

**VARIETAL VARIATION IN STOMATAL CONDUCTANCE OF SUGARCANE
(*Saccharum officinarum* L.) UNDER RAIN-FED CONDITIONS IN SRI LANKA**

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ABSTRACT

Stomatal conductance (g_s) is an important regulator of transpiration and photosynthesis in plants, especially under water-limited conditions. The objective of this study was to determine the genotypic variation in g_s of sugarcane (*Saccharum officinarum* L.) under rainfed conditions. A field experiment was conducted at the Sugarcane Research Institute, Uda Walawe, Sri Lanka using 16 sugarcane varieties grown under rainfed conditions in a Randomized Complete Block Design with three replicates. The g_s and photosynthetically active radiation (PAR) per unit leaf area were measured in the morning, mid-day and afternoon. Varieties SL 88 116, SL 92 4918, SL 94 3325, SL 92 4997 and SL 90 6237 recorded higher g_s that varied in the morning ($250-400 \text{ mmolm}^{-2}\text{s}^{-1}$), mid-day ($164-237 \text{ mmolm}^{-2}\text{s}^{-1}$) and afternoon ($58-167 \text{ mmolm}^{-2}\text{s}^{-1}$), and would maintain higher photosynthetic rate, thus suitable to grow under intermittent drought. Varieties SL 71 03, Co 775, SL 83 06, SL 93 1466, SL 93 945 and SL 89 1673 recorded lower g_s that varied in the morning ($175-215 \text{ mmolm}^{-2}\text{s}^{-1}$), mid-day ($84-120 \text{ mmolm}^{-2}\text{s}^{-1}$) and afternoon ($36-70 \text{ mmolm}^{-2}\text{s}^{-1}$), and would tolerate drought as genotypes with more sensitive stomata could conserve limited supply of water until yield formation and completion of the life cycle.

Keywords: Photosynthetically active radiation, rainfed, stomatal conductance, sugarcane, varietal variation, water stress

INTRODUCTION

Stomatal conductance (g_s) is a key parameter controlling the physiological processes in plants due to the central position of stomata in the leaf gas exchange pathway, and could be used to determine water use, water status, response to climatic factors, or response to chemical and insect injury in the plants (Jones, 1992). Therefore, measurement of leaf g_s is important for numerous aspects of crop physiological researches. However, it is widely dependent on

varying climatic conditions. Under limited soil moisture availability, reductions in g_s can occur even before any change in plant water status, meaning that monitoring g_s can be a better indicator of plant responses to drying soil than monitoring plant water potential (Davies *et al.*, 2000; Jones, 2004). Moreover, sensitivity of stomata to water stress could contribute to drought tolerance of a genotype because a genotype with more sensitive stomata could conserve a limited supply of water until yield formation and completion of the life cycle. On the other

hand, a genotype with less sensitive stomata may be able to maintain photosynthesis (P_n) at a higher rate and may produce a higher yield under intermittent drought, which does not persist for a long period (Ludlow and Muchow, 1990). The behaviour of g_s is in many respects was similar to the responses seen in P_n . The g_s responds to the onset of stress at about the same value of water stress as P_n and after prolonged stress very low g_s are observed. Maximum values of g_s of around $400 \text{ mmol m}^{-2} \text{ s}^{-1}$ were observed on well irrigated cane, in full radiation but with only moderate vapour pressure deficit (Roberts *et al.*, 1990; Grantz *et al.*, 1987). Therefore, measurements of g_s made directly by porometers could be used as a means of selecting drought tolerant varieties of sugarcane (Roberts *et al.*, 1990). Drought tolerance is an essential trait required for achieving high sugarcane yield in Sri Lanka. Therefore, the objective of the study was to determine the genotypic variation of stomatal conductance and thereby identifying suitable sugarcane varieties to cultivate under water limited conditions.

MATERIALS AND METHODS

A field experiment was conducted at the Sugarcane Research Institute (SRI), Uda Walawe ($6^{\circ}21'N$ latitude, $80^{\circ}48'E$ longitude and 76 m altitude), Sri Lanka under rainfed conditions using sixteen sugarcane hybrid (*Saccharum officinarum* L.) varieties in a RCBD in three replicates. Plot size was 9 m x 8.22 m containing 6 furrows at 1.37 m of recommended spacing (SRI, 2004).

The stomatal conductance (g_s) and photosynthetically active radiation (PAR; incident radiation) per unit leaf area in

three leaves of the canopy including top visible dewlap (TVD) leaf and two younger leaves above the TVD leaf was measured by an automatic diffusion porometer (AP4, Delta-T) at clear sunshine days. Measurements were started at 70 days after ratooning the third ratoon crop of the experiment and continued during the period from 24th February to 4th March 2010 in five days to coincide with the dry spell between *Maha* and *Yala* seasons. Measurements were made three times a day [Morning (07:30-10:15 hrs), mid-day (10:15-14:15 hrs) and afternoon (16:30-18:00 hrs)]. Three replicate plants were measured in each experimental plot. Significance of treatment differences was tested by the Proc GLM procedure of the SAS statistical package (2004). Means were separated by using the least square means (LSmean).

