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Comparative studies of chlorophyll content, yield and juice quality of eight sugarcane varieties

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Abstract: An experiment was conducted at the experimental farm and laboratory of the Physiology and Sugar Chemistry Division of Bangladesh Sugarcane Research Institute (BSRI), Ishurdi-6620, Pabna, Bangladesh during 2008-2009 cropping season to compare chlorophyll content, yield and juice quality of eight sugarcane varieties. The selected varieties of sugarcane were found to differ significantly in chlorophyll content, tiller, millable cane, stalk height, stalk diameter, cane yield, Brix (%), pol (%) cane, purity (%), reducing sugar (%), as well as sugar yield. Thus, the sugarcane varieties Isd 37, Isd 38 and Isd 35 proved best in respect of cane yield, sugar yield and juice quality, and variety Isd 32 in respect of cane yield.
Key words: chlorophyll content, yield, juice quality, sugarcane.

Introduction

Sugarcane is one of the most important food-cum-cash crops in Bangladesh. It is a principle cash crop especially in north-western and south-western low rainfall belt of Bangladesh. Sugarcane is the raw materials of sugar industry and the main source of white sugar and jaggary (locally called *'gur'*). At present, the area under sugarcane in Bangladesh is about 130 thousand hectares covering both mill and non-mill zones with an annual production of about 162 thousand tones of sugar and 310 thousand tones of *'gur'* (BBS, 2008) as against the current requirement of 1820 thousand tones estimated at 13 Kg of sugar or 17 Kg of *'gur'* per capita per annum (FAO, 1982). Therefore, there is an annual deficit of 1348 thousand tones of sugar and *'gur'*. As a result, the country's requirement is met by importing sugar spending huge amount of hard earned foreign currency. To improve this situation and stop drainage of foreign currency, there is an urgent need to increased the country's sugarcane production from the current level of around 4,984 thousand tons (BBS, 2008) to 19,218 thousand tones per year. The soil and climate of Bangladesh are very much conducive to obtain maximum yield of sugarcane. Despite a favorable land, soil type and agro climatic condition, per hectare yield of sugarcane in Bangladesh is about 41 tons (46 tha^{-1} in sugar mills zone areas and 36 t ha^{-1} in non mill zone areas) (BBS, 2008), whereas on an average 71. $5tha^{-1}$ in other sugar producing countries (FAOSTAT, 2009). The low yield of sugarcane is mainly due to improper and poor land preparation, ultimately planting, poor intercultural operation such as weeding, disease and pest control and irrigation water (Eusufzai *et al.* 2000). Sugarcane varieties show a tendency to decline in yield and vigour after a considerable period of cultivation (Barnes, 1954). It is an obscure and puzzling problem to scientists, growers and processors. Sugar industries in Bangladesh continuously need high yielding high sugar durable sugarcane varieties. Bangladesh Sugarcane Research Institute (BSRI) released varieties do not perform equally well in all location. It has been observed that some varieties doing well in one climatic conditions have also given good results in the other climatic conditional thus has high genetic buffering capacity (Funguy and Fontenaty, 1989). Leaf is an important organ and is associated with photosynthesis and evapotranspiration. The chlorophyll content of the leaf tissue varies with different cultivars, light and temperature. With these in mind this comparative studies of chlorophyll content, yield and juice quality of eight sugarcane varieties were taken to evaluate them for cultivation in Bangladesh.

Materials and Methods

The trial was conducted at the experimental farm and laboratory of the Physiology and Sugar Chemistry Division of the Bangladesh Sugarcane Research Institute (BSRI), Ishurdi-6620, Pabna, Bangladesh during November, 2008 to December, 2009. The site is located at $24^0$8' North latitude and $89^0$08' East longitude and situated about 15. 5 m above the mean sea level. The experimental site represents the High Ganges River Flood Plain soils under the AEZ 11. Eight selected sugarcane varieties viz. Isd 31, Isd 32, Isd 33 Isd 34, Isd 35, Isd 36, Isd 37 and Isd 38 were tested. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Two budded sets were planted at furrow following end to end method of planting in month of November 15, 2008. Row to row distance was maintained 100 cm. NPKS fertilizers were applied @ 325 Kg urea, 250 Kg TSP, 190 Kg MP, 180 Kg Gypsum and 9 Kg $ZnSO_4$ per hectare. Urea was applied in 3 splits and MP was applied in two splits. Total TSP, $ZnSO_4$ half MP, one third urea were applied at planting. Rest of urea and MP were applied as top dressing. For controlling insect pests, chlorpyrifos (trade name: regent 3 GR) was applied @ 33 ha^{-1} during planting and carbofuran (trade name: furadan 5G) was applied @ 40 Kg ha^{-1} in two splits between March to May, 2009. All cultural practices were done as and when required. Number of millable cane and cane yield were recorded at harvest in the month of December 14, 2009.

