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Chlorophyll fluorescence, stomatal conductance and yield of cashew germplasm from three agro-climatic regions of South India

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Cashew is a native of northern part of south America and introduced into India in 16th century. It has gained economic importance because of its export potential. In west and east coast regions, cashew is gown under rainfed conditions. There is long spell of dry season during summer extending from 3 to 6 months. Photosynthetic studies on cashew was first reported by Balasimha (1991). The effect of leaf position, irradiance and environmental parameters were described. The photosynthetic rate (Pn) was studied in cashew in relation to plant density (Balasimha and Yadukumar, 1993), leaf position and radiation (Palanisamy and Yadukumar, 1993). Influence of leaf age and branch girdling (Schaper and Chacko, 1993); effects of drying and irrigation on gas exchange (Schaper *et al*., 1996; Blaikie *et al*., 2001) have been studied in Australia. In Brazil, photosynthetic responses to varying environmental conditions in young cashew plants are studied (Pereira de Souza *et al*., 2005). However, there is no information on whether there are genetic differences in their drought tolerant behavior among the accessions in varying agro-climatic regions. The proposed study will help to understand genetic diversity among cashew collections in relation to physiological characters that are responsive to drought conditions. The cluster analysis and principal component analysis will give a better understanding of the relations of these characters.

A total of 188, 168 and 96 accessions of cashew (*Anacardium occidentale* L) from the germplasm holding of RRS, Vriddachalam., DCR, Puttur and ARS, Chinthamani were selected for the study. The trees from each accession were used for measurements during summer season (April-May) 2005 and 2006. Stomatal conductance was measured using Porometer (Model AP 4, Delta-T Devices, UK). Chlorophyll fluorescence parameters were measured with Plant Efficiency Analyzer (Hansatech Instruments, USA). Epicuticular wax (EW) was removed from the leaf surface by dipping for brief period in acetone. Acetone was then evaporated and colour developed using dichromate reagent which was read at 460 nm in a spectrophotometer. Specific leaf weight (SLW) was measured by oven drying specified leaf area and weighed. Annual yield of all accessions collected during these two years were used for the study.

The rainfall patterns showed distinct pattern in the three regions (Fig.1). Although the rainfall was high at Puttur, the dry period was long. However, the rainfall patterns were well distributed in other regions viz., Vriddachalam and Chinthamani. Vriddachalam represents east coast while Puttur is located in west coast. Chinthamani is situated more or less in the middle of the peninsula. The physiological characters like stomatal conductance and chlorophyll fluorescence indices showed similar trend in these regions when overall means were compared (Fig.2, 3). However, there were significant variations in various characters including yield among the accessions. These responses of cashew accessions demonstrate high adaptability to dry environments. Since cashew is adapted to semi-arid conditions, even under water deficits, relatively high stomatal conductance was observed. The possible mechanism may be that plants are able to retain high leaf

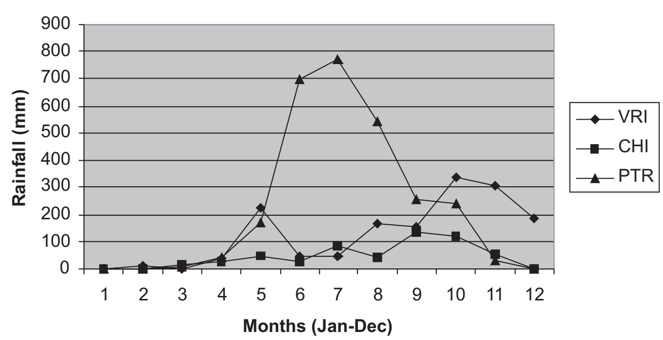

Fig.1 . Mean rainfall data for the three locations during the experimental period

