Diurnal Variation in Stomatal Conductance of Sugarcane Varieties 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 under rain-fed conditions. A field experiment was conducted at the Sugarcane Research Institute, Uda Walawe (6°21'N latitude, 80°48'E longitude and 76 m altitude) using sixteen sugarcane (*Saccharum* hybrid L) varieties grown under rain-fed conditions in a randomized complete block design. g_s and photosynthetically active radiation (PAR) per unit leaf area were measured in morning, mid-day and afternoon. Varieties SL88 116, SL92 4918, SL94 3325, SL92 4997 and SL 90 6237 recorded higher g_s *varying in morning (250-400 mmolm^{-2}s^{-1}), mid-day (164-237 mmolm^{-2}s^{-1}) and afternoon (58-167 mmolm^{-2}s^{-1}).* These varieties would be able to maintain higher photosynthetic rate, thus suitable to grow under intermittent drought. Varieties SL71 03, Co775, SL83 06, SL 93 1466, SL93 945 and SL89 1673 recorded lower g_s *varying in morning (175-215 mmolm^{-2}s^{-1}), mid-day (84-120 mmolm^{-2}s^{-1}) and afternoon (36-70 mmolm^{-2}s^{-1}).* These varieties tolerate the drought because a genotype with more sensitive stomata could conserve a limited supply of water until yield formation and completion of the life cycle.

Key words: Rain-fed, Stomatal conductance (**g_s**), Sugarcane, Varietal variation, Water stress

Introduction

Stomatal conductance (g_s) is a key parameter controlling physiological processes in plants because of 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. 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). 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 respond 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 mmol m^{-2} s^{-1} were observed on well irrigated cane, in full radiation but with only moderate vapour pressure deficit (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 **g_s** 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°21'N latitude, 80°48'E longitude and 76 m altitude) under rain-fed conditions using sixteen sugarcane (*Saccharum* hybrid L.) varieties in a RCBD design in three replicates. Plot size was 9 m x 8.22 m, containing 6 furrows at 1.37 m of recommended spacing. *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 3rd 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 at three times per day [Morning (07:30-10:15h), mid-day (10:15-14:15h) and afternoon (16:30-18:00h)]. 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

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 1-3). Also, except 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: g_s in different sugarcane varieties at morning, mid-day, afternoon and averaged g_s in the day under rain-fed conditions

Variety	g_s (m molm^{-2}s^{-1})			
	Morning	Mid day	Afternoon	Average
SL 88 116	384^{ab}	238^{a}	58.1^{bc}	281^{a}
SL 92 4918	404^{a}	171^{abc}	86.8^{bc}	273^{a}
SL 94 3325	300^{abc}	164^{abc}	167.0^{a}	232^{ab}
SL 90 6237	255^{bc}	208^{ab}	103.4^{b}	214^{abc}
SL 92 4997	261^{bc}	178^{abc}	106.5^{b}	207^{abc}
M 438/59	276^{abc}	134^{bc}	79.9^{bc}	196^{bc}
SL 93 945	291^{abc}	99.1^{c}	100.5^{b}	195^{bc}
SL 71 30	260^{bc}	153^{abc}	63.4^{bc}	191^{bc}
SL 89 1673	241^{c}	109^{c}	82.0^{bc}	169^{bc}
SL 92 5588	209^{c}	146^{abc}	76.7^{bc}	168^{bc}
SL 92 4223	206^{bc}	138^{bc}	81.4^{bc}	165^{bc}
SL 93 938	184^{c}	171^{abc}	69.9^{bc}	159^{bc}
SL 83 06	215^{c}	84.5^{c}	64.5^{bc}	146^{c}
SL 93 1466	175^{c}	110^{c}	71.5^{bc}	136^{c}
Co 775	177^{c}	120^{bc}	35.6^{c}	136^{c}
SL 71 03	192^{c}	88.9^{c}	54.9^{bc}	135^{c}
Mean	252	144	81.4	188
Probability	P=0.002	P=0.003	P<0.01	P<0.01

Means of the same letter are not significantly different at 0.05 % significant level

The morning had greater g_s than the mid-day which in turn had greater g_s than the afternoon consistently in all varieties except the varieties of SL 94 3325 and SL 93 945 which had slightly increased g_s in the afternoon than the mid-day (Tables 1). However, in PAR, mid-day had greater values than the morning which in turn had greater values than the afternoon (Results not shown). Despite of PAR, all varieties reduced g_s in 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. 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 gs in the afternoon. SL 92 4918 recorded the highest g_s in the morning and the second highest average g_s in the day. Also, 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. 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 which had lower g_s with sensitive stomata to water stress could tolerate the drought whereas varieties which had higher g_s with 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 may be able to maintain photosynthesis at a higher rate and produce a higher yield under intermittent drought (Ludlow and Muchow 1990). Moreover, De Silva (2007) showed that the variety SL 88 116 which had the highest biomass production showed the highest g_s

under irrigated conditions and the second lowest g_s under rain-fed conditions. The variety Co 775 which had second highest biomass production recorded lowest g_s under rain-fed conditions.

References

Davies WJ, Bacon MA, Thompson DS, Sobeih W and Rodrıguez LG 2000 Regulation of leaf and fruit growth in plants growing in drying soil: exploitation of the plants' chemical signaling system and hydraulic architecture to increase the efficiency of water use in agriculture. Journal of Experimental Botany 51:1617–1626.

De Silva ALC 2007 Investigation of growth, yield, ratooning ability and some important physiological attributes of a selected set of commercial sugarcane varieties in Sri Lanka under irrigated and rainfed conditions. M. Phil. Theses. Postgraduate Institute of Agriculture, University of Peredeniya, Sri Lanka.

Du Y-C, Nose A, Kondo A and Wasano K 2000 Diurnal changes in photosynthesis in sugarcane leaves. 1. Carbon dioxide exchange rate, photosynthetic enzymes activities and metabolite levels relating to the C_4 pathway and the Calvin cycle. *Plant Production Sciences* 3(1): 3-8.

Grantz DA, Moore PH and Zeiger E 1987 Stomatal responses to light and humidity in sugarcane: prediction of daily time courses and identification of potential selection criteria. Plant Cell and Environment 10: 197-204.

Ludlow MM and Muchow RC 1990 A Critical evaluation of traits for improving crop yield in water-limited environments. Advances in Agronomy 43: 107-153.

Roberts J, Nayamuth RA, Batchelo RCH and Soopramanien GC 1990 Plant-water relations of sugarcane (*Saccharum officinarum* L.) under a range of irrigated treatments. Agricultural Water Management 17:95-115.