

**CHARACTERIZATION OF SRI LANKAN INDIGENOUS COCONUT
(*Cocos nucifera* L.) VARIETIES FOR DIVERSITY IN QUANTITATIVE
MORPHOLOGY**

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ABSTRACT

The coconut palm, *Cocos nucifera* L. is the most important palm of the wet tropics offering a multitude of uses for the mankind. Wild relatives of coconut are non-existent and thus indigenous coconut forms provide the diversity required in breeding coconut. Coconut possesses a long history of cultivation in Sri Lanka and much less characterized and utilized indigenous varieties are found within the country. The current study aimed at characterizing 15 coconut forms found in Sri Lanka for quantitative traits and pollination behaviour. A total of 26 stem, leaf, inflorescence and fruit morphological traits were scored and analyzed using multivariate methods. Principal Component analysis revealed the traits which contributed in higher magnitudes for the observed variation. The PC plots, dendrogram and the genetic distances revealed 2 groups of coconuts giving contrary evidence to the existing classification which indicates 3 groups, tall, dwarf and intermediate coconuts. Intermediates in the existing classification were found to group along with the dwarfs. Several important correlations were also identified between traits. Results revealed a higher diversity among the indigenous coconut forms indicating the importance of multiplication, conservation and further evaluation of indigenous varieties to safeguard the diversity of them for future use in coconut breeding for diverse uses.

KEYWORDS: Indigenous coconut, Morphological characterization, Multivariate discrimination

INTRODUCTION

The coconut palm, *Cocos nucifera* L. is the most important palm of the wet tropics. It is a major plantation crop and the most extensively grown and used

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nut in the world. Coconut plays a significant role in the economical, cultural and social life of the people in the coconut growing countries. More than one half of the world's coconut production is from the South East Asia, mainly from the Philippines and Indonesia. Almost one quarter is from Asia, mainly from India and Sri Lanka. The remainder comes almost equally from American, African and Pacific regions. Coconut is both a plantation crop as well as a smallholders' crop and it remains an important crop for small farmers almost everywhere it grow. Burkill (1966) described the coconut palm as 'one of Nature's greatest gifts to man' because of its great multiplicity of uses to humankind. Coconut is also called 'The Tree of Life' as it provides food, drink, fuel and shelter to man. Coconut is mainly harvested for oil although almost every part of the palm has a use. The kernel (or the endosperm) of the nut is used to produce coconut milk and creams which are often required for cooking curries; desiccated coconut (shredded dried endosperm) for the basic raw materials in confectionaries; and copra (dried endosperm) which is used to extract coconut oil. Coconut oil is a principal raw material used in the manufacture of soap, glycerine, margarine and fatty acids in addition to its value as cooking oil. Coconut oil contains 48% lauric acid, which is used to manufacture detergents, cosmetics and pharmaceuticals. Some parts of the coconut palm, mainly the husk is also used for the production of mats, mattresses, doormats, ropes, baskets, hats and brooms while its fronds are woven into roofing materials. The trunk is made into furniture, handicrafts and building materials. An alcoholic beverage is produced from the sugary sap obtained by tapping unopened inflorescence (toddy or palm wine). Fermented toddy is the base for the coconut arrack (alcohol) and vinegar. The shell (endocarp) of the nut is used to produce activated charcoal and is polished and decorated for ornaments. Poonac (the remainder of the copra after oil is extracted) is the principal ingredient in animal feed manufacture. Due to these endless uses of the palm, coconut has been identified as a tree that can be used for the elimination of poverty in the rural communities. Consequently, the economical importance of almost all the parts of the palm warrants the investigation of morphological diversity of the coconut palm in its entirety.

The classification of coconut in the world has been highly non-standardized, resulting in different authors in different countries using different terminology of coconut. However, the major coconut classifications in the world are based on stature and breeding behaviour which categorizes coconut broadly into two groups or types; tall (also termed *typica*) and dwarf (also termed *nana*). In addition to the

tall and dwarf groups, a few intermediate groups, sometimes referred to as semi-talls or semi-dwarfs are also found. King coconut in Sri Lanka (Liyanage, 1958), Gangabondom in India (Menon and Pandalai, 1958) and Niu Leka Dwarf in Fiji (Powell, 1868; Bourdeix et al., 2005) are examples of such intermediate groups. However the King coconut classified as *aurantiaca* by Liyanage (1958) is totally different from the Niu Leka and they cannot be classified in the same group.

The first systematic classification of Sri Lankan coconut germplasm was reported in 1958 (Liyanage, 1958). In this classification Sri Lankan coconut germplasm was divided into 3 main varieties namely, *Typica* (tall), *Nana* (dwarf) and *Aurantiaca* (intermediate) mainly on the basis of stature and reproductive behaviour of the palm. Each of the main variety was found to include several different morphotypes and these were termed as forms (the vernacular names of these varieties were used as the form name also) within varieties. Liyanage (1958) identified 13 different such forms within the three main varieties and later additions were made by Wickremaratne (1984) and Perera et al. (1997) making the total number of Sri Lankan coconut forms to be 15 within the three main varieties, *Typica*, *Nana* and *Aurantiaca*.

