EVALUATION OF SOME QUALITATIVE AND QUANTITATIVE CHARACTERS OF TEN SUGARCANE GENOTYPES UNDER WATER-LOGGING STRESS CONDITION

By

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ABSTRACT

A field experiment was conducted at Bangladesh Sugarcane Research Institute (BSRI) farm, Ishurdi-6620, Pabna, Bangladesh during 2009-2010 cropping season to evaluate some qualitative and quantitative characters of ten sugarcane genotypes under water-logging stress condition. The genotypes were I 124-00, I 112-01, I 7-03, I 78-03, I 111-03, I 137-03, I 231-03, and water-logging commercial varieties Isd 39 (Standard) and Isd 40 (Standard). Significantly highest number of tillers was recorded in genotype I 231-03 (137.73 × 10^3 ha^{-1}) and highest number of millable cane was recorded in variety Isd 39 (99.76 × 10^3 ha^{-1}). The significantly highest cane yield was obtained in variety Isd 39 (98.04 t ha^{-1}), and the lowest cane yield was obtained in genotype I 111-03 (51.83 t ha^{-1}). Significantly highest Brix per cent, highest pol per cent juice, highest pol per cent cane, highest purity per cent, highest recoverable sucrose per cent were found in genotype I 124-00 under water-logging stress condition, respectively. The highest sugar yields was obtained in variety Isd 39 (10.88 t ha^{-1}) followed by variety Isd 40 (10.49 t ha^{-1}), genotype I 231-03 (10.22 t ha^{-1}) and the lowest was genotype I 139-03 (5.47 t ha^{-1}). Genotype I 231-03, Isd 39 and Isd 40 are highly tolerant having tolerance rating scale 1 against induced water-logging stress condition. Thus, the genotype I 231-03 proved highly potential tolerant in respect of cane yield, sugar yield, juice quality and utilization of potentiality breeding as parents to evolve varieties resistant to water-loggng.

Keyword: Sugarcane, yield, pol % cane and water-logging.

INTRODUCTION

Water-logging is associated with monsoon rainfall, river floods, in adequate and improper drainage facilities due to unplanned road development in Bangladesh. Cane yield and juice quality loss due to water-logging depends upon genotype, environmental conditions, stage of development and duration of inundation (Orchard and Jessop, 1984). In sugarcane cultivation, water-logging is an acute problem particularly where surface drainage facilities are inadequate. Due to growing demand of cereal and vegetables crops one-third areas of land where sugarcane is grown are relatively low lying where water remains stagnant for longer period resulting poor growth and yield. Higher water table during active growth phase adversely affects stalk weight and plant population resulting yield loss at the rate of about one ton per acre for one inch increase in excess water (Carter and Floyed 1974 and Carter 1976), although sugarcane is a relatively tolerant to high water tables and flooding (Roach and Mullins, 1985; Kang *et al.* 1986; Deren *et al.* 1991a, Deren *et al.* 1991b and Deren *et al.* 1993). Well-established cane survives few months in to flood, while less established cane appears to be much more vulnerable to flooding (Deren and Raid, 1997). The cause of low yield, attributed to low moisture and nitrogen in the tissue at grand growth phase. Increase in number of internodes, profuse tillering and increase in % P in plant but decrease in nitrogen content are the characteristics tolerance to flood condition (Pandey, 1964). Some physiological effects of cane are found due to water-logging are (i) transpiration rates are reduced due to stomata closure, (ii) rate of photosynthesis is considerably reduced presumably that causes the reduction of effective leaf areas, (iii) growth rates are drastically reduced during water-logging (iv) higher respiration rate of submerged organs compared to leaves. A shift in respiratory metabolism from aerobic to anaerobic pathways is one of the main effects of oxygen deficiency causing from water-logging. This result is accumulation of various end products of an aerobic respiration and rapid depletion of organic compounds. The effects of water-logging on respiration rate depend on the varieties, and on its physiological age. Nutrient uptake is badly affected under water-logging where aerobic respiration by sugarcane root system is poor (Singh, 1990). It is also reported that under water-logging condition, some morphological, anatomical, physiological and biochemical changes take place in plant for the sack of adaptation/survival (Barclay and Crawford, 1982). In general, water-logging induces anaerobic condition in soil. It also leads to a real rooting resulting rapid moisture loss, increase fiber per cent and non-sugars and yellowing of leaves in anaerobic state during water-logging condition (Malik and Tomer, 2003). Therefore, the present study was undertaken with the objectives to investigate the some qualitative and quantitative characters of ten sugarcane genotypes under water-logging stress condition.

MATERIALS AND METHODS

The trial was conducted at the experimental farm and laboratory of the Physiology and Sugar Chemistry Division in Bangladesh Sugarcane Research Institute (BSRI), Ishurdi-6620, Pabna, Bangladesh during November 14, 2009 to December 25, 2010. The site is located at $24^0$8□ Nortl latitude and $89^0$04□ 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 genotypes viz. I 124-00, I 112-01, I 7-03, I 78-03, I 111-03, I 137-03, I 231-03 and two water-logging tolerant slandered variety Isd 39, Isd 40 were tested. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Two budded setts were planted at furrow following end to end method of planting in the month of November, 2009. Row to row distance was maintained 100 cm. The 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, ZnSO4, half of 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 kg ha^{-1} during planting and carbofuran (trade name: furadan 5G) was applied @ 40 kg ha^{-1} in two splits between March to May, 2010. All cultural practices were done as and when required. Water-logging treatment was imposed by deep tube well water. The experimental field was inundated and maintained at least 90 cm deep water for 120 days (15 June to15 October). Tillering was recorded at an interval of 30 days starting from March until August. Millable cane and cane yield were recorded at harvest in the month of December 25, 2010.

Stalk height at harvest

At harvest 20 cane stalks were selected randomly and the length of individual cane stalk was measured from the bottom to the top using a meter tape. The stalk height of cane was expressed in m.

Cane diameter

Slide calipers from 20 randomly selected stalks measured the stalks diameter. Average of bottom, middle and top diameter was considered as the actual diameter of the cane stalks. The cane diameter was expressed in cm.

Chemical analysis of sugarcane juice

Chemical analyses of sugarcane juice for Brix (%), pol (%), purity (%) and reducing sugar (%) 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 per cent was calculated by the method prescribed in Queensland Laboratory Manual (Anon, 1970).

Brix (%)

Percentage of total soluble solids present in solution (juice)

Purity (%)

Percentage of pure sucrose in dry matter = $\frac{Pol}{Brix} \times 100$

Pol % Cane

Percentage of sucrose content in whole cane.

Recoverable sucrose

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

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

Where, juice factor was 0.65 (extraction percentage)

Sugar yield

Sugar yield was calculated using the following formula:

$$\text{Sugar yield (t ha}^{-1}) = \frac{\text{Cane yield (t ha}^{-1}) \times \text{Recoverable sucrose}}{100}$$

The data was analyzed following slandered statistical procedures (Gomez and Gomez, 1984) and mean difference were adjusted by Duncan's Multiple Range Test (DMRT) using a computer operated program named MSTAT.

RESULTS AND DISCUSSION

Tiller production

Water-logging stress condition as affected significantly in tiller production of sugarcane. The results on tiller have been presented in the Table 1.The highest number of tillers was recorded in genotype I 231-03 (137.73×10^3 ha^{-1}) and the lowest tiller production was observed in genotype I 137-03 (115.35×10^3 ha^{-1}) under water-logging stress condition. The results are in agreement with this finding of Islam *et al.* (2011a) and Islam *et al.* (2007).

Millable cane production

The results on millable cane have been presented in Table 1. Significantly highest number of millable cane was recorded in variety Isd 39 (99.76×10^3 ha^{-1}) followed by variety Isd 40 (97.41×10^3 ha^{-1}) while the lowest millable cane production was observed in genotype I 111-03 (72.83×10^3 ha^{-1}). Similar results were also reported by Islam *et al.* (2011b), Islam *et al.* (2009a) and Hasan *et al.* (2003) under water-logging stress condition.

Stalk height

Significantly highest stalk height was recorded in varieties Isd 39 (2.81m) and while the lowest stalk height was obtained in genotype I 111-03 (2.24m) (Table 1). These

results are in agreement with findings of Alam *et al.* 2010, Rahman *et al.* 2010 and Islam *et al.* 2009c.

Stalk diameter

It was also seen from the Table 1 that the highest stalk diameter was obtained in variety Isd 39 (2.72 cm) and the lowest stalk diameter was obtained in genotype I 111-03 (2.06 cm). The findings of the present experiment are in agreement with Alam *et al.* 2010 and Kabiraj *et al.* 2007.

Cane yield

Cane yield have been shown in the Table 1. It was seen that the significantly highest cane yield were obtained in variety Isd 39 (98.04 t ha^{-1}) and the lowest cane yield was obtained in genotype I 111-03 (51.83 t ha^{-1}). The results were in agreement with Islam *et al.* (2011a), Rahman *et al.* (2010), Islam *et al.* (2009a) Islam *et al.* (2009b), Islam *et al* (2007), Kabiraj *et al.* (2007), Paul *et al.* (1994) and Miah *et al.* (1994) described different sugarcane varieties/promising genotypes and revealed different trend for cane yield per unit area.

Brix (%)

Table 2 shows that the highest Brix per cent were found under water-logging stress condition in genotype I 124-00 (20.8%), followed by genotype I 7-03 (20.2%), genotype I 111-03 (20.2%), variety Isd 40 (20.2%), genotype I 231-03 (20.0%), genotype I 112-01 (19.9%), variety Isd 39 (19.8%) while the lowest Brix per cent obtained in genotype I 78-03 (17.8%). These results were in agreement with findings of Islam *et al.* (2011a), Islam *et al.* (2011b), Rahman *et al.* (2010), Islam *et al.* (2009a), Islam *et al.* (2007) and Kabiraj *et al.* (2007) who studied Brix per cent of sugarcane varieties/clones and found different levels of Brix per cent.

Pol % juice

Pol % juice has been presented in the Table 2 and found that the highest pol % juice were obtained in variety I 124-00 (18.96%) and the lowest was I 78-03 (15.48%).

Pol % cane

Table 2 shows that the significantly highest pol per cent cane was found under water-logging stress condition in genotype I 124-00 (14.79%) and the lowest pol percent cane in genotype I 78-03 (12.07%). The results were in well agreement with the findings of Islam *et al.* (2011a) and Islam *et al.* (2011b).

Purity (%)

Purity per cent has been shown in Table 2. It was seen that the significantly highest purity per cent were obtained in genotype I 124-00 (91.17%) and the lowest purity per cent was obtained in genotype I 139-03 (86.17%). Present findings agree with the findings of Islam

et al. (2011a) who carried out studies on purity per cent in one commercial variety/five clones and found different results for purity per cent under water-logging stress condition.

Recoverable sucrose (%)

Recoverable sucrose per cent has been shown in Table 2. It was seen that the highest recoverable sucrose per cent was obtained in genotype I 124-00 (11.73%) followed by variety Isd 39 (11.10%) and variety Isd 40 (11.02%). The lowest recoverable sucrose per cent was obtained in genotype I 78-03 (9.31%). Similar results were also reported by Islam *et al.* (2011a) Islam *et al.* (2011b) and Islam *et al.* (2007).

Sugar yield

Sugar yield has been presented in the Figure 1 and found that the highest sugar yield were obtained in variety Isd 39 (10.88 t ha^{-1}) followed by variety Isd 40 (10.49 t ha^{-1}), genotypes I 231-03 (10.22 t ha^{-1}) and the lowest was I 139-03 (5.47 t ha^{-1}). The results were in agreement with the finding of Islam *et al.* (2011a), Islam *et al.* (2011b) and Islam *et al.* (2007).

Tolerance rating scale

Tolerance rating scale was measured on the basis of tiller number, millable cane number, cane yield, sugar yield, Brix per cent, purity per cent, pol per cent cane, and recoverable sucrose percent. Results of tolerance rating scale have been presented in Figure 1. It revealed that genotype I 231-03, variety Isd 39, variety Isd 40 were highly tolerant having tolerance rating scale 1 and genotypes I 124-00 was found to be tolerant to water-logging stress having tolerance rating 2. Genotypes I 112-01 and I 7-03, I 78-03 were found to be moderately tolerant to water-logging stress having tolerance rating scale 3 and genotypes I 111-03, I 137-03 and I 139-03 were found to be intolerant to water-logging stress having tolerance rating scale 4 against induced water-logging stress condition. These findings were in supported by Islam *et al.* (2011a), Islam *et al.* (2011b), Islam *et al.* (2009a) and Islam *et al.* (2009b).

CONCLUSION

It may be concluded that genotype I 231-03 may be considered as highly tolerant on the basis of cane yield, sugar yield and juice quality under induced water-logging stress condition.

Table-1 Yield and yield attributing parameters of ten sugarcane genotypes under water-logging stress condition

Genotypes	No. of tiller ($10^3 ha^{-1}$)	No. of millable cane ($10^3 ha^{-1}$)	Stalk height (m)	Stalk diameter (cm)	Cane yield (t ha^{-1})
I 124-00	121.28b	91.23abc	2.74ab	2.62ab	76.54b
I 112-01	119.63b	83.51cd	2.63abc	2.57ab	65.62c
I 7-03	121.65b	80.09de	2.51cd	2.48b	61.85c
I 78-03	120.92b	86.25bcd	2.57bc	2.54ab	63.57c
I 111-03	125.37b	72.83e	2.24e	2.06c	51.83d
I 137-03	115.35b	76.87de	2.27e	2.15c	53.05d
I 139-03	118.26b	78.53de	2.31de	2.18c	54.51d
I 231-03	137.73a	95.91ab	2.78ab	2.65ab	94.54a
Isd 39 (Standard)	124.47b	99.76a	2.81a	2.72a	98.04a
Isd 40 (Standard)	122.68b	97.41a	2.79ab	2.69a	95.25a
Level of significant	*	**	**	**	**
CV (%)	5.11	6.25	4.81	3.99	5.15
LSD (0.05)	10.77	9.24	0.21	0.17	6.31

** Significant at 1% level of probability, * Significant at 5% level of probability, NS = Not significant

Table-2 Juice quality and sugar yield of ten sugarcane genotypes under water-logging stress condition

Genotypes	**Brix (%)**	**Pol % juice**	**Pol % cane**	**Purity (%)**	**Recoverable sucrose (%)**
I 124-00	20.8a	18.96a	14.79a	91.17a	11.73a
I 112-01	19.9a	17.76a	13.86a	89.26abc	10.84b
I 7-03	20.2a	17.87a	13.94a	88.48bcd	10.85b
I 78-03	17.8c	15.48b	12.07b	86.97cd	9.31d
I 111-03	20.2a	17.80a	13.88a	88.10cd	10.79b
I 137-03	19.7ab	17.59a	13.72a	89.29abc	10.74bc
I 139-03	18.7bc	16.11b	12.57b	86.17d	10.05c
I 231-03	20.0a	17.76a	13.86a	88.82abc	10.81b
Isd 39 (Standard)	19.8a	17.99a	14.03a	90.85ab	11.10ab
Isd 40 (Standard)	20.2a	18.04a	14.07a	89.33abc	11.02ab
Level of significant	**	**	**	**	**
CV (%)	3.07	4.89	4.64	1.49	3.81
LSD (0.05)	1.04	1.47	1.09	2.28	0.70

** Significant at 1% level of probability, * Significant at 5% level of probability, NS = Not significant

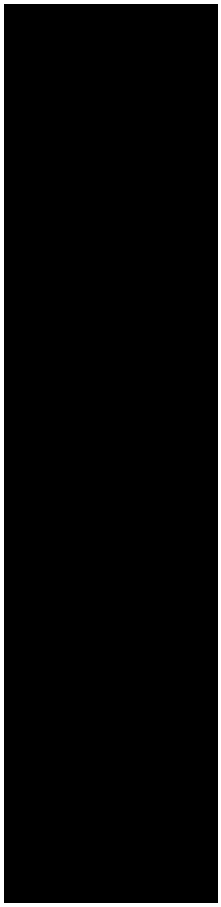

Figure-1 Sugar yield (t ha^{-1}) and tolerance rating scale of ten sugarcane genotypes under water-logging stress condition. ***Tolerance rating scale (1-5), where, 1 = Highly tolerant, 2 =Tolerant, 3 = Moderately tolerant, 4 = Intolerant and 5 = Highly intolerant.

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