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Stomatal parameters in nine species of *Corchorus* (Tiliaceae)

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ABSTRACT

Stomatal parameters namely stomatal size variation including aperture size (area), frequency of distribution, and conductance were studied in nine species (cultivated- *C. capsularis* L.- JRC 321, *C. olitorius* L. – JRO 524; wild - *C. aestuans* L. – WCIJ 088, *C. fascicularis* Lam. – WCIJ 150, *C. pseudocapsularis* L.- CIM 036, *C. pseudoolitorius* I. and Z. – OIN 507, *C. tridens* L.- WCIJ 149, *C. trilocularis* L.- KBA 222 and *C. urticaefolius* W. and A.- WCIJ 070- the species were grown under uniform agro-climatic condition) of Jute in an attempt to screen drought tolerant species and genotypes demonstrating enhanced photosynthetic efficiency. Stomata of jute species are paracytic, amphistomatic and anisostomatic. Results indicated that *C. aestuans*, *C. urticaefolius*, *C. trilocularis* and *C. pseudoolitorius* were drought tolerant; while *C. pseudoolitorius* and *C. fascicularis* were apparently with enhanced photosynthetic efficiency. The desirable traits in wild germplasm may be used for efficient breeding and crop improvement.

Keywords: Jute species, drought tolerance, photosynthetic efficiency, efficient breeding.

INTRODUCTION

Stomata are a unique biological window which effectively influences physiological activities of plants (Levitt, 1974; Berry et al., 2010; Haworth et al., 2010). Stomatal size, frequency and distribution differ significantly among different genotypes (Jones, 1979; Uprety et al., 2002; Zheng et al., 2006) as well as between leaf surfaces (Ricciardi, 1984) not withstanding the importance of stomata as a useful marker to identify genotypes (Ghosh et al., 2004). Stomatal spacing (Hazra, 1991) and aperture size (Tsuno and Sugumoto, 1981) are reported to influence photosynthetic rate positively (Medlyn et al., 2001; Xu and Baldocchi, 2003). Further, comparison of stomatal frequency between leaf surfaces is being related to drought resistance (Hu, 1989; Vaz et al., 2010) and this may be one of the useful criteria in screening for drought tolerant genotypes (Shawesh et al., 1985; Munns et al., 2010). The present study documents stomatal features (size variation including aperture size, frequency distribution, interstomatal spacing and conductance) in nine species (2 cultivated: *Corchorus olitorius* L. var. JRO 524, and *C. capsularis* L. var. JRC 321- globally important fibre yielding plant species; seven wild species: *C. aestuans* L.-WCIJ 088, *C. fascicularis* Lam.- WCIJ 150, *C. pseudocapsularis* L.-CIM 036, *C. pseudoolitorius* I. and Z.-OIN 507, *C. tridens* L.-WCIJ 149, *C. trilocularis* L.-KBA 222 and

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C. urticaefolius W. and A.-WCIJ 070) of Jute (*Corchorus*; Family: Tiliaceae) with an objective to screen drought tolerant species and genotypes with improved photosynthetic efficiency which may be explored for efficient breeding and crop improvement. Only limited information is available regarding stomatal parameters in Jute (Ghosh et al., 2004; Maity and Datta, 2009).

MATERIALS AND METHODS

For the study of stomata, Quickfix image impression technique (Nayeem and Dalvi, 1989) was followed. The leaf prints (for each species 3 plants were scored and 3 leaves near to the apex from each plant were assessed-both surfaces) were taken at bud initiation stage. Stomatal frequency (mm^{-2}) and its distribution (near apex and away from mid vein) were recorded (light microscopic observation – 10x X 40x) among the species. Interstomatal distance and size (µ) of the stomata and aperture were measured. Considering that the shape of stomata to be elliptical its area was calculated as per Ghosh et al. (2004) using the formula [$\pi/4$ (L X W)], where L and W are length and width of stomata respectively. Stomatal conductance was ascertained by multiplying stomatal aperture size and frequency according to Nerker et al. (1981).