Out of all the above mentioned varieties and forms of coconut, a single coconut form, Sri Lanka Tall (SLT) (variety *Typica*, form *Typica*) is been extensively used as planting material in Sri Lanka while dwarfs x SLT hybrids have also become a favourable choice of coconut growers. Hybrids or improved planting material are in short supply while the choice of cultivars also is limited. Out of the indigenous varieties only a few have so far been used in breeding programmes to produce improved cultivars and the shortage of improved planting material is covered by the wide scale planting of Sri Lanka Tall coconut form. As a result, a few of the indigenous varieties are widely planted in replanting programmes and many others face the threat of extinction.

Several programmes for collection and conservation of coconut germplasm have been in operation in Sri Lanka (Wickremaratne, 1984) and as a result the indigenous forms have been conserved in limited quantities in coconut field gene banks in Sri Lanka. In addition, there is a collection of Sri Lanka tall coconut accessions mainly selected by random sampling covering most of the coconut growing areas in the country. However, both morphological (Perera et al., 2009) and molecular (Perera et al., 2001) studies have revealed a rather narrow genetic

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base among the conserved tall coconut accessions comprising of Sri Lankan tall. Yet, there is a need to identify diverse sources of important traits in order to provide material for breeding coconuts for desirable traits, especially considering the diverse uses of the coconut palm. It will thus be worthwhile to characterize and evaluate the much less utilized indigenous material mainly because of the diverse visual morphology of the indigenous varieties. Molecular characterization of these conserved indigenous varieties have been reported (Perera et al., 1998) but so far no attempts have been made on identifying the diversity of quantitative traits to complement the genetic variation. Therefore the objective of this study was to characterize 14 indigenous Sri Lankan coconut forms, along with one exotic coconut form for descriptors pertaining to leaf, inflorescence, stem and fruit characters.

MATERIALS AND METHODS

Fifteen coconut forms planted in a gene bank belonging to the Coconut Research Institute of Sri Lanka were subjected for morphological characterization (Table 1). All the forms were Sri Lankan indigenous coconut forms except for San Ramon which has an exotic origin (Fernando, 1987) although it may have mixed with Sri Lankan material to a certain extent by now. The plants were 20 years of age at the time of data recording and were managed with average standard management practices for coconut.

A total of 26 descriptors listed by Bioversity International for leaf, inflorescence and fruit and nut morphology were recorded. Seven characters, namely, length of the petiole, width and thickness of the petiole (recorded at the point of leaflet origination), length of the rachis, average length and width of four leaflets, and the number of leaflets were scored as leaf morphology. Inflorescences bearing receptive female flowers were scored for 10 descriptors namely, peduncle length and the diameter at the point where spikelets initiate, length of central axis, number of spikelets with and without female flowers and the total number of spikelets, number of female flowers, female flower distribution, average length of four spikelets and the pollination behaviour. Fruit morphological characters, fresh nut weight, husked nut weight, husk weight, kernel weight, kernel thickness, fruit breadth and fruit length were measured. In addition to the above traits, stem characters, the presence/absence of the bole and the growth habit of the stem (dwarf/tall like) were scored. Data recording was done in randomly selected 30

palms per form following the sample sizes outlined in IPGRI descriptors for coconut germplasm characterization (Santos et al., 1997).

Table 1. Details of varieties/forms subjected to characterization.

Name /form	Variety	International gene bank accession code	Specific morphological feature
Sri Lanka tall (SLT)	Typica	SLT02	Common tall
Gon thembili (GT)	Typica	GTBT	Ivory coloured nuts & petioles
Porapol (PPT)	Typica	PPT	Thick shelled elongated somewhat smaller nuts
Nawasi (NWT)	Typica	NAWT	Soft mesocarp
Kamandala (KMT)	Typica	KMT	A few very large nuts per bunch
Bodiri (BDT)	Typica	BDRT	A large number of small nuts per bunch
Ran thembili (RT)	Typica	CRAT	Pink colouration under the perianth
Dikiri (DIT)	Typica	DIT	Jelly like (macapuno type) endosperm
Green dwarf (SLGD)	Nana	PGD01	Dwarf with green coloured epicarp
Yellow dwarf (SLYD)	Nana	CYD01	Dwarf with yellow coloured epicarp
Red dwarf (SLRD)	Nana	SLRD01	Dwarf with orange coloured epicarp
Brown dwarf (SLBD)	Nana	SLBD	Dwarf with brown coloured epicarp
King coconut (KC)	Aurantiaca	RTB01	Intermediate type orange coloured nuts
Rathran thembili (RRT)	Aurantiaca	RTB03	King coconuts having pink colour under the perianth
San Ramon* (SR)	Typica	SNRT01	Large palms bearing large nuts

* San Ramon is an exotic variety introduced to Sri Lanka from the Philippines in the mid 1900's.