Estimation of total chlorophyll, chlorophyll-a and chlorophyll-b: Total chlorophyll, chlorophyll-a, and chlorophyll-b were calculated on a fresh weight basis employing following formulae (Mahadevan and Sridhar, 1982):

$$\text{Total chlorophyll (mg g}^{-1}) = \frac{20.2A645+8.02A663}{a\times1000\times w}\times v$$

$$\text{Chlorophyll-a (mg g}^{-1}) = \frac{12.7A663-2.69A645}{a\times1000\times w}\times v$$

$$\text{Chlorophyll-b (mg g}^{-1}) = \frac{22.9A645 - 4.68A663}{a\times1000\times w}\times v$$

Where, A = Optical density in each sample, a = Length of light path in the cell (usually l cm), v = Volume of the extract in ml and w = Fresh weight of sample in 'g'.

Chemical analysis of sugarcane juice: Chemical analyses of sugarcane juice for Brix (%), pol (%) and

purity (%) were done at harvest of sugarcane. Randomly selected 15 sample cane stalks were crushed with a mini power crusher to get juice for analysis. Brix was determined by Brix hydrometer standardized at 20^0C and sucrose determination was done using automatic Polarimeter (AP-300), ATAGO ® Company limited, Made in Japan, by Horne's dry lead method. Pol % cane percent was calculated by the method prescribed in Oueensland Laboratory Manual (Anon, 1970), while reducing sugar were measured by Lanc and Eynon method (Chen, 1985).

Brix (%): Percentage of total soluble solids present in solution (juice) $=\frac{\text{Pol}}{\text{Brix}}\times 100$.

Purity (%): percentage of pure sucrose in dry matter $=\frac{\text{Pol}}{\text{Brix}}\times 100$.

Pol % Cane: Percentage of sucrose content in whole cane.

Recoverable sucrose: The recoverable sucrose (%) was calculated by using the following formula:

$$\text{Recoverable sucrose \%} = [\text{Pol-} (\frac{\text{Brix-Pol}}{2})]\times \text{juice factor}$$

Where, juice factor was 0.65 (extraction percentage)

Sugar yield: Sugar yield was calculated using the following formula: Sugar yield (tha^{-1}) $= \frac{\text{Cane yield (t ha-1)}\times \text{ Recoverable Sucrose}}{100}$

The obtained data on different parameters under the experiment were statistically analyzed to obtain the level of significance using MSTAT-C computer program developed by Russel (1986). If the treatments are significant then the treatments means were compared by LSD followed by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

Results and Discussion

Total chlorophyll content: Total chlorophyll content showed a significant variation for different sugarcane varieties (Fig. 1). The highest total chlorophyll content were found in varieties Isd 38 (2.17 mg g^{-1}) followed by varieties Isd 37 (2.14 mg g^{-1}), Isd 35 (1.89 mg g^{-1}), Isd 33 (1.82 mg g^{-1}) and Isd 36 (1.82 mg g^{-1}). The lowest total chlorophyll content was obtained in variety Isd 32 (1.48 mg g^{-1}) (Fig. 1). Kamat and Singh, (2002) also reported variable report of different genotypes for chlorophyll content in sugarcane leaf.