RESULTS AND DISCUSSION

The stomatal conductance (g_s) and photosynthetically active radiation (PAR) per unit leaf area showed a significant variation on varieties ($p \leq 0.04$), time (*i.e.* morning, mid-day and afternoon) of the measurements ($p \leq 0.0001$) and leaf number in the canopy ($p \leq 0.005$). Moreover, g_s in morning, mid-day and afternoon had a significant ($p < 0.01$) variation on varieties and leaf number whereas PAR showed a significant ($p < 0.01$) variation on varieties alone in the afternoon and on the leaf number in morning and mid-day (Tables 1, 2 and 3). Except in the morning, there was a significant correlation between g_s and PAR in mid-day ($p = 0.002$), afternoon ($p = 0.0001$) and average over the day ($p = 0.0006$).

Table 1. Stomatal conductance (g_s) in different sugarcane varieties at morning, mid-day, afternoon and averaged g_s in the day under rain-fed conditions

Variety	Stomatal conductance ($\text{mmolm}^{-2}\text{s}^{-1}$)			
	Morning	Mid day	Afternoon	Average
SL 88 116	384.41 ^{ab}	237.82 ^a	58.14 ^{bc}	281.17 ^a
SL 92 4918	404.58 ^a	170.75 ^{abc}	86.80 ^{bc}	273.68 ^a
SL 94 3325	300.14 ^a	163.75 ^{abc}	167.03 ^a	232.49 ^{ab}
SL 90 6237	255.10 ^{bc}	207.88 ^{ab}	103.38 ^b	214.07 ^{abc}
SL 92 4997	261.28 ^{bc}	177.67 ^{abc}	106.47 ^b	207.61 ^{abc}
M 438/59	276.46 ^{abc}	134.16 ^{bc}	79.98 ^{bc}	196.28 ^{bc}
SL 93 945	291.64 ^{abc}	99.14 ^c	100.56 ^b	195.63 ^{bc}
SL 71 30	260.02 ^{bc}	153.65 ^{abc}	63.44 ^{bc}	191.80 ^{bc}
SL 89 1673	241.33 ^c	106.84 ^c	82.00 ^{bc}	169.94 ^{bc}
SL 92 5588	209.32 ^c	146.52 ^{abc}	76.71 ^{bc}	168.08 ^{bc}
SL 92 4223	206.69 ^{bc}	138.90 ^{bc}	81.40 ^{bc}	165.42 ^{bc}
SL 93 938	184.14 ^c	171.17 ^{abc}	69.89 ^{bc}	159.83 ^{bc}
SL 83 06	215.75 ^c	84.56 ^c	64.55 ^{bc}	146.82 ^c
SL 93 1466	175.61 ^c	110.96 ^c	71.55 ^{bc}	136.72 ^c
Co 775	177.40 ^c	120.62 ^{bc}	35.65 ^c	136.14 ^c
SL 71 03	192.88 ^c	88.89 ^c	54.96 ^{bc}	135.23 ^c
Mean	252.30	144.60	81.41	188.84
Probability	0.0016	0.0026	<0.0001	<0.0001

Within a column, the means followed by the same letter are not significantly different at $p=0.05$

A greater g_s was observed in the morning than during the mid-day, which in turn had greater g_s than the afternoon, consistently in all varieties except in SL 94 3325 and SL 93 945 that had slightly increased g_s in the afternoon than mid-day (Table 1). However, in PAR, mid-day showed higher values than in the morning resulting in higher values than the afternoon (Tables 2). All varieties reduced g_s during mid-day compared to morning. Roberts *et al.* (1990) observed similar diurnal changes in g_s . However, in contrast, Du *et al.* (2000) observed the maximum value of g_s in mid-day and the diurnal changes in g_s were closely related with the changes in PAR. Moreover, varieties showed varying response in g_s in times of measurements. The variety SL 88 116 recorded the highest g_s in the mid-day, the highest average g_s in the day, the second highest g_s the morning and third lowest g_s in the afternoon. The SL 92 4918 recorded

the highest g_s in the morning and the second highest average g_s in the day. In addition, the varieties SL 94 3325, SL 92 4997 and SL 90 6237 recorded higher g_s in all the times of measurements. In contrast, varieties SL 71 03 and Co 775 recorded the lower g_s in mid-day, afternoon and the lowest average g_s in the day. The SL 83 06 and SL 93 1466 had a lower g_s in morning, mid-day and lower average in the day. SL 93 945 and SL 89 1673 recorded lower g_s in the mid-day. Varieties with lower g_s and sensitive stomata to water stress could tolerate the drought whereas those with higher g_s and less sensitive stomata may be drought susceptible or alternatively maintain a high g_s and moderate leaf water potential by more efficient or deeper rooting patterns to maintain photosynthesis at a higher rate and produce a higher yield under intermittent drought (Ludlow and Muchow, 1990).