Multivariate data analytical methods, principal component analysis and cluster analysis were performed to derive principal components, distance

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matrices, and to construct the phenetic tree for the varieties. Pearson Correlation coefficients were also derived between pair-wise coconut forms and General Linear Models Procedure and mean separation were performed to analyze the quantitative variables. Statistical software package MINITAB version 14 was used for the analysis of data.

RESULTS

Principal Component Analysis

Principal component analysis quantifies each parameter to calculate the Principal components (PCs) which help in describing the variation in the data set. The first 3 principal components (PC1, PC2 and PC3) accounted for 54.4%, 13.5% and 10% of the variation respectively accumulating to a total of 77.8% of the total variability among the coconut forms evaluated.

All the leaf characters, all fruit weight related characters together with kernel thickness recorded loadings of higher magnitudes (above 0.2) for the PC1 (Table 2). All these characters were positively correlated with PC1. Furthermore, number of female flowers, female flower distribution and number of spikelets with female flowers were negatively correlated with PC2 recording magnitudes of -0.441, -0.431 and -0.359 respectively. In addition growth habit of stem recorded a high positive loading of 0.326 for PC2.

Analysis of variance revealed significant differences among different forms for all the quantitative traits scored except for the inflorescence character peduncle diameter. Means and the standard deviations of the measured traits which contributed in higher magnitudes for PC1 and PC2 are given in Table 3. These results shows that SR, GT and RT to produce the largest nuts and SLT, RT and SR to have tall and massive crowns. Dwarfs as expected produced smaller nuts in smaller crowns.

PC Plots

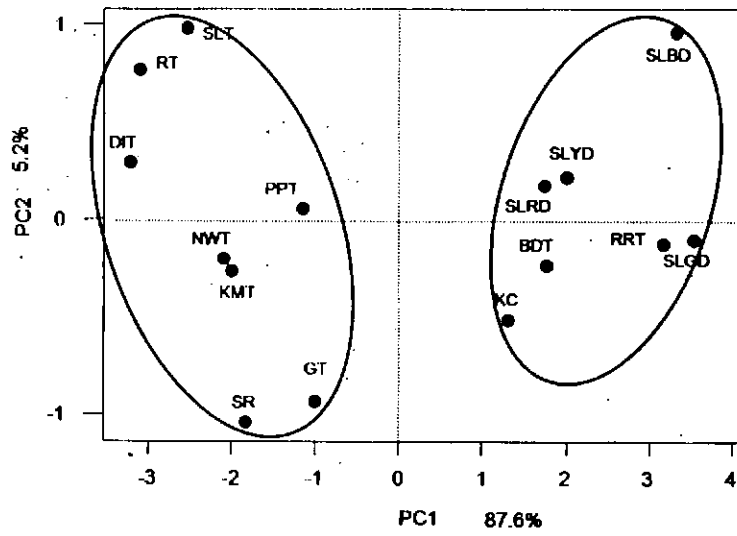
The two major PCs derived separately for leaf, inflorescence, fruit characters and for all the traits scored were plotted against each other (Figures 1a, 1b, 1c and 1d).

Table 2. Matrix of eigenvalues and vectors of principal components.

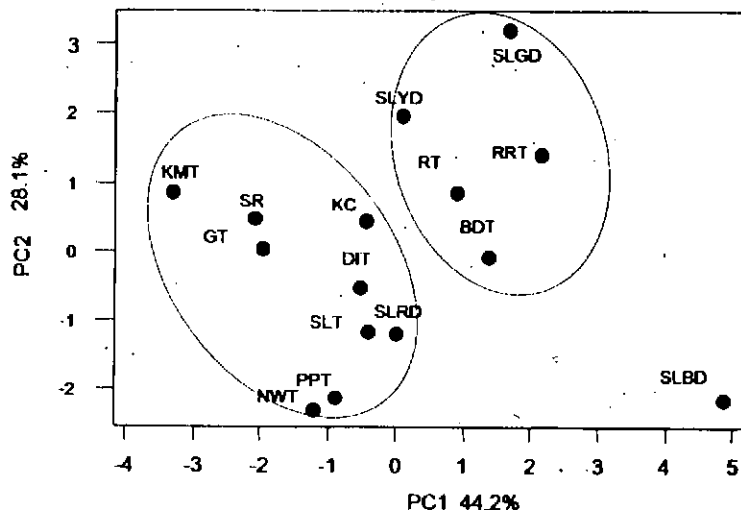
	principal components (PC)		
	PC1	PC2	PC3
Eigen values			
Variance	14.143	3.499	2.593
% individual contribution	0.544	0.135	0.1
% accumulated variation	0.544	0.679	0.788
Eigen vectors			
Petiole length (PL)	0.2	-0.25	-0.019
Petiole thickness (PT)	0.247	-0.089	-0.12
Petiole width (PW)	0.253	-0.032	-0.053
Rachis length (RL)	0.231	-0.134	-0.137
No. of leaflets (NL)	0.252	-0.034	-0.119
Leaflet width (LW)	0.234	-0.018	-0.042
Leaflet length (LL)	0.22	-0.068	-0.207
Peduncle length (Pd L)	0.151	-0.099	-0.153
Peduncle diameter (Pd D)	0.106	-0.198	0.155
Spikelets with female flowers (SWFF)	-0.145	-0.359	0.142
Spikelets without female flowers (SWOFF)	0.19	0.281	0.033
Number of female flowers (NF)	-0.11	-0.441	0.183
Length of central axis (LCA)	0.196	-0.259	-0.119
Spikelet length (SL)	0.178	-0.17	-0.303
No. of spikelets (NS)	0.125	0.008	0.27
Female flower distribution (FFD)	-0.123	-0.431	0.102
Fresh nut weight (FNW)	0.24	0.077	0.188
Husked nut weight (HNW)	0.224	0.129	0.193
Husk weight (HW)	0.215	0.009	0.153
Kernel weight (KW)	0.225	0.116	0.2
Kernel thickness (KT)	0.25	-0.04	-0.037
Fruit breadth (FB)	0.197	-0.037	0.266
Fruit length (FL)	0.178	-0.038	0.409
Presence of bole (bole)	0.15	0.131	-0.396
Pollination behaviour (PB)	-0.191	-0.079	-0.266
Stem character (tall/dwarf like) (SC)	-0.119	0.326	0.103