Chlorophyll-a content: Chlorophyll-a content was found significant at 5% level of probability (Fig. 1). It is seen from Fig. 1 that the highest chlorophyll-a content was obtained in variety Isd 38 (1.55 mg g^{-1}) followed by varieties Isd 37 (1.53 mg g^{-1}), Isd 35 (1.36 mg g^{-1}) and lowest in variety Isd 32 (1.08 mg g^{-1}). Present findings are in agreement with the findings of Kamat *et al*. (2004) who carried out studies on chlorophyll a content in selection of drought stress tolerant soma clones of sugarcane under field condition.

Chlorophyll-b content: The chlorophyll-b content was significantly influenced in different varieties (Fig. 1-3). Highest chlorophyll-b content was obtained in variety Isd 38 (0.56 mg g^{-1}) followed by Isd 37 (0.54 mg g^{-1}) and while the lowest in variety Isd 37 (0.48 mg g^{-1}) (Fig. 1). Kamat *et al.* (2004) also reported variable report of different genotypes for chlorophyll b content in sugarcane leaf.

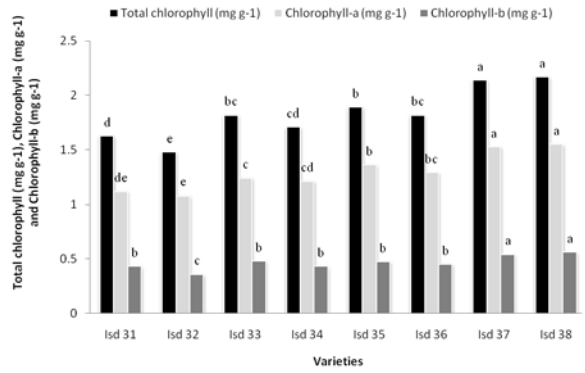

Fig. 1. Performance of total chlorophyll (mg g^{-1}), chlorophyll a (mg g^{-1}) and chlorophyll b (mg g^{-1}) in eight varieties of sugarcane.

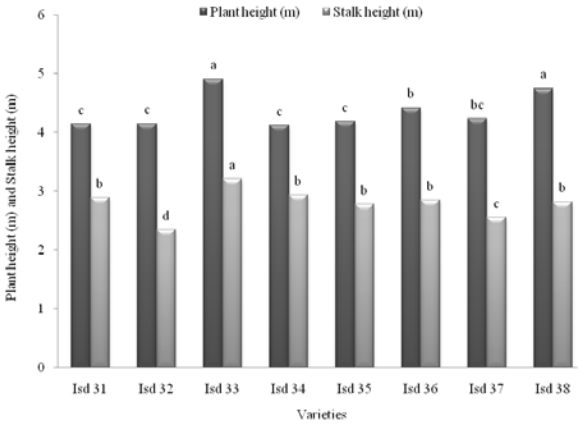

Fig. 2. Performance of plant height (m) and stalk height (m) of eight sugarcane varieties.

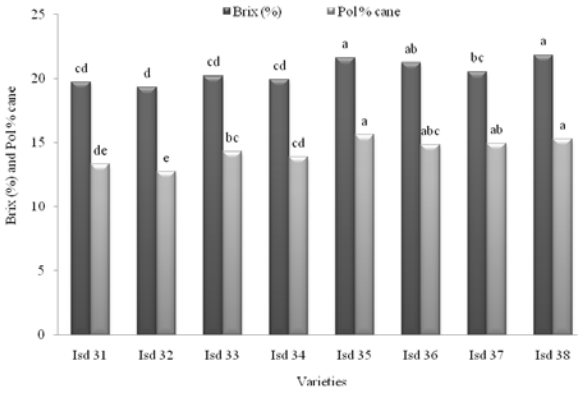

Fig. 3. Performance of Brix (%) and pol % cane of eight sugarcane varieties.

Chlorophyll a:b ratio: It appears from the data presented in (Table 1) that the chlorophyll a:b ratio was ranged in 2.58 to 3.00 in different varieties under High Ganges River Flood Plain Soils. The results are in agreement with the finding of Islam *et al.* (2010) who studied different sugarcane somaclones and found a:b ratio ranged in 2.7 to 3.3 under field condition.