Statistical analysis

To assess significant variation, if any, critical difference (0.05 probability level) following ANOVA was performed amongst the species for attributes like stomatal frequency, distribution and distance; while, student t-test (0.05, 0.01 and 0.001 probability levels) was computed between two parameters taken at a time for a species. Correlation analysis (based on pooled data of all genotypes) considering five traits, namely stomatal frequency, size, pore area and distance along with leaf area was made for understanding interrelationship between/ among the traits (0.05, 0.01 and 0.001 probability levels, DF 14).

RESULTS

Results of stomatal parameters (Figures 1-6) are presented in Tables 1 and 2. Stomatal frequency (mm^{-2}) among the *Corchorus* species was significantly ($p < 0.05$ to < 0.001) higher or lower than upper, ranging from 81.39 (*C. trilocularis*) to 176.43 (*C. olitorius*) in upper and 303.34 (*C. pseudocapsularis*) to 719.72 (*C. aestuans*) in lower leaf epidermis. The estimates of stomatal frequency between the upper and lower surfaces (range: 0.21 to 0.58) being minimum in *C. aestuans* (0.21), *C. urticaefolius* (0.25), *C. trilocularis* (0.26), *C. pseudoolitorius* (0.26) and *C. fascicularis* (0.28). Interstomatal distance among species varied from 53.3 µ (*C. olitorius*) to 98.7 µ (*C. pseudocapsularis*) in upper and 20.6 µ (*C. aestuans*) to 44.5 µ (*C. capsularis* and *C. pseudoolitorius*) in lower leaf surfaces. *C. olitorius* and *C. urticaefolius* in both leaf surfaces and *C. aestuans* and *C. pseudocapsularis* in lower surface were with closely spaced stomata. Stomatal frequency and interstomatal distance were negatively correlated in both upper ($r = -0.56$, $p < 0.05$) and lower ($r = -0.55$, $p < 0.05$) leaf surfaces.

T-test revealed both site specific (near mid vein- *C. capsularis*, *C. olitorius* and *C. trilocularis* in upper and *C. fascicularis*, *C. pseudoolitorius* and *C. trilocularis* in lower; away from mid vein – *C. aestuans, C. pseudocapsularis, C. tridens* and *C. urticaefolius* in upper and *C. tridens* and *C. urticaefolius* in lower leaf surfaces- $p< 0.05$ to $p< 0.001$) and random (*C. fascicularis* and *C. pseudoolitorius* in upper, and *C. capsularis, C. olitorius, C. aestuans* and *C. pseudocapsularis* in lower- $p> 0.05$) distribution of stomata.

Mostly (excepting *C. fascicularis, C. pseudocapsularis* and *C. pseudoolitorius*) stomatal area were significantly ($p< 0.05$ to $<$ 0.001) larger in upper than lower leaf surfaces. *C. capsularis* and *C. olitorius* (both leaf surfaces) had significantly broader stomata than the wild species.

Table 1: Stomatal distribution in nine Jute species.

Genotypes	Stomatal frequency (mm^{-2})			Frequency distribution (mm^{-2})				Interstomatal distance (μ)	
	U	L	U/L	Upper surface		Lower surface		U	L
				NMV	AMV	NMV	AMV		
C. capsularis	147.57	522.71	0.28	162.38	132.76	518.22	527.20	67.3	44.5
C. olitorius	176.43	497.70	0.35	215.27	137.59	496.38	498.35	53.3	24.1
C. aestuans	147.60	719.72	0.21	136.08	159.12	718.89	720.54	74.9	20.6
C. fascicularis	89.72	317.10	0.28	90.42	89.02	344.80	289.40	82.6	43.1
C. pseudocapsularis	168.92	303.34	0.58	131.66	206.19	305.00	301.67	98.7	27.2
C. pseudoolitorius	90.00	325.87	0.26	93.26	86.73	352.86	298.89	84.5	44.5
C. tridens	174.46	332.79	0.52	167.22	181.70	285.06	380.51	65.8	33.9
C. trilocularis	81.39	316.52	0.26	92.82	69.95	331.14	301.89	89.6	29.4
C. urticaefolius	170.51	690.59	0.25	164.58	176.43	626.73	754.44	58.2	23.9
CD at 5% level	2.03	3.54		1.81	2.06	2.89	3.55	8.12	6.40

U- Upper leaf surface, L- Lower leaf surface, NMV- Near mid vein, AMV- Away from mid vein

