World Journal of Agricultural Sciences 7 (4): 504-509, 2011
ISSN 1817-3047

Growth, Yield and Juice Quality of Some Selected Sugarcane Clones Under, Water-Logging Stress Condition

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Abstract: Growth, yield and juice quality of some selected sugarcane clones under water-logging stress condition was investigated at the Lalpur upazilla in Natore district of Bangladesh during November, 2006 to Decenber, 2007. The clones were I 24-00, I 80-00, I 124-00, I 133-00, I 149-00 and water-logging commercial variety Isd 20 (standard). Data were collected on tiller production, millable cane, cane yield, Brix per cent, purity per cent, pol per cent cane, reducing sugar per cent, recoverable sucrose per cent and sugar yield and tolerance rating scale. Significantly higher number of tillers was recorded in clone I 133-00 ($255.2 \times 10^3 ha^{-1}$) and the lowest tiller production was observed in clone I 124 ($208.3 \times 10^3 ha^{-1}$). The highest number of millable cane were recorded in variety Isd 20 ($114.4 \times 10^3 ha^{-1}$), clones I 133-00 ($110.6 \times 10^3 ha^{-1}$) and I 149-00 ($108.3 \times 10^3 ha^{-1}$). The highest cane yield and Brix per cent were obtained in clones I 133-00 and I 149-00, respectively. The highest purity per cent was obtained in variety Isd 20 (89.3%) followed by clone I 149-00 (87.7%), while the lowest purity per cent was obtained in clone I 80-00 (85.9%). The highest pol per cent cane was found under water-logging stress condition in clone I 149-00 (13.4%) followed by clone I 133-00 (13.2%), while the lowest pol per cent cane in clone I 80-00 (12.0%). The highest recoverable sucrose per cent was obtained in clone I 149-00 (10.3%) followed by variety Isd 20 (10.2%),while the lowest recoverable sucrose per cent was obtained in clone I 80-00 (9.1%). The highest reducing sugar per cent was recorded in clone I 80-00 (1.31%) and the lowest reducing sugar per cent were obtained in clones I 149 (0.91%), I 133 (0.94%) and variety Isd 20 (0.95%). The highest sugar yield were obtained in clones I 133-00 (10.2 t ha^{-1}) and I 149-00 (10.3 t ha^{-1}) and the lowest was I 24-00 (6.9 t ha^{-1}). Clones I 133-00, I 149-00 and variety Isd 20 are highly tolerant having tolerance rating scale 1 and clone I 80-00 was found to be tolerant to water-logging stress having tolerance rating 2. Clones I 24-00 and I 124-00 were found to be moderately tolerant to water-logging stress having tolerance rating scale 3 against natural water-logging stress condition. Thus, clones I 1 133-00 and I 149-00 showed the best performance in respect of cane yield, sugar yield, juice quality and utilization of potentiality breeding as parents to evolve varieties resistant to water-loggng.

Key word: Sugarcane · Water-logging · Tiller · Millable cane · Yield and juice quality

INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is an important sugar crops in the world. It is grown as cash crop in Bangladesh. It faces different vagaries of nature including biotic/abiotic stress during its active growth phases. Water-logging is one of the serious environmental constrain for optimum growth and yield of sugarcane. Higher rate of stalk mortality, low relative growth rate and reduced cane yield are major effects of water-logging. In Bangladesh water-logging is associated with monsoon rainfall, river floods, inadequate and improper drainage facilities due to unplanned road development. Cane yield and juice quality loss due to water-logging depends upon genotype, environmental conditions, stage of development and duration of inundation [1]. 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

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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 [2,3], although sugarcane is a relatively tolerant to high water tables and flooding [4-8]. It is reported that well-established cane can survive few months in to flood, while less established cane appears to be much more vulnerable to flooding [9]. The reduction in yield attributed to low moisture and nitrogen in the tissue at grand growth phase. Increase number of internodes, profuse tillering and increase in % P in both stem and plant as a whole, decrease in nitrogen content characterized tolerance to flood condition [10]. 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. Plant hormones have been shown to play an important role in adaptation to match an adverse environmental stress. Nutrient uptake is badly affected under water-logging where aerobic respiration by sugarcane root system is poor [11]. 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 [12]. 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 [13]. Therefore, the present study was undertaken to study the growth, yield and juice quality of some selected sugarcane clones under water-logging stress condition.