Table 3. Means and the standard deviations (in parenthesis) of morphological traits accounting for major portion of the diversity among coconut varieties and forms evaluated.

Form	PL	PT	PW	RL	NL	LW	LL	FNW	HNW	HW	KW	KT	NF	FFD	SWFF
SUT	164 (19.6)	3.7 (0.29)	8.3 (0.76)	574 (58.3)	225 (12.28)	5.9 (0.853)	125 (13.65)	1436 (294)	716.7 (162.7)	719.5 (209)	338.1 (71.46)	13.53 (0.994)	28.2 (13.13)	0.703 (0.337)	25.2 (9.36)
GT	121 (14.5)	3.4 (0.27)	7.9 (0.93)	492 (66.8)	227 (12.74)	5.8 (0.601)	19 (16.17)	1648 (435)	796.4 (128.5)	852 (327)	389.6 (60.2)	13.25 (1.061)	18.17 (7.67)	0.449 (0.172)	18.1 (7.65)
PPT	141 (13.9)	3.2 (0.5)	7.8 (0.67)	526 (24.81)	218 (17.63)	5.0 (0.369)	137 (15.43)	980.3 (149.2)	421.5 (38.4)	558.8 (118.1)	179 (13.94)	13.69 (0.714)	32.33 (17.46)	1.02 (0.623)	19.6 (8.76)
NWT	145 (7.9)	3.3 (0.35)	8.8 (1.23)	522 (27.07)	234 (13.22)	6.3 (0.72)	126 (8.72)	1547 (176.7)	487.4 (79)	1059 (128)	248.2 (35.7)	14.25 (1.087)	32.91 (29.94)	0.989 (0.948)	20 (10.23)
KMT	141 (14.1)	3.3 (0.37)	8.6 (0.78)	542 (53.9)	237 (12.01)	5.9 (0.547)	127 (16.95)	2629 (380)	1359 (321)	1270 (190.1)	593.8 (96.6)	15.82 (1.501)	10.6 (8.54)	0.274 (0.217)	10.6 (8.54)
BDT	111 (36.8)	2.6 (0.29)	6.3 (0.7)	467 (47.5)	204 (10.34)	4.4 (0.603)	114 (11.1)	711.3 (177.8)	359.9 (35.5)	351.4 (158.9)	209.8 (41.7)	10.8 (1.103)	28 (22.74)	0.957 (0.711)	24.6 (20.72)
RT	162 (8.1)	3.2 (0.22)	8.7 (0.57)	581 (25.57)	227 (18.34)	6.9 (0.41)	137 (8.33)	1380 (160.1)	911.2 (95.7)	469 (90.7)	401.2 (40.2)	13.12 (1.371)	22 (11.91)	0.683 (0.266)	20.8 (9.86)
DIT	157 (16.3)	3.7 (0.13)	8.5 (0.62)	579 (50.9)	235 (21.2)	6.3 (0.53)	139 (9.19)	1622 (118.1)	915.2 (111.5)	706.8 (71.1)	454.8 (38.5)	14.12 (1.289)	21.5 (0.707)	0.751 (0.134)	18 (2.83)
SLGD	102 (23.3)	2.3 (0.5)	5.6 (0.85)	410 (53.2)	183 (53.1)	4.5 (0.504)	107 (11.05)	5851 (109.2)	243.5 (41)	341.6 (78.2)	130.5 (12.81)	9.74 (0.67)	17.04 (9.24)	0.652 (0.327)	15.4 (7.41)
SLYD	114 (21)	2.6 (0.39)	6.2 (0.84)	445 (74.7)	189 (11.06)	5.2 (0.724)	105 (14.24)	909.9 (73.8)	489.2 (52.3)	420.7 (24.55)	241.9 (24.75)	11.31 (0.673)	17 (11.45)	0.492 (0.303)	16.5 (10.77)
SLRD	117 (5.22)	2.5 (0.21)	6.6 (0.6)	451 (22.76)	182 (7.85)	4.7 (0.366)	121 (5.94)	1080 (98.4)	566.1 (58.4)	513.6 (43.9)	293 (25.24)	12.4 (0.81)	27.63 (16.67)	0.739 (0.379)	23.6 (8.97)
SLBD	125 (5.74)	2.3 (0.36)	5.5 (0.45)	411 (27.98)	181 (12.48)	4.2 (0.344)	94.5 (9.86)	1044 (251.4)	567.9 (158)	475.8 (148.6)	221.9 (49.26)	9.781 (1.111)	64.4 (51.39)	1.974 (1.486)	29.8 (5.71)
KC	114 (8.38)	2.9 (0.27)	7.4 (0.52)	444 (23.07)	206 (3.94)	4.8 (0.562)	106 (8.64)	1074 (262)	692.4 (189.3)	381.8 (131.4)	285.5 (54.02)	10.28 (1.026)	20.9 (5.78)	0.564 (0.14)	20.7 (5.68)
RRT	87 (15.2)	1.7 (0.52)	6.3 (0.76)	329 (42.7)	179 (14.19)	2.9 (0.144)	90.4 (13)	851.4 (118.7)	408.8 (50.1)	456.3 (69)	190.4 (29)	9.644 (0.736)	26 (2.65)	0.744 (0.017)	26 (2.65)
SR	130 (16.1)	3.3 (0.26)	8.8 (1.04)	507 (39.85)	241 (23.19)	5.9 (0.693)	131 (16.2)	1762 (221.6)	931.6 (224.5)	829.9 (99)	449.1 (113.7)	13.7 (2.149)	17.15 (11.19)	0.459 (0.289)	15.6 (9.03)

