Leaf Anatomical Characteristics Associated wth Water Use Efficiency in groundnut (*Arachis hypogaea* L.)

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Transpiration efficiency (TE, defined as g of dry matter produced per kg of water transpired) is one of the important physiological traits, which contributes toward crop productivity under water-deficit conditions. A strong negative relationship between carbon isotope discrimination ratio (Δ) and TE in groundnut allowed use of Δ as a surrogate to select groundnut germplasm with high levels of TE (Farquhar and Richard, 1984). Several studies (Wright *et al.*, 1994, Wright *et al.*, 1996; Craufurd *et al.*, 1999) reported a significantly positive correlation between specific leaf area (SLA, ratio between leaf area in cm2 and leaf dry weight in g) and Δ, suggesting that the SLA could be used as a rapid and economical tool to select for high levels of TE in Groundnut breeding programs. We believe that more information on the relationships between leaf anatomical aspects contributing to lower SLA in groundnut is necessary to enhance over all understanding. Therefore, the aim of present investigation was to study the leaf anatomical parameters in a set of selected groundnut genotypes with a range of SLA and examine relationships between leaf anatomical characters and leaf gas exchange parameters.

Material and Methods

Seven genotypes, ICG 476, TMV 2, and ICGV 86031 belonging to subsp. fastigiata var. vulgaris (Spanish) and ICG 3826, TMV 2 NLM, ICGS 76, and NC Ac 343 belonging to subsp. hypogaea var. hypogaea (Virginia), were selected for this study based on earlier information on SLA. (Nageswara Rao and Wright, 1994). These genotypes represented a significant range with ICGV 86031 having the lowest and ICG 476 having the highest in SLA. These genotypes were grown on an Alfisol field under adequately irrigated conditions during the rainy season (June-October) at ICRISAT Centre, Patancheru, India. The specific leaf area (SLA) calculated by measuring leaf area of 2nd or 3rd leaf from the apex of main stem and corresponding oven dried weight. Leaf photosynthetic rate was measured at 65 DAS on two proximal leaflets of fully expanded 2nd or 3rd leaf from the apex of the main axis in four plants in each plot with a portable leaf chamber analyser (model LCA 4, ADC, Herts, UK) under natural day light conditions during 1000-1200 h local time. After measuring photosynthetic rates, the fresh weight and leaf area were determined before chlorophyll was extracted and analysed as described by Arnon, 1949. Leaf anatomical characteristics of the fresh leaf samples (3rd leaf from the apex of main stem) were measured at 65 DAS by preparing slides (Spurr,1969) and the measurements were recorded on thickness of midrib region, lamina region, water storage cells, mesophyll cells, vascular bundle of midrib region, and number of veins per 1000 micrometer of lamina length at 100 times magnification of microscope.

Results and Discussion

The genotypic differences for SLA were significant (Table 1). ICGV 86031 had the lowest SLA (thickest leaves) and ICG 476 the highest (thinnest leaves) among the genotypes. The photosynthetic rate (Pn) and chlorophyll content also differed significantly among the genotypes with the minimum in ICG 476 and the maximum in ICGV 86031. Pallas (1982) also reported significant genotypic variation for Pn and chlorophyll content in groundnut. The SLA was a negatively correlated with Pn (R^2 =0.80*) and chlorophyll (R^2 =0.62*), reconfirming the earlier findings. Nageswara Rao *et al.* (1995) have also showed a negative relationship between SLA and content of ribulose–1,5-bisphosphate carboxylase (Rubisco) in leaves, suggesting that the Rubisco could be a major cause of variation in photosynthetic capacity in groundnut genotypes. A close positive relationship between photosynthetic rates and leaf thickness is reported in other legume crops (Gupta *et al.*, 1989).

The genotypes showed significant variation in the thickness of different layers of leaf tissues (Table 2). ICGV 86031, which had the thickest leaves (lowest SLA), ranked 4th in the thickness of midrib region but scored 1st rank in lamina thickness. The thickness rank of ICG 476, which had the thinnest leaves (highest SLA), was 6th for midrib region and 4th for lamina region. The relationships of SLA with the thickness of midrib region (R^2 =0.20), thickness of lamina region (R^2 = 0.23), and thickness of layer of water storage cells (R^2 =0.20) were not significant. On the other hand, there was significant negative relationship between SLA and thickness of mesophyll cells layer (R^2=0.58) and number of vascular bundles in lamina (R^2=0.68). The highest rate of photosynthesis in ICGV 86031 could be due to the highest number of vascular bundles in lamina region present in this genotype. The closer spacing of vascular bundles caused greater translocation out of leaf blades, resulting in less build up of photosynthates in leaves of grasses (Dengler and Dengler 1990), and in higher photosynthetic rate in Arundinella hirta- C4 grass (Dengler and Dendler 1990). These results suggest that mesophyll cells and vascular bundles are the major contributors toward the physical thickness of the groundnut leaf. In the present study, thickness of mesophyll cells layer and number of vascular bundles in lamina accounted for 51 % and 68 % of variation in Pn. To account for the remaining variation in Pn and SLA, more detailed studies on leaf anatomy like surface area of mesophyll cells, area of cross section of vascular bundle tissues, volume of vacuoles, storage cells etc. are needed.

