



Assessment of diversity in coconut varieties for drought responsive physiological traits

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Coconut is an important perennial crop of humid tropics. Genetic improvement of coconut has been enhanced by utilization of germplasm. Utilization of germplasm could be made effective by broadening the knowledge on diversity. In coconut, morphometric traits (Sugimura *et al.*, 1997), biochemical (Cardena *et al.*, 1998) and molecular markers (Meerow *et al.*, 2003) were used to understand the diversity.

Drought is a major limiting factor in coconut cultivation. Both atmospheric and soil factors are found to influence the crop in its productive features. Physiological (stomatal resistance- s_r , leaf water potential- ψ_{leaf} and transpiration rate- E) and biochemical parameters (epicuticular wax content- ECW) were used to screen coconut cultivars/ hybrids for tolerance to drought. Based on the ranking given to each trait, the cultivar/ hybrids were categorized into moderately susceptible and tolerant types (Rajagopal *et al.*, 1990). However, diversity of coconut varieties for drought responsive traits is not understood. Hence, an attempt was made to understand (a) the diversity pattern in coconut varieties based on the stress sensitive traits such as s_r , E , ψ_{leaf} and ECW content and (b) the most important trait contributing to diversity.

Observations on the stress sensitive traits were recorded on 22 year old coconut cultivars/ hybrids belonging to eleven Talls, five Dwarfs and seven Hybrids (listed in Table 1) growing under recommended uniform cultural management in rainfed conditions. All the observations on the stress sensitive traits were taken in the 11th leaf during summer months. The s_r and E were determined with a Steady State Porometer as standardized by Rajagopal *et al.* (1986). ψ_{leaf} was determined using Scholanders' Pressure Chamber (Plant

Water Consol, Model 3000, Soil Moisture Co., USA) as standardized by Milburn and Zimmermann (1977) and Rajagopal *et al.* (1987). ECW was extracted from the leaf lets using the method of Ebercon *et al.* (1977). The data was subjected to principal component analysis and cluster analysis using non-hierarchical Euclidean clustering procedure (Adams and Wiersma, 1978).

Clustering

The results indicated that 23 varieties/hybrids could be classified into 5 major groups based on clustering analysis (Table 1). Only three dwarf varieties MOD, MYD and GBDG formed a separate cluster. Grouping of varieties did not follow any pattern of geographical affinity, botanical form (Tall / Dwarf) or variety / hybrid, but was found to be directly related to nature of the tolerance to drought. Rajagopal *et al.* (1990) have reported the drought susceptible nature of the three dwarf varieties, grouped in the third cluster and the drought tolerant nature of the cultivars/ hybrids in the fourth cluster. Inter and intra cluster distances involving the 23 cultivars/ hybrids indicated minimum distance between the cultivars/ hybrids falling in cluster I. Inter cluster distances indicated maximum distances between III and the IV clusters as well as between IV and V clusters. When the clusters were compared for divergence, the third cluster containing all three susceptible dwarf varieties was found far away from other clusters (Table 2). Among the clusters differing by maximum distance (III and IV), the differences in cluster means were substantially high for ECW (Table 3). Cluster III with the drought susceptible cultivars had low ECW content ($82.22 \mu\text{g cm}^{-2}$) while cluster IV with drought tolerant cultivars showed high ECW content ($116.71 \mu\text{g cm}^{-2}$).

Table 1. Composition of cluster groups of 23 coconut varieties/ hybrids

Cluster Number	Varieties / hybrids
I	WCT, LMT, PHOT, JVGT, COD x COD
II	SSAT, ADOT, FMST, FJT, COD, WCT x GBGD
III	MOD, MYD, GBGD
IV	AGT, WCT x COD, WCT x WCT, LCT x GBGD, LCT x COD
V	CCNT, SSGT, MGD, COD x WCT

(Talls: WCT- West Coast Tall, LMT- Laccadive Micro Tall, PHOT- Philippines Ordinary Tall, JVGT- Java Giant Tall, SSAT- SS Apricot, ADOT- Andaman Ordinary Tall, FMS- Federated Malay States Tall, FJT- Fiji Tall, AGT- Andaman Giant Tall, CCNT- Cochin China Tall, SSGT- Strait Settlement Green Tall, Dwarfs: COD- Chowghat Orange Dwarf, GBGD- Gangabondam Green Dwarf, MOD- Malayan Orange Dwarf, MYD- Malayan Yellow Dwarf, MGD- Malayan Green Dwarf, Hybrids: WCT x WCT, WCT x GBGD, WCT x COD, COD x WCT, LCT (Laccadive Ordinary Tall) x COD, LCT x GBGD, COD x COD)