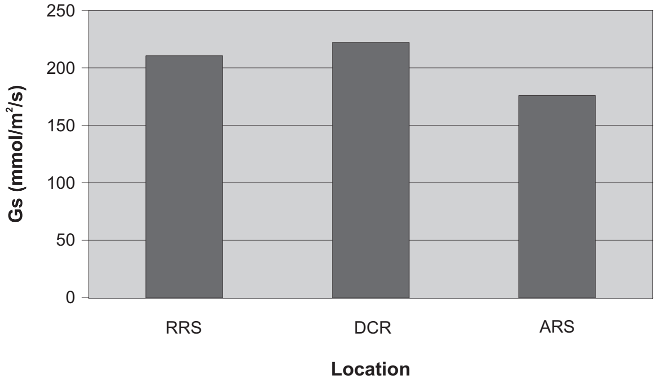

Fig. 2. Mean stomatal conductance in cashew at three locations

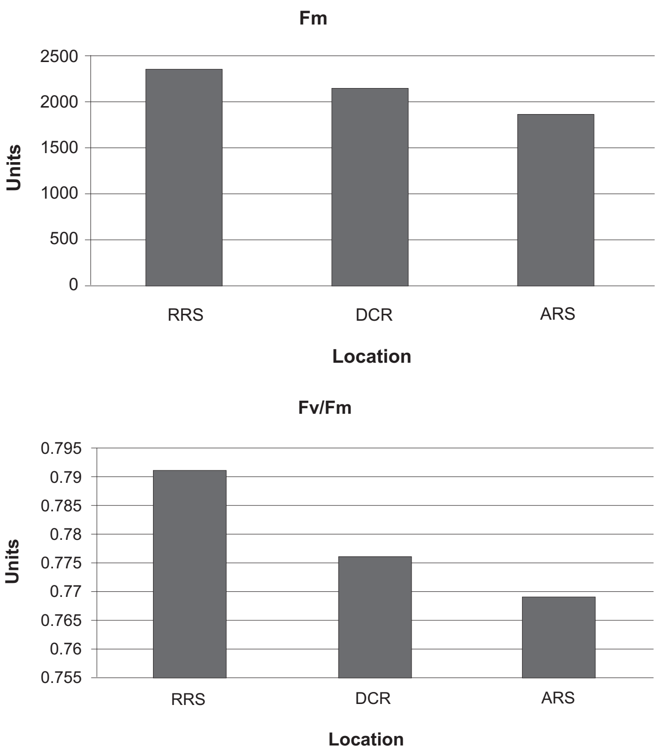

Fig.3 . Chlorophyll fluorescence characters (Fm and Fv/Fm) in cashew at three locations

turgor due to very deep rooted system in cashew, similar to that reported for coffee (Pinheiro *et al.*, 2005).

The epicuticular wax contents of cashew showed wide differences ranging from 65 to 202 μg/cm². There were also significant variations in Specific Leaf Weight among the accessions at Puttur. These parameters are also contributing factors for drought tolerance and higher values are positive traits. Thus, these results show an understanding of cashew physiology that will help in developing new cultivars with superior performance.

The data of six traits at Vriddachalam and Chinthamani and eight traits at Puttur were subjected to cluster analysis. Hierarchical classification was done separately for the three locations. A total of seven groups could be resolved for RRS germplasm (Table 1). Significant variations in fluorescence indices and yield could be resolved among the 188 accessions. Among the DCR accessions six clusters were obtained (Table 2). Yield, Fv, Fm and Fv/Fm parameters differed significantly between clusters. The cluster five with the two accessions M 44/3 and Brazil has highest yield. Similar analysis in Chinthamani accessions also showed six distinct clusters (Table 3). There was significant differences as far as yield was considered with the accessions 5/37 (U-4) and V5, which fell in 4th cluster having highest yield. The highest yielders were grouped in cluster 1 at RRS. The highest yielder in this group is TAF-13.

Table 1. Group means of clustering of physiological traits in RRS, Vriddachalam

	Clusters						
	1	2	3	4	5	6	7
N	1	77	11	84	1	13	1
Fo	374	448	420	505	695	497	548
Fm	1658	2095	1710	2582	2247	2410	2282
Fv	1284	1648	1290	2085	1552	1913	1734
Fv / Fm	0.77	0.78	0.74	0.80	0.72	0.79	0.76
Gs (mmol/m²/s)	287	205	172	199	234	354	421
Yield (g/plant)	3355	2727	2498	2679	2110	2780	1998

Table 2. Group means of clustering of physiological traits in DCR, Puttur

	Clusters					
	1	2	3	4	5	6
N	103	54	7	1	2	1
Fo	463	440	464	423	460	495
Fm	2274	1881	2154	2016	1753	2699
Fv	1815	1430	1693	1593	1294	2204
Fv / Fm	0.792	0.748	0.777	0.785	0.701	0.813
Wax (mg/cm²)	0.123	0.136	0.124	0.413	0.111	0.097
SLW (g/cm²)	0.011	0.010	0.049	0.009	0.010	0.008
Gs (mmol/m²/s)	208	237	222	152	152	87
Yield (g/plant)	4563	4825	5229	3817	9956	6158