Tiller production: Different sugarcane varieties as significantly affected in number of tiller production of sugarcane. The results on tiller have been presented in the Table 1. Significantly highest number of tiller was recorded in variety Isd 34 ($239.42\times10^3 ha^{-1}$) and the lowest tiller production was observed in variety Isd 31 ($182.61\times10^3 ha^{-1}$). The results are in agreement with this finding of Rahman *et al.* (2010) and Bashar *et al.* (2011).

Table 1. Performance of number of tiller, number of millable cane, stalk diameter, number of internodes, chlorophyll a:b ratio and cane yield of eight sugarcane varieties

Varieties	Number of tiller ($10^3 ha^{-1}$)	Number of millable cane ($10^3 ha^{-1}$)	Stalk diameter (cm)	Number of internodes $stalk^{-1}$	Chlorophyll a:b ratio	Cane yield (t ha^{-1})
Isd 31	182.61 d	89.26 b	1.46 f	26.35 cd	2.60	65.14 c
Isd 32	201.52 bcd	96.37 b	2.51b	28.49 bc	3.00	91.31 ab
Isd 33	216.31 b	95.61 b	2.38 bc	25.13 d	2.58	82.64c
Isd 34	239.42 a	106.82 a	2.12 d	31.86 a	2.81	81.94 c
Isd 35	202.67 bcd	91.13 b	1.93 e	26.25 cd	2.89	85.26 ab
Isd 36	197.37 bcd	93.52 b	2.31 c	29.72 ab	2.87	83.15bc
Isd 37	193.41 cd	96.46 b	2.78 a	28.41 bc	2.83	94.73 a
Isd 38	204.63 bd	98.24 ab	2.31 c	29.37 abc	2.77	89.52 ab
Level of significance	**	*	**	**	-	**
CV (%)	5.32	5.16	3.49	6.03	-	5.46
LSD (0.05)	19.07	8.67	0.13	2.97	-	8.04

** Significant at 1% level of probability, * Significant at 5% level of probability, NS = Not significant, Mean values in a column having the same letter (s) do not differ significantly at 5% level of probability as per DMRT.

Table 2. Performance of juice quality and sugar yield of eight sugarcane varieties

Varieties	Purity (%)	Reducing sugar (%)	Recoverable sucrose (%)	Sugar yield (t ha^{-1})
Isd 31	86.50 de	0.45 a	10.21 e	6.65 d
Isd 32	84.55 e	0.30 b	9.63 f	8.79 c
Isd 33	89.37 bcd	0.19 e	11.19 cd	9.24 c
Isd 34	88.84 cd	0.24 c	10.79 d	8.84 c
Isd 35	92.02 ab	0.22 d	12.36 a	10.53 ab
Isd 36	89.95 abc	0.16 g	11.65 bc	9.93 bc
Isd 37	92.59 a	0.18 ef	11.84 ab	11.21 a
Isd 38	89.22 bcd	0.17 fg	11.87 ab	10.62 ab
Level of significance	**	**	**	**
CV (%)	1.71	5.79	2.74	6.37
LSD (0.05)	2.67	0.01	0.53	1.05

** Significant at 1% level of probability, * Significant at 5% level of probability, NS = Not significant, Mean values in a column having the same letter (s) do not differ significantly at 5% level of probability as per DMRT.

Millable cane Production: The results on millable cane have been presented in the Table 1. Significantly highest number of millable cane was recorded in variety Isd 34 ($106.82\times10^3 ha^{-1}$) followed by Isd 32 ($96.37\times10^3 ha^{-1}$), Isd 33 ($95.61\times10^3 ha^{-1}$) and Isd 37 ($96.46\times10^3 ha^{-1}$), Isd 38 ($98.24\times10^3 ha^{-1}$) while the lowest millable cane production was observed in variety Isd 31 ($89.26\times10^3 ha^{-1}$). Similar results were also reported by Bashar *et al.* (2011) and Rahman *et al.* (2010).

Plant height: The highest plant height was recorded in varieties Isd 33 (4.91m) followed by Isd 38 (4.75m) and while the lowest plant height was obtained in variety Isd 31 (4.l4 m, Fig. 2).

Stalk height: The highest stalk height was recorded in varieties Isd 33 (3.21m) and while the lowest stalk height was obtained in variety Isd 32 (2.35m) (Fig. 2). These results are in agreement with findings of Alam *et al.* (2010), Rahman *et al.* (2010) and Islam *et al.* (2009).