Table 2. Inter and intra (diagonal) cluster distances involving 23 coconut varieties/ hybrids

	I	II	III	IV	V
I	0.707				
II	1.911	0.982			
III	2.795	3.350	0.950		
IV	2.117	2.239	4.765	1.056	
V	1.906	1.890	2.098	3.509	0.907

Table 3. Cluster means of drought sensitive physiological traits in coconut

Cluster group	sr (s cm ²)	E (μg cm ⁻² s ⁻¹)	ψ_{leaf} (-bars)	ECW (μg cm ⁻²)
I	7.03	2.67	11.43	100.39
II	6.19	2.78	11.48	102.31
III	4.04	4.39	14.90	82.22
IV	10.93	1.93	12.18	116.71
V	4.57	4.32	12.99	103.34
SD	2.73	1.09	1.44	12.32

Principal component analysis

Principal Component analysis attempted on 23 varieties/hybrids using the four physiological parameters (Table 4) revealed that PC1 axis covered 66% of variation. In this axis, characters such as ECW and sr recorded high factor loading of 0.736 and 0.563 respectively. PC2 axis contributed 19% of variation. Here again ECW continues to record high factor loading of 0.646 and sr recorded -0.555 factor loading. These two axes together contributed to nearly 85% of variation. This implies that these two parameters viz., ECW and sr are very important traits discriminating drought tolerant and susceptible varieties. ψ_{leaf} could be the third important criteria, because factor loading in PC1 is low (-0.307) but there is high factor loading in PC2 (0.523).

Based on the low factor loadings in PC1 and PC2, E seems to be less important in classifying coconut varieties based on drought responsive physiological traits.

Table 4. Latent roots and vectors of physiological traits in coconut

Trait	PC1	PC2	PC3	PC4
sr	0.563	-0.555	-0.374	0.485
E	0.217	-0.012	0.883	0.416
ψ_{leaf}	-0.307	0.523	-0.270	0.748
ECW	0.736	0.646	-0.086	-0.181
Eigen root	2.653	0.764	0.428	0.154
Contribution	66.33	19.11	10.71	3.85
Cumulative contribution	66.33	85.44	96.15	100

Leaf to air vapour pressure deficit, light saturated photosynthesis and stomatal conductance of same variety were found to significantly vary between locations differing in temperature and humidity levels (Rajagopal *et al.*, 2000, Gomes *et al.*, 2002). In coconut, Rajagopal *et al.* (1990) have observed higher sr and ECW content in the drought tolerant types than susceptible types. A positive correlation between these traits and yield was also reported (Rajagopal *et al.*, 1992). Kasturi Bai *et al.* (1996) also have established the importance of both sr and ECW content in the evaluation of coconut cultivars/ hybrids for higher dry matter production. The above observations clearly imply that sr and ECW content are important traits for higher drought tolerance, yield and dry matter production in coconut. The importance of sr (Jones, 1985) and ECW content (Blum, 1975) on water use efficiency (WUE) has already been established in crop plants. Alkane distribution of ECW and its contribution has been used as a diagnostic trait in the taxonomy of Velloziaceae, a South American tropical monocot (Salatino *et al.*, 1989). Composition and morphology of epicuticular wax crystalloids has also been used in understanding evolution and taxonomy (Meusel *et al.*, 1994). Although, the expression of physiological traits are influenced by weather variables (Kasturi Bai *et al.*, 1988; Rajagopal *et al.*, 2000 and Gomes *et al.*, 2002) the present study established that among the drought sensitive parameters studied both sr and ECW are important variables, which contribute to diversity. Earlier studies grouped the varieties based on their geographical origin, plant habit (Tall/ Dwarf) etc. (Ratnambal *et al.*, 2002). The present study has given a line of information that in coconut, grouping could also be formed based on their tolerance to stress when appropriate traits are specifically used in diversity analysis.

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