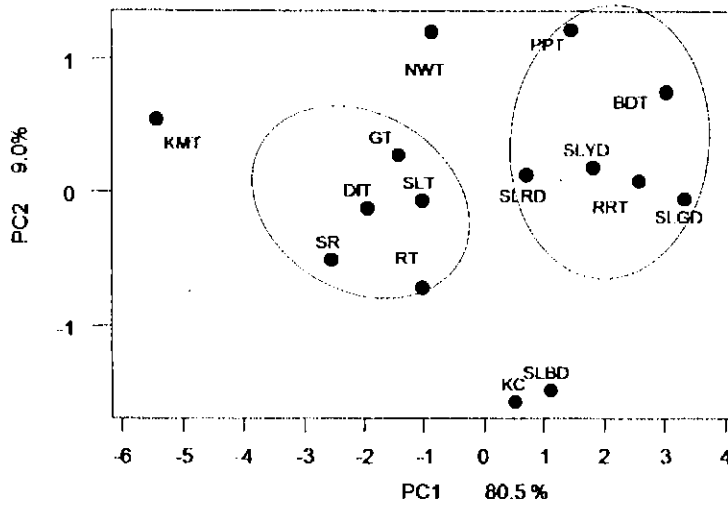


1a

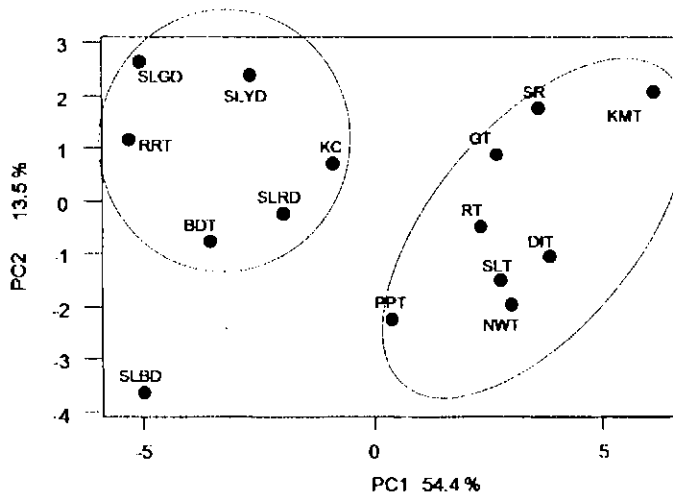


1b

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1c



1d

Figure 1a. PCO plot for leaf characters; 1b. PCO plot for inflorescence characters; 1c. PCO plot for fruit characters; 1d. PCO plot for all the traits scored.