Table 3. Group means of clustering of physiological traits in ARS, Chinthamani

	Clusters					
	1	2	3	4	5	6
N	85	2	1	2	5	1
Fo	401	382	668	384	430	485
Fm	1826	1303	2277	1697	1966	2512
Fv	1423	855	1609	1314	1536	2027
Fv / Fm	0.77	0.69	0.75	0.77	0.77	0.80
Gs (mmol/m²/s)	171	192	115	134	276	112
Yield (g/plant)	6141	5667	7583	26458	8317	4333

The mean yield of three locations indicated that highest yield was recorded at ARS followed by DCR and RRS accessions (Fig.4). These clearly indicate yield variations influenced by agro-climatic regions.

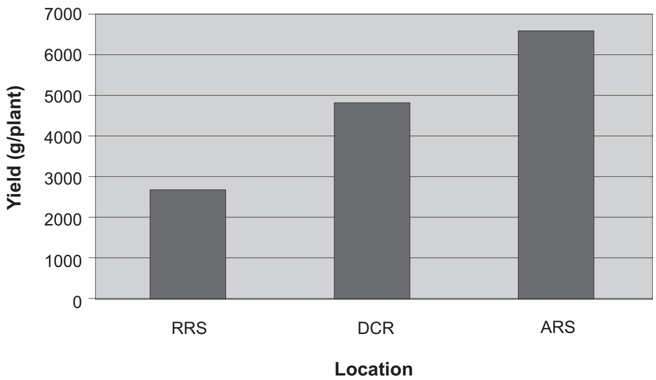

Fig. 4. Mean yield in cashew at three locations

The principal component analysis (PCA) of RRS germplasm showed that 84 % of the total variation was explained by the first three principal components with first contributing 49 % (Table 4). The characters Fv, Fm, F0 and Fv/Fm with high coefficients in the first component are the important discriminating characters.

Table 4. First three principal components of RRS, Vriddachalam

	PC1	PC2	PC3
Fo	-0.42	0.43	0.39
Fm	-0.58	0.02	0.08
Fv	-0.58	-0.07	0.03
Fv / Fm	-0.39	-0.46	-0.40
Gs (mmol/m^2/s)	-0.09	0.28	-0.80
Yield (g/plant)	0.01	-0.72	0.18
%Variance	0.49	0.18	0.17
Cumulative	0.49	0.67	0.84

The yield in the second component and Gs in the third component have comparatively high coefficients and they are also important characters in discrimination.

The PCA of DCR, Puttur showed that 65 % of the total variation was explained by the first three principal components with first contributing 37 % (Table 5). The characters Fv, Fm, Fv/Fm and F0 with high coefficients in the first component are the important discriminating characters. The SLW in the second component has comparatively high coefficient and this is also an important character in discrimination.

Table 5. First three principal components of DCR, Puttur

	PC1	PC2	PC3
Fo	-0.31	-0.01	-0.60
Fm	-0.57	-0.02	-0.03
Fv	-0.57	-0.01	0.05
Fv / Fm	-0.46	0.04	0.35
Wax (mg/cm^2)	0.17	-0.23	-0.31
SLW (g/cm^2)	-0.03	0.72	-0.03
Gs (mmol/m^2/s)	0.01	0.49	-0.50
Yield (g/plant)	0.11	0.43	0.42
%Variance	0.37	0.14	0.14
Cumulative	0.37	0.51	0.65

The PCA of ARS, Chinthamani showed that 82 % of the total variation was explained by the first three principal components with first contributing 44 % (Table 6). The characters Fv, Fm and Fv/Fm with high coefficients in the first component are the important discriminating characters. The yield in the second component and Gs in the third component have comparatively high coefficients and they are also important characters in discrimination. Based on PCA in coconut chlorophyll fluorescence transients viz., Fo and leaf water potential were found to be important characters to differentiate and hybrid seedlings (Kasturi Bai *et al*., 2008).

Table 6. First three principal components of ARS, Chinthamani

	PC1	PC2	PC3
Fo	0.27	0.78	-0.05
Fm	0.60	0.13	0.02
Fv	0.61	-0.05	0.03
Fv / Fm	0.42	-0.60	0.09
Gs (mmol/m^2/s)	-0.14	-0.04	0.28
Yield (g/plant)	0.02	-0.11	-0.95
%Variance	0.44	0.21	0.17
Cumulative	0.44	0.66	0.82

Acknowledgments

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