Table 2. Photosynthetically active radiation (PAR) in unit leaf area in different sugarcane varieties at morning, mid-day, afternoon and averaged per day

Variety	PAR ($\mu\text{mol m}^{-2} \text{s}^{-1}$)			
	Morning	Mid day	Afternoon	Overall
SL 90 6237	1827.6 ^a	2478.8 ^{ab}	714.2 ^a	1859.1 ^a
SL 94 3325	1613.5 ^{ab}	2295.8 ^{abc}	588.8 ^{abc}	1670.1 ^{ab}
SL 92 4918	1464.0 ^{ab}	2564.2 ^a	358.8 ^{b cde}	1646.5 ^{abc}
SL 88 116	1549.0 ^{ab}	2375.8 ^{abc}	441.2 ^{abcde}	1640.0 ^{abc}
SL 83 06	1444.5 ^{ab}	2395.0 ^{abc}	673.7 ^{ab}	1632.9 ^{abc}
SL 93 945	1543.7 ^{ab}	2240.0 ^{abc}	577.1 ^{abcd}	1614.7 ^{bc}
M 438/59	1573.2 ^{ab}	2271.3 ^{abc}	352.8 ^{bcde}	1602.5 ^{bc}
SL 92 4223	1530.3 ^{ab}	2493.3 ^{ab}	446.3 ^{abcd}	1595.8 ^{bc}
SL 71 30	1509.6 ^{ab}	2277.1 ^{abc}	237.9 ^{de}	1553.5 ^{bc}
Co 775	1474.2 ^{ab}	2325.0 ^{abc}	578.3 ^{abcd}	1543.3 ^{bc}
SL 92 4997	1408.5 ^b	2297.5 ^{abc}	377.5 ^{bcde}	1533.0 ^{bc}
SL 71 03	1386.0 ^b	2348.3 ^{abc}	333.6 ^{bcde}	1531.4 ^{bc}
SL 92 5588	1423.1 ^{ab}	2297.2 ^{abc}	442.0 ^{abcde}	1483.1 ^{bc}
SL 93 1466	1394.0 ^b	2197.1 ^{bc}	239.9 ^{de}	1469.3 ^{bc}
SL 89 1673	1338.7 ^b	2192.5 ^{bc}	202.5 ^e	1433.9 ^{bc}
SL 93 938	1431.4 ^{ab}	2107.2 ^c	269.2 ^{cde}	1404.4 ^c
Mean	1494.45	2323.36	427.10	1577.32
Probability	0.5712	0.1918	0.0030	0.0452

Within a column, the means followed by the same letter are not significantly different at $p=0.05$

De Silva (2007) reported that the variety SL 88 116, which gave the highest biomass production in this study, showed the highest g_s under irrigated conditions and the second lowest g_s under rainfed conditions. The variety Co 775, which had the second highest biomass production recorded the lowest g_s under rainfed conditions. As most erect orientation of the youngest first leaf in the canopy, its surface received the significantly lowest

($p=0.005$) amount of irradiance during the day, followed by a significantly lowest ($p=0.0001$) rate of g_s . The TVD leaf had the significantly highest ($p=0.0001$) g_s than other two leaves during mid-day (Table.3). In contrast to these findings, Venkataramana and Ramanujam (1999) reported that variation in irradiance among the leaves did not influence the g_s , as much as the photosynthetic rate.

Table 3. Variation in g_s ($\text{mmol m}^{-2} \text{s}^{-1}$) and PAR ($\mu\text{mol m}^{-2} \text{s}^{-1}$) among three leaves in sugarcane canopy at morning, mid-day, afternoon and averaged from morning to afternoon.

Leaf No.	Morning		Mid day		Afternoon		Overall	
	g_s	PAR	g_s	PAR	g_s	PAR	g_s	PAR
1	175 ^b	1371 ^b	83 ^c	2230 ^b	68 ^b	464 ^a	128 ^b	1491 ^b
2	285 ^a	1597 ^a	142 ^b	2324 ^{ab}	80 ^{ab}	396 ^a	205 ^a	1627 ^a
3 (TVD)	295 ^a	1513 ^{ab}	208 ^a	2415 ^a	95 ^a	421 ^a	233 ^a	1613 ^a
Mean	252	1494	144	2323	81	427	189	1577
Probability	0.0001	0.01	0.0001	0.01	0.02	0.54 ^{ns}	0.0001	0.0055

Within a column, means followed by the same letter are not significantly different at $p=0.05$

CONCLUSIONS

There is adequate varietal variation in sugarcane leaf g_s under rainfed conditions. However, the g_s varied significantly with the time of the day and the position of the leaf. The varieties also showed different response in g_s within the day. Thus, impact of climatic conditions and water stress on plants during contrasting growth stages should be assessed to accurately determine the g_s response in determining yield and drought resistance in sugarcane.

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