PC plot for leaf characters indicates a clear distinction of the coconut forms into 2 groups, the tall group and the dwarfs combined with the intermediate forms, KC and RRT (Figure 1a). However, BDT which is categorized as a tall grouped within the combined group of the dwarfs and intermediates. A wider dispersion was observed among the tall group while the dwarfs and intermediates clustered more closely together except for SLBD which separated out from the rest. When considering the inflorescence morphology the same separation of the 2 groups was observed but with less distinction, with the locations of RT, SLRD, & KC preventing a clear separation (Fig 1b). The dwarf & intermediate group was more spread out with respect to inflorescence characters while both SLGD and SLBD detaching out from the group. When the same grouping is applied to the fruit morphology KMT, NWT and PPT from the tall group and KC together with SLBD fell out from the combined group of dwarf and intermediates (Fig 1c). The score plot for all the scored traits displays the grouping of tall separately from the dwarf group including intermediates also (Fig 1d). However these forms show more of a dispersed distribution rather than forming congested clusters. Here also the SLBD was observed to locate further away from the rest of the dwarf group.

Phenetic tree

Phenetic tree derived based on Euclidean distances is presented in Figure 2. The dendrogram given in Figure 2 displays the relative positions of coconut forms based on the morphological characters scored. It is shown that RT, SLT, KMT, GT and exotic SR formed the major tall group while SLRD, SLYD, SLGD & KC formed the dwarf & intermediate group. SLBD, and RRT in the dwarf & intermediate group and PPT, DIT, BDT and NWT in the tall coconut group were located out of their respective groups indicating considerable variation in quantitatively measured traits in addition to their visually distinguishable specific features which are listed in Table 01. Exotic SR which bears large nuts formed a sub cluster with indigenous GT and this sub cluster was closely related to KMT which produces the largest fruits out of all the indigenous varieties. SLYD and SLGD both of which are currently used in the hybrid production are the closest among the dwarfs and these two forms were closer to KC (which is termed as an intermediate) than SLRD (which is a dwarf).

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Distance matrix

Pairwise distance matrix (Table 04) reveals KMT to have the greatest distance from the rest of the forms. GT was identified as the closest form for the exotic SR as is revealed in the dendrogram too.

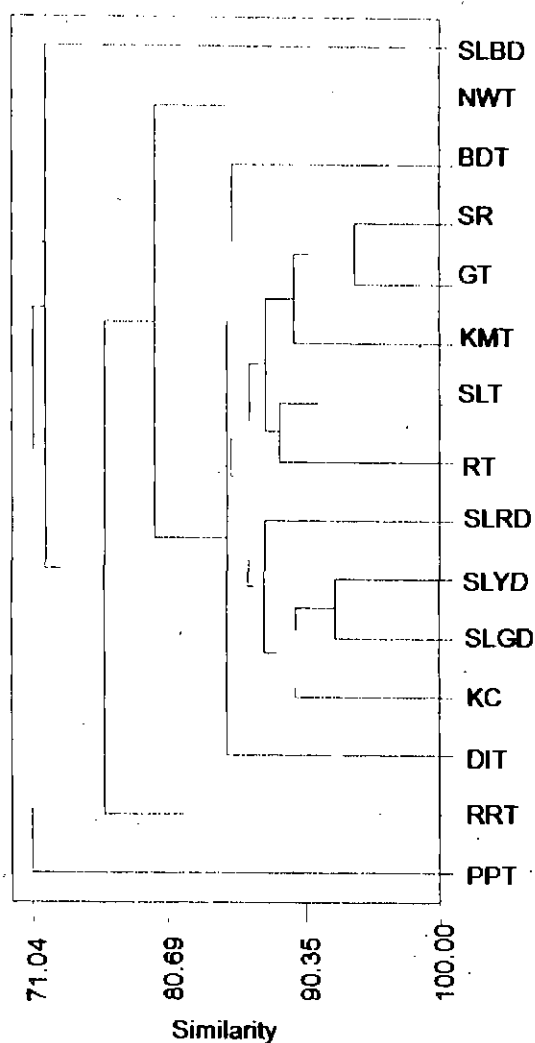


Figure 2. Dendrogram based on Euclidean distances.

Table 04. Pair-wise distance matrix among the coconut forms based on the scored morphological traits