MATERIALS AND METHODS

The experiment was conducted at water-logging prone farmers' field at Lalpur upazilla in Natore district of Bangladesh with five selected sugarcane clones viz. I 24-00, I 80-00, I 124-00, I 133-00, I 149-00 and one water-logging tolerant slandered variety Isd 20 during 2006-2007 cropping season. 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, 2006. NPKS fertilizers were applied @ 325kg 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 MP, one third urea were applied at planting. Rest of urea and MP were applied as top dressing. For sugarcane to control 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, 2007. All cultural practices were done as and when required. In the month of July to October the experimental field inundated 30-90 cm for 120 days to create water-logging stress condition. 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, 2007.

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 (ADP-220) by Horne's dry lead method. Pol% cane per cent was calculated by the method prescribed in Queensland Laboratory Manual [14], while reducing sugars were measured by Lanc and Eynon method [15].

Brix (%): Percentage of total soluble solids percent 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:

$$\text{Recoverable sucrose \%} = \{\text{Pol} - (\frac{Brix - Pol}{2})\} \times Juicefactor$$

Where, juice factor was 0.65 (extraction percentage)

Sugar Yield: Sugar yield was calculated using the following formula:

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

Data were analyzed statistically by Duncan's New Multiple Range (DNMRT) Test.

RESULTS AND DISCUSSION

Tiller Production: In the present study significantly difference in tillers production were obtained in different tested clones. The results on tiller production have been presented in the Table 1. Significantly highest number of tillers production was recorded in clone I 133-00 (255.2 × 10^3ha^{-1}) followed by clones I 149 (251.4 × 10^3ha^{-1}), I 80-00 (238.9 × 10^3ha^{-1}), while the lowest tillers production was observed in clone I 124 (208.3 × 10^3ha^{-1}) under water-logging stress condition. The results are in agreement with this finding of BSRI [16-17].

Millable Cane Production: The results on millable cane have been presented in the Table 1. Significantly highest number of millable cane were recorded in variety Isd 20 (114.4 × 10^3ha^{-1}), clones I 133-00 (110.6 × 10^3ha^{-1}), I 149-00 (108.3 × 10^3ha^{-1}) under water-logging stress condition followed by clones I 80-00 (96.1 × 10^3ha^{-1}), I 24-00 (88.3 × 10^3ha^{-1}), while the lowest millable cane production was observed in clone I 124-00 (78.3 × 10^3ha^{-1}). Present findings are in agreement with those obtained by Bokhtiar and Sakurai [18].

Cane Yield: Cane yield have been shown in the Table 1. It was seen that the significantly highest cane yield were obtained in clones I 133-00 (101.2 t ha^{-1}), I 149-00 (99.8 t ha^{-1}) and the lowest cane yield were obtained in clone I 24-00 (71.3 t ha^{-1}) and I 124-00 (65.8 t ha^{-1}). The results are in agreement with Rahman *et al*. [19], Islam *et al*. [20], Islam *et al*. [21], Kabiraj *et al*. [22], Hossain *et al*. [23], Paul, *et al*. [24] and Miah *et al*. [25], who carried out studies on different sugarcane varieties/promising clones and found different trend for cane yield per unit area.

Brix (%): Table 2 shows that the significantly highest Brix per cent were found under water-logging stress condition in clones I 149-00 (19.5%) and I 133-00 (19.3%) and the lowest Brix per cent in clone I 80-00 (17.8%).