Among the wild species, *C. trilocularis* had the largest stomata. Pore area (upper: 33.62 μ^2 to 93.43 μ^2; lower: 27.26 μ^2 to 114.62 μ^2) and total leaf area (910.0 mm^2-2986.70 mm^2) varied among *Corchorus spp*. About 0.32% to 1.38% and 0.91% to 5.99% of area were represented by stomatal pore in upper and lower leaf surfaces respectively. Pore area was positively and significantly correlated with stomatal size (upper r = 0.77, p< 0.01; lower- r = 0.87, p<0.001) and leaf area (upper- r = 0.57, p<0.05; lower-r = 0.67, p<0.01) in both leaf surfaces and consequently stomatal size and leaf area were interrelated significantly (upper- r = 0.77, p< 0.01; lower- r = 0.67, p<0.01).

Stomatal conductance was nearly 0.20 (*C. pseudoolitorius*) to 0.68 (*C. tridens*) times higher or lower than upper leaf surface. Among the species stomatal conductance ($\mu m/mm^2$) varied from 3170.7 (*C. pseudoolitorius*) to 13787.5 (*C. capsularis*) in upper and 9071.9 (*C. tridens*) to 59913.0 (*C. capsularis*) in lower leaf surfaces.

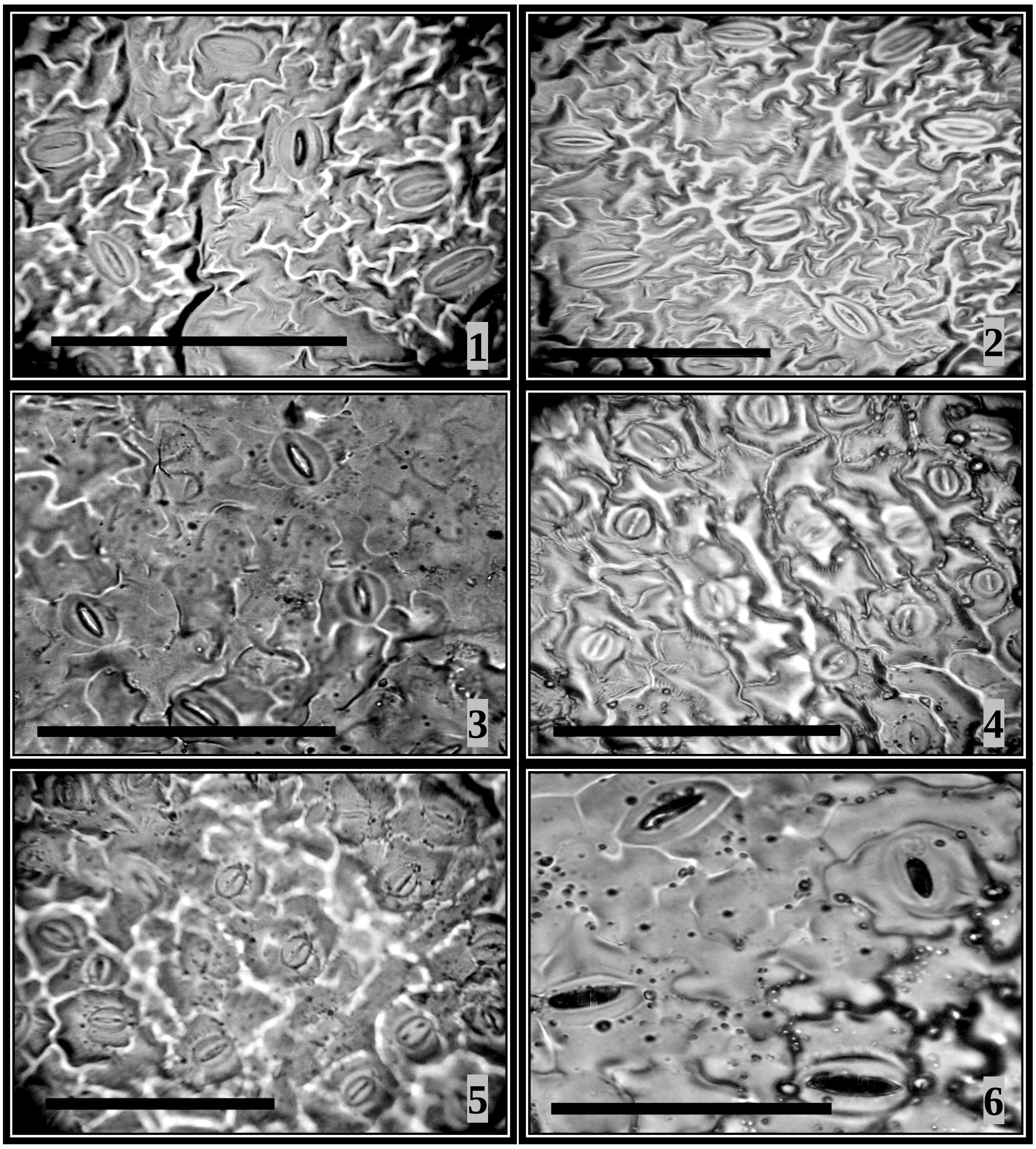
DISCUSSION

Estimates of stomatal frequency between upper and lower leaf surfaces revealed that *C. aestuans*, *C. urticaefolius*, *C. trilocularis*, *C. pseudoolitorius* and *C. fascicularis* may be utilized as drought tolerant species. Shamsuzzaman et al. (1999) reported a drought tolerant mutant in *C. capsularis* (C – 278) following sodium azide treatment (12 mM), which performed well in field trial experiment, but failed to respond adequately in multilocational trials. Drought tolerant genotypes are also reported in other plant species (Munns et al., 2010; Vaz et al., 2010). In the present investigation, stomatal distribution was both sites specific and random, thereby corroborating the findings of Ghosh et al. (2004) in Tossa jute (*C. olitorius*).

Table 2: Stomatal area, aperture area and conductance in nine Jute species.

Genotypes	Leaf area (mm^2)	Stomatal area (μ^2)		Pore area (μ^2)		Per cent pore area of total leaf area		Stomatal conductance (μ^2 mm^{-2})		