	RRT	DIT	KC	SLGD	RT	SLYD	SLRD	KMT	PPT	GT	BDT	NWT	SR	SLBD	SLT
RRT	0														
DIT	1022	0													
KC	147.6	506.4	0												
SLGD	115.45	1801.7	468.9	0											
RT	615.2	118.5	185.3	1203.9	0										
SLYD	15.9	839.9	72.4	186.1	450.7	0									
SLRD	93.7	501.1	34.4	407.5	244.5	46.6	0								
KMT	4914	1550	3758.4	6522.8	2442.1	4571.3	3704.8	0							
PPT	47.9	757.6	134.4	256.5	461.8	43.3	54.5	4277.5	0						
GT	993.1	49.5	575.5	1773.8	241.9	851.9	503.9	1498.7	719.4	0					
BDT	38.8	1341.1	250.2	40.7	819.5	63.8	212.9	5676.9	126.2	1353.2	0				
NWT	877.3	359.9	734.9	1532.3	584.6	824.4	533.4	2097.3	581.3	171.1	1222.4	0			
SR	135.5	41.3	763.7	2213	285.7	1139.8	730.4	1151.4	1019.1	35.8	1720.9	337.9	0		
SLBD	7.1	936.1	144.4	155.2	574.2	20.7	73.9	4696.2	31.8	894.5	64.4	763.9	1219.3	0	
SLT	563.8	88.5	268.9	1168.5	108.2	449	213.6	2206.5	349.8	80.4	820.6	192.2	182.9	492	0

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Both BDT and PPT showed closer distances to dwarfs than the talls although these are traditionally classified as talls based on the stature and breeding behaviour. However, the current study provides evidence for these two forms to have closer links with the dwarfs and intermediates than the talls. NWT and DIT which are the remaining 2 forms which separated out from the main tall group show considerable distances from the rest of the forms evaluated explaining their location on the dendrogram.

Correlation

Pearson correlation coefficients among the quantitative traits are presented in Table 5. Highly strong positive correlations (>0.8) were observed between many leaf related traits. Out of the inflorescence traits CAL & SL and FFD & NF were positively correlated. Several of the fruit characters (mainly FNW) also showed strong positive correlations with other fruit traits. A strong positive correlation was observed between CAL & PT which are 2 traits representing different morphologies inflorescence and leaf. The most important observation was the strong positive correlation of the fruit trait KT with many of the scored leaf characters (PT, PW, RI, NL, LW & LL). Furthermore positive correlation with less magnitude (>0.657) were observed between the KW and PT (0.684), PW (0.726), RI (0.657), NL (0.731) and LW (0.698) which are all leaf related traits that contribute to the size of the crown.

DISCUSSION

This characterization helps identifying the economically important forms of coconuts with respect to the sizes and weights of the palms and nuts. Furthermore, the genetic distances revealed will help in selecting parents for hybridization in order to achieve maximum heterosis by crossing genetically distant forms rather than the close forms. Moreover, the correlation of characters will also be useful in coconut breeding for the identification of elite palms. The worldwide classification of coconut is mainly based on the stature and pollination behavior while the differentiation of forms within varieties in Sri Lanka is based on the specific qualitative morphological features of such forms. In this study, mainly the quantitative traits related to leaf, inflorescence, stem and fruit morphology were studied. Both quantitative and qualitative morphological differences are

Table 5. Correlation matrix among the measured traits.

	PL	PT	PW	RL	N L	LW	LL	Pd L	Pd D	SW FF	SW OFF	N F	CAL	SL	NS	FFD	FN W	HN W	HW	KW	KT	FB	FL	Bole
PT	0.8																							
PW	0.8	0.9																						
RL	0.9	0.9	0.9																					
N L	0.7	0.9	1.0	0.9																				
LW	0.8	0.9	0.9	0.9	0.9																			
LL	0.7	0.9	0.9	0.9	0.8	0.8																		
Pd L	0.3	0.6	0.5	0.4	0.7	0.4	0.4																	
Pd D	0.4	0.3	0.4	0.3	0.2	0.3	0.5	0.2																
SWFF	-0.1	-0.4	-0.4	-0.3	-0.5	-0.5	-0.4	-0.2	0.0															
SWOFF	0.2	0.6	0.6	0.4	0.6	0.5	0.5	0.4	0.3	-0.8														
N F	0.0	-0.3	-0.4	-0.3	-0.4	-0.4	-0.4	-0.1	0.2	0.8	-0.7													
CAL	0.7	0.8	0.7	0.7	0.7	0.6	0.7	0.6	0.7	-0.2	0.4	0.0												
SL	0.5	0.7	0.7	0.7	0.8	0.5	0.8	0.6	0.4	-0.3	0.4	-0.1	0.8											
NS	0.2	0.4	0.5	0.2	0.3	0.2	0.2	0.2	0.5	0.0	0.6	-0.1	0.4	0.3										
FFD	0.0	-0.4	-0.4	-0.3	-0.4	-0.4	-0.4	-0.1	0.1	0.7	-0.8	1.0	0.0	-0.1	-0.3									
FNW	0.6	0.7	0.8	0.7	0.8	0.7	0.6	0.5	0.3	-0.6	0.8	-0.4	0.5	0.4	0.5	-0.5								
HNW	0.5	0.7	0.7	0.7	0.7	0.7	0.6	0.3	0.2	-0.5	0.7	-0.5	0.4	0.3	0.4	-0.5	0.9							
HW	0.5	0.6	0.7	0.5	0.7	0.6	0.5	0.6	0.4	-0.5	0.7	-0.2	0.6	0.5	0.5	-0.3	0.9	0.7						
KW	0.5	0.7	0.7	0.7	0.7	0.7	0.6	0.4	0.3	-0.5	0.6	-0.5	0.4	0.3	0.4	-0.5	0.9	1.0	0.7					
KT	0.7	0.9	0.9	0.9	0.9	0.8	0.9	0.6	0.6	-0.5	0.7	-0.3	0.8	0.7	0.4	-0.4	0.9	0.7	0.8	0.8				
FB	0.6	0.7	0.7	0.5	0.7	0.6	0.4	0.3	0.3	-0.3	0.5	-0.1	0.5	0.3	0.5	-0.2	0.7	0.7	0.6	0.7	0.6			
FL	0.6	0.5	0.6	0.5	0.6	0.6	0.3	0.2	0.3	-0.2	0.4	0.0	0.3	0.1	0.4	-0.1	0.8	0.8	0.7	0.8	0.6	0.8		
bole	0.4	0.7	0.6	0.6	0.7	0.6	0.5	0.4	-0.2	-0.7	0.5	-0.6	0.4	0.5	-0.1	-0.5	0.3	0.3	0.3	0.3	0.5	0.3	0.0	
PB	-0.6	-0.6	-0.7	-0.6	-0.6	-0.8	-0.4	-0.3	-0.2	0.3	-0.5	0.3	-0.3	-0.1	-0.4	0.4	-0.8	-0.7	-0.7	-0.7	-0.6	-0.7	-0.8	-0.2
SH	-0.6	-0.6	-0.4	-0.6	-0.5	-0.4	-0.4	-0.5	-0.1	-0.1	0.0	-0.3	-0.6	-0.5	-0.1	-0.3	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4	-0.5	-0.4

