNT. Villarreal and Pinero (1998) also reported the grouping of dwarf cultivars of Malaysia in to a single cluster in Mexico. It was observed that in India, the Malayan dwarfs have more fruit weight and less %HSK/FRT compared to values reported from Mexico. Unlike the dwarfs, the tall cultivars from Malaysia had shown large variability for fruit characters and were distributed among clusters that are far apart (Table 6).

Table 6. Clusters derived by following the method of partition

Cluster	Members	Intra-cluster distance
1	NWHT, NUFT, NUGT, STKT	6.5
2	WCT, TPT, EAT32, SKGT	7.9
3	NIGD, EAT33, ADOT, NLAD	6.3
4	PNT, CRD, BLIT, NIT	7.6
5	WAT, JMT	6.3
6	MRD, MYD01, SSAT, MGD, WCT01, JVT, CCNT	12.1
7	GPNT, SLT, CALT, PHOT, NDRT, GBGD, LFT	15.3

8	RKBT, GUAT, KPDT, BSIT, AGT	14.3
9	PDLT, GTBT	15.8
10	VKBT, NUQT	17.8
11	SUBD, CGD	18.8
12	SUT, GUBT	21.1
13	MLT, MVT, KTYT, KKT	27.8
14	AYRT, LMT	23.8
15	COD, BENT	32.5
16	LAGT, PLNT, SSGT, NGAT, FJT	47.9
17	RTB04, KTOD	40.1
18-28	KWGT, MLT01, PPWT, SNRT, BONT, RTMT,PNT03, SCT, LCT, CGD01	Not applicable

The tall cultivars RKBT, KPDT and AGT (all indigenous) clustered together with BSIT and GUAT (Pacific Ocean Is.) and KTYT (Indonesia). These cultivars have relatively big fruits except for BSIT. The similarity of RKBT (Andhra Pradesh) and AGT (Andaman & Nicobar Is.) for size and shape of fruit was also reported by Menon and Pandalai (1960). These two regions in India are far apart and RKBT might have been introduced to Andhra Pardesh from the Islands.

In both the methods of clustering, SUT (Atlantic Region) and GUBT (Pacific Ocean Is.) were found to be nearer. But an examination of D^2 values revealed that SUT is closer to ADOT, SLT and GUAT whereas GUBT is closer to JVT, MGD and MRD. In other words, neither of them are close to each other. This result indicates that the computational problems in the process of clustering (irrespective of algorithms), point to the need for a detailed examination of the D^2 matrix while drawing conclusions. It was observed that the two tall accessions from Guam Is. (GUAT and GUBT) were distinct. The cultivars MVT and MLT were close to each other; KKT is grouped along with this but it is closer to JVT and CCNT. In the denrogram of N'cho *et al.* (1993) too, the cultivars MLT and KKT were in adjacent clusters. Though both MLT and MLT01 are from Malaysia, the former has higher values for the fruit characteristics. The pattern of amalgamation of clusters at shorter distance had changed to larger distance after this point in the dendrogram.

The profuse bearing indigenous tall cultivars with small sized fruits, LMT and AYRT were grouped together in the partition method. It was observed that AYRT was nearer to LMT, while cultivars closer to the latter were NDRT, CALT (west coast) and SKGT (east coast of India). This kind of asymmetry in closeness among accessions was more noticeable towards the 'lower' end of the dendrogram. It is to be noted here that LMT is an Island population while the rest are from the mainland. The dwarf cultivar COD has relatively big sized nuts compared to other dwarfs while BENT, a tall cultivar from Goa (India) has smaller fruits like LMT and AYRT. All these cultivars might be of common origin. Their relationships became more apparent in the partition method than in the dendrogram.

The dwarf cultivars SUBD and CGD were found to be in one cluster. The fruit measurements of CGD01 (from Pattukottai located in the eastern coast of India) were found to be lesser than that of CGD (from western coast). In other words, these two accessions need to be treated as different which is against the suggestion of Bourdeiux (personal communication).

The cultivars LAGT and PLNT (both from Philippines) were close to each other and nearer to SSGT (Malaysia), FJT(Fiji Is.) and NGAT (Papua New Guinea). The intra-cluster distance of this group was notably high. The cultivar nearer to RTB04 was found to be KTOD but it was closer to NUFT, VKBT and BENT. The remaining 10 cultivars were found to be distinctly apart from others and need to be considered as separate populations. All of them were talls except CGD01. Among the talls, five are from the South-East Asian region (MLT01, KWGT, PPWT, SNRT and BONT) and one each from Fiji (RTMT), Seychelles (SCT), India (LCT) and Jamaica (PNT03). The cultivar LCT is an island population from Lakshadweep (India).

The pattern of clustering of coconut germplasm assemblage in India showed that the exotic cultivars retained their variability for fruit components. The accessions from the Pacific Ocean and South-East Asian regions were spread throughout the dendrogram, confirming the earlier reports that these regions offer maximum variability (Purseglove, 1972; N'cho *et al.*, 1993). The indigenous collections also offer enormous variability to be exploited in breeding. Certain pattern of similarity may also be of interest from the view point of movement of coconut germplasm across the continents.

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