Table 1. Specific leaf area, photosynthetic rate, and chlorophyll content in seven groundnut genotypes grown during the rainy season, ICRISAT Center, Patancheru, India

Genotype	Specific leaf area (cm^2/g)	Photosynthetic rate (μ moles $CO_2/m^2/s$)	Chlorophyll content (mg/g fresh leaf weight)
ICG 476	181	13.7	1.29
ICG 3826	128	24.8	1.02
TMV 2	0.85	139	22.2
TMV 2 NLM	2.16	114	22.0
ICGV 86031	1.92	111	26.5
ICGS 76	1.51	120	21.8
NC Ac 343	1.52	122	23.8
Mean	1.5	131	22.1
SE±	4.3	0.13	1.70

Table 2. Leaf anatomical characteristics of seven groundnut genotypes grown under adequately irrigated conditions during the rainy season at ICRISAT Center, Patancheru, India

Genotype	Thickness (micron)						Number of VB (100^{-1} mm lamina)
	Midrib region			Lamina region			
	Total	Cortex	VB	Total	MC	WSC	
ICG 476	593	214	236	260	165	110	370
ICG 3824	635	213	235	273	178	90	420
TMV 2	638	243	248	253	175	99	400
TMV 2 NLM	613	214	225	278	192	100	410
ICGV 86031	625	242	285	292	195	107	450
ICGS 76	650	202	212	256	170	98	430
NC Ac 343	588	214	215	260	185	89	400
Mean	620	217	236	267	180	99	411
SE±	3.9	4.5	6	4.6	4.4	1.8	7

VB = Vascular bundles, MC = Mesophyll cells, WSC= Water storage cells

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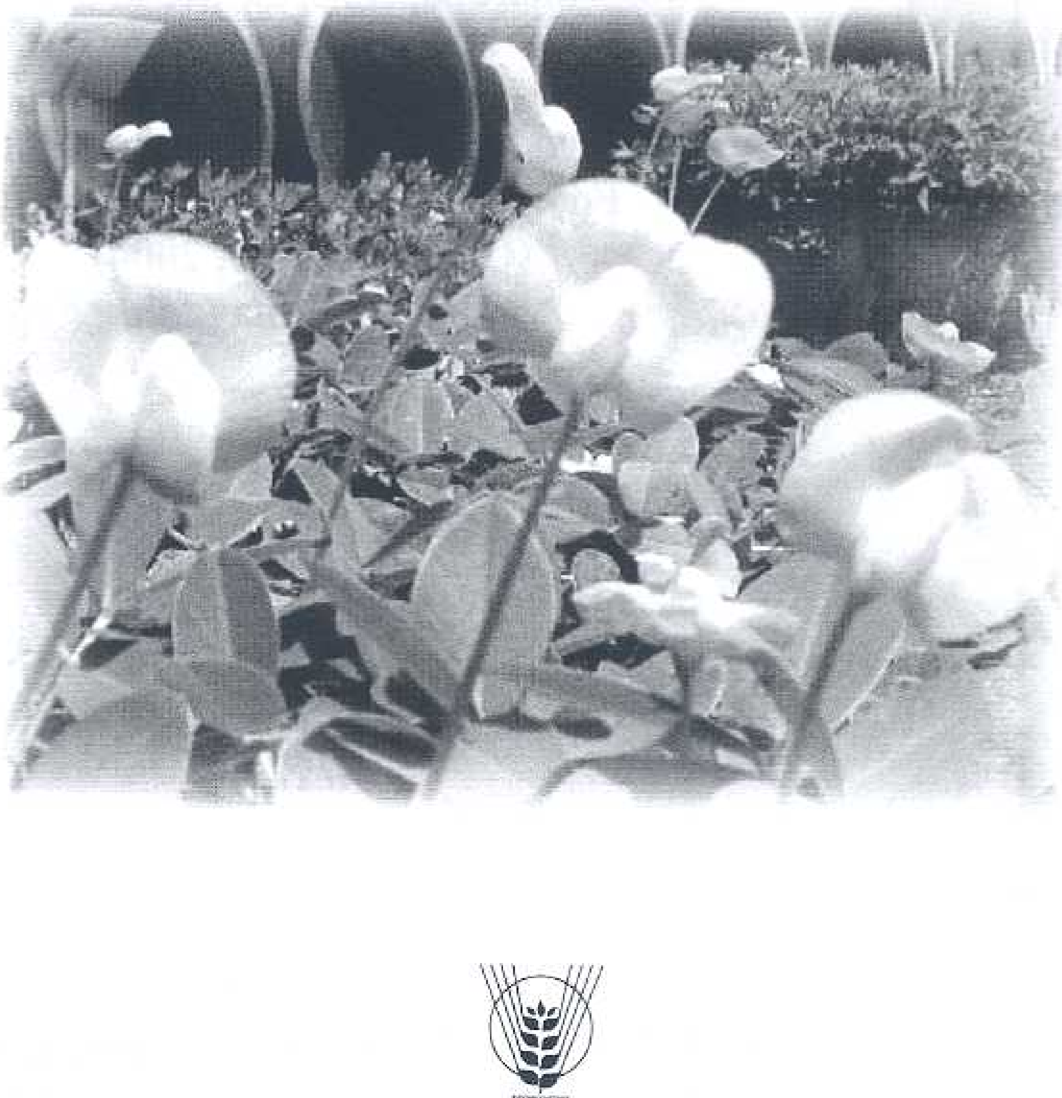

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