Table 1: Effects of water-logging stress on tillers and millable cane and cane yield of some selected sugarcane clones

Clones / Varieties	Tillers (× 10^3 ha^{-1})	Millable cane (× 10^3 ha^{-1})	Cane yield (t ha^{-1})
I 24-00	227.8 bc	88.3 b	71.3 c
I 80-00	238.9 ab	96.1 b	88.0 b
I 124-00	208.3 c	78.3 c	65.8 c
I 133-00	255.2 a	110.6 a	101.2 a
I 149-00	251.4 ab	108.3 a	99.8 a
Isd 20 (Std.)	217.7 c	114.4 a	97.2 b
CV (%)	6.09	5.16	7.27
LSD (0.05)	24.20	8.82	10.80

Mean values in a column having the same letter (s) do not differ significantly at 5% level of probability as per DMRT

Table 2: Effects of water-logging stress on juice quality of some selected sugarcane clones

Clones / Varieties	Brix (%)	Purity (%)	Pol % cane
I 24-00	18.4 b	86.9 cd	12.6 c
I 80-00	17.8 c	85.9 e	12.0 d
I 124-00	18.2 b	86.8 d	12.4 c
I 133-00	19.3 a	87.0 c	13.2 ab
I 149-00	19.5 a	87.7 b	13.4 a
Isd 20 (Std.)	18.7 b	89.3 a	13.1 b
CV (%)	1.03	0.10	1.11
LSD (0.05)	0.33	0.15	0.24

Mean values in a column having the same letter (s) do not differ significantly at 5% level of probability as per DMRT

These results are in agreement with findings of Rahman *et al*. [19], Islam *et al*. [18], Islam *et al*. [21], Khan *et al*. [26] and Kabiraj *et al*. [22] who studied a number of sugarcane varieties/clones and found different levels of Brix per cent.

Purity (%): Significantly differences purity per cent have been shown in the Table 2. It was seen that the highest purity per cent was obtained in variety Isd 20 (89.3%) followed by clone I 149-00 (87.7%), while the lowest purity per cent was obtained in clone I 80-00 (85.9%) under water-logging stress condition. Present findings agree with the findings of Islam *et al.* [21] who carried out studies on purity per cent in three commercial varieties/nine clones and found different results for purity per cent under water-logging stress condition.

Pol % Cane: The Table 2 shows that the significantly highest pol per cent cane was found under water-logging stress condition in clone I 149-00 (13.4%) followed by clone I 133-00 (13.2%), while the lowest pol per cent cane in clone I 80-00 (12.0%) under water-logging stress condition. The results are in agreement with the finding of Arefin *et al*. [27].

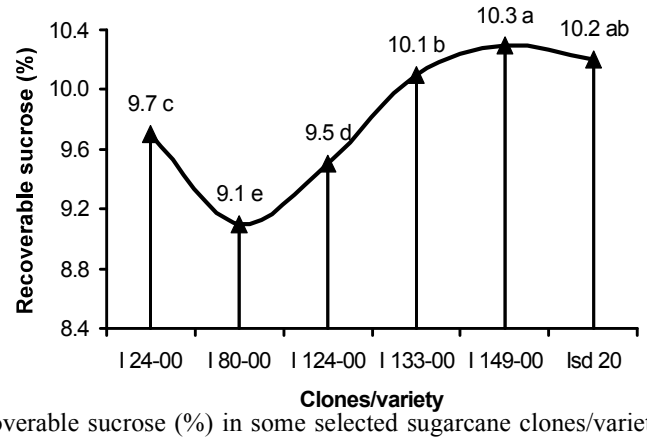

Fig. 1: Performance of recoverable sucrose (%) in some selected sugarcane clones/variety under water-logging stress condition