Stalk diameter: It was also seen from the Table 1 that the highest stalk diameter was obtained in variety Isd 32 (2.78 cm) and the lowest stalk diameter was obtained in variety Isd 31 (1.46 cm). The findings of the present experiment are in agreement with Alam *et al.* (2010).

Number of internodes: The highest number of internodes $stalks^{-1}$ was recorded in varieties Isd 34 (31.8) and while the lowest number of internodes $stalks^{-1}$ was obtained in variety Isd 33 (25.lm) (Table 1). Similar result was also reported by Hossain *et al.* (2011).

Cane yield: Cane yield have been shown in the (Table 1). It was seen that the significantly highest cane yield was obtained in variety Isd 37 (94. 73 t ha^{-1}) followed by Isd 32 (91.31 t ha^1), Isd 35 (85.26 t ha^1), Isd 38 (89.52 t ha^1) and the lowest cane yield was obtained in variety Isd 31 (65.14 t ha^1). The results are in agreement with Alam *et al.* (2010), Bashar *et al.* (2011) and Rahman *et al.* (2010) who carried out studies out studies on different sugarcane varieties and found different trend for cane yield per unit area.

Brix (%): The Figure 3 shows that the highest Brix per cent were found in variety Isd 38 (21.8%) followed by Isd 35 (21.6%), Isd 36 (21.2%) while the lowest Brix per cent in variety Isd 31 (19.09%), Isd 34 (19.7%). These results are in agreement with findings of Alam *et al.* (2010), Bashar *et al.* (2011), Raham *et al.* (2010) and Khan *et al.* (2007) who studied a number of sugarcane varieties and found different level of Brix per cent.

Pol % cane: The Figure 3 shows that the significantly highest pol per cent cane was found in variety Isd 35 (15.60%), followed by variety Isd 38 (15.27%) while the lowest pol per cent cane in variety Isd 32 (12.73%). The results are in agreement with this finding of Alam *et al*. (2010) and BSRI, (2010).

Purity (%): Purity percent has been shown in the Table 2. It was seen that the significantly highest purity percent was obtained in variety Isd 37 (92.59%) followed by varieties Isd 35 (92.02%), Isd 33 (89.37%), Isd 36 (89.95%), Isd 38 (89.22%) and while the lowest purity percent was obtained in variety Isd 31 (86.50%). Present findings agree with the findings of Islam *et al.* (2007) who carried out studies on purity percent in one commercial varieties/five clones and found different results for purity percent.

Reducing sugar (%): Significantly different on rescuing sugar per cent have been presented in the Table 2. The highest reducing sugar per cent was recoded in variety Isd 31 (0.45%) and the lowest reducing sugar per cent were obtained in variety Isd 36 (0.16%). Less reducing sugar is the best character of a variety. The results are in agreement with this finding of Jabber *et al*. (2005) and Hasan *et al*. (2003) who studied different varieties and found different levels of reducing sugar per cent.

Recoverable sucrose (%): Recoverable sucrose per cent has been shown in the Table 2. It was seen that the highest recoverable sucrose per cent were obtained in variety Isd 35 (12.36%) followed by Isd 33 (11.19%), Isd 36 (11.65%), Isd 37 (11.84%), Isd 38 (11.87%) and the lowest recoverable sucrose per cent was obtained in variety Isd 32 (9.63%). Similar results were also reported by Hossain *et al*. (2011) and Islam *et al.* (2007).

Sugar yield: Sugar yield has been presented in the Table 2 and found that the highest sugar yield were obtained in variety Isd 37 (11.21 t ha^{-1}) followed by variety Isd 38 (10.62 t ha^{-1}), Isd 35 (10.53 t ha^{-1}) and the lowest sugar yield was variety Isd 31 (6.53 t ha^{-1}). The results are in agreement with this finding of Hossain *et al*. (2011) and Islam *et al*. (2007). From the above results it may be concluded that varieties Isd 37, Isd 38 and Isd 35 performed better than other varieties in respect of cane yield, sugar yield and juice quality and variety Isd 32 performed better in respect of cane yield than other varieties.

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