		U	L	U	L	U	L	U	L	U/L
C. capsularis	2229.7	454.0	413.9	93.4	114.6	1.38	5.99	13787.5	59913.0	0.23
C. olitorius	2986.7	404.9	254.1	65.2	70.3	1.15	3.50	11503.2	34988.3	0.33
C. aestuans	910.0	282.6	164.0	79.6	54.5	1.18	3.92	11750.4	39239.1	0.30
C. fascicularis	789.0	246.3	262.4	36.5	48.3	0.32	1.53	3274.8	15300.1	0.21
C. pseudocapsularis	1682.3	272.6	279.2	71.5	64.8	1.21	1.97	12076.1	19650.4	0.61
C. pseudoolitorius	935.5	240.3	260.6	35.2	47.8	0.32	1.56	3170.7	15563.6	0.20
C. tridens	1060.4	166.8	132.2	35.4	27.3	0.62	0.91	6179.4	9071.9	0.68
C. trilocularis	1156.4	346.2	326.1	57.6	62.0	0.47	1.96	4686.4	19608.4	0.24
C. urticaefolius	921.4	221.0	141.4	33.6	33.5	0.57	2.31	5732.5	23134.7	0.25

U- Upper leaf surface, L- Lower leaf surface



Figures: 1-6. Paracytic stomata of *Corchorus* spp.

1) *C. pseudocapsularis*. 2) *C. fascicularis.* 3) *C. pseudoolitorius*- showing relatively larger interstomatal distance. 4) *C. urticaefolius*- closely spaced small sized stomata. 5) *C. tridens*- showing small sized stomata. 6) *C. capsularis*- showing larger sized stomata. Scale bar: 100 µ.

However, Troughton and Donaldson (1972) documented site specific distribution of stomata in maize irrespective of the leaf surfaces. Upon comparing stomatal conductance ratio (U/L) it may be inferred that *C. capsularis* and *C. fascicularis* were apparently most efficient photosynthetically in relation to water stress management. Medrano et al. (2002) reported that stomatal conductance may be used as the reference parameter to reflect drought intensity. Venora and Calcagno (1991) suggested the essentiality for assessing stomatal parameters like, leaf area, number of stomata, stomatal area, and conductance amongst others for screening drought tolerant genotypes.

Stomatal parameters assessed amongst *Corchorus spp.* revealed significant variations as well as interrelationships, which may be utilized for efficient breeding and crop improvement.

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