CHARACTERIZATION OF INDIGENOUS COCONUT

immensely important in characterization and evaluation of germplasm.

Currently accepted classification of indigenous coconuts in Sri Lanka include the 3 groups tall, dwarfs and the intermediate group based on the major varietal differences recorded. However, the current study with quantitative traits gives evidence for certain deviations from the above grouping. Accordingly, two coconut groups, tall and dwarf are identified by quantitative measurements with respect to the leaf characters while this grouping was less evident either with inflorescence or fruit morphological traits. However, the same broad grouping could be observed when all the traits are considered simultaneously with several coconut forms falling out of their respective groups.

Characterization of Sri Lankan indigenous coconut varieties using 8 pairs of AFLP markers (Perera et al., 1998) revealed that grouping of tall and dwarf separately with intermediates grouping along with the dwarf. The findings of this study basically agree with the results of the AFLP marker characterization, mainly with the grouping of coconuts from the previously classified intermediate group along with the dwarf group. Therefore, the molecular study of Perera et al., (1998) and this study provide contrary evidence to the existing classification of coconut which separated out an intermediate group of coconut between tall and dwarf groups. The tall stature and root bole formation resembling tall coconuts and the self pollinating behavior resembling dwarf coconuts was the basis for placing king coconut in the intermediate group. However, as mentioned above, the molecular data and the quantitative data relating to leaf, inflorescence and fruit morphology identifies the intermediate king coconut within the dwarf group.

Perera et al. (2009) reported the grouping of tall and dwarf coconuts separately in a study of morphological characterization of conserved coconut accessions of Sri Lankan tall along with a few Sri Lankan and exotic dwarf accessions. The current study demonstrated the outgrouping of certain tall and dwarf forms from their respective groups. Therefore the current study identifies both tall and dwarf forms which differ greatly from the rest of the forms of tall and dwarf coconut varieties respectively indicating a higher morphological diversity of indigenous coconut varieties compared with the commercially grown Sri Lankan tall coconuts.

Each of the different forms especially within the tall group of coconut possesses a specific morphological difference as given in table 01. These features combined with the important variation in quantitative morphological traits,

especially in fruit morphology will be of use in improving coconuts for the multitude of diverse uses including food and beverage, industrial and ornamental uses of the coconut palm. Multiplication and conservation of these less perceived indigenous coconut forms should be simultaneously undertaken to prevent the erosion of important genes which are responsible for the displayed diversity among the indigenous coconut material. Coconut is a crop of which the wild relatives are nonexistent and thus the indigenous forms are the only source of diverse genes which are very important in crop improvement programmes. This fact coupled with the narrow genetic base of cultivated tall coconuts in Sri Lanka as revealed by Perera et al. (2001) reiterates the need for focusing more attention on the indigenous coconut forms found in Sri Lanka. Certain indigenous varieties and phenotypes of coconuts are reported in other countries where coconuts have been growing over a long time. Macapuno coconuts and, aromatic beverage coconuts found in the South Eastern region, prolific bearers such as Laccadive micro tall in India are some examples for such indigenous varieties. Evaluation of such material also for diversity with respect to quantitative traits may reveal important distinctions which will be vital for identifying material for breeding coconuts for diverse uses.

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