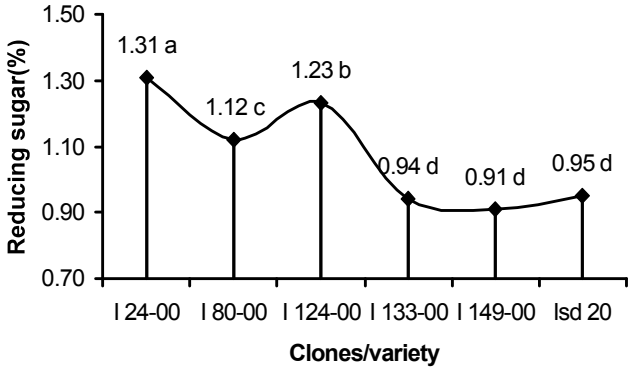

Fig. 2: Performance of reducing sugar (%) in some selected sugarcane clones/variety under water-logging stress condition

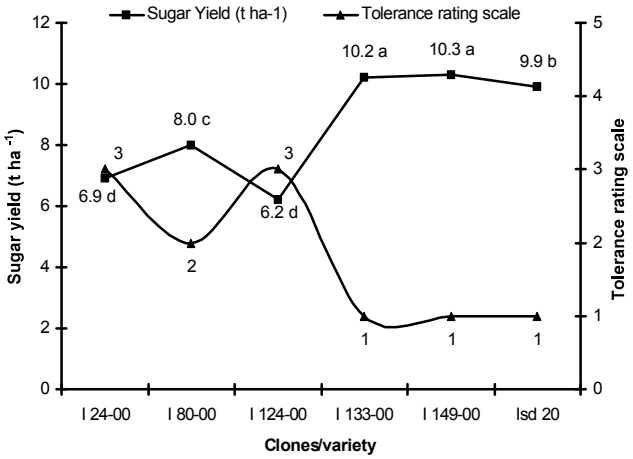

Fig. 3: Performance of sugar yield (t ha^{-1}) and tolerance rating scale in some selected clones/variety under water-logging stress condition
Tolerance rating scale (1-5), 1 = highly tolerant, 2 = tolerant, 3 = moderately tolerant, 4 = intolerant and 5 = highly intolerant

Recoverable Sucrose (%): Recoverable sucrose per cent has been shown in the Figure 1. It was seen that the significantly highest recoverable sucrose per cent was obtained in clone I 149-00 (10.3%) followed by variety Isd 20 (10.2%) and the lowest recoverable sucrose per cent was obtained in clone I 80-00 (9.1%) under water-loggong stress condition. Similar results were also observed by Islam *et al*. [21] under water-loggong stress condition.

Reducing Sugar (%): Results on reducing sugar per cent have been presented in the Fig. 2. Significantly highest reducing sugar per cent was recorded in clone I 80-00 (1.31%) and the lowest reducing sugar per cent were obtained in clones I 149 (0.91%), I 133 (0.94%) and variety Isd 20 (0.95%) under water-logging stress condition. The results are in agreement with the finding of Jabber *et al*. [28], who studied five clones and one commercial variety and found different levels of reducing sugar per cent.

Sugar Yield: The significant result was found on sugar yield due to water-logging stress condition (Fig. 3). The highest sugar yield were obtained in clones I 133-00 (10.2 t ha^{-1}) and I 149-00 (10.3 t ha^{-1}) followed by variety Isd 20 (9.9 t ha^{-1}) and the lowest was I 24-00 (6.9 t ha^{-1}) under water-logging stress condition. The results are in agreement with the finding of Islam *et al*. [21], Hossain, [29], Bokhtiar and Sakurrai, [29].

Tolerance Rating Scale: Tolerance rating scale was measured on the basis of tiller number, millable cane number, cane yield, Brix per cent, purity per cent, pol per cent cane, recoverable sucrose per cent, reducing sugar and sugar yield. Results of tolerance rating scale have been presented in the Figure 3. It is revealed that clones I 133-00 and I 149-00and variety Isd 20 are highly tolerant having tolerance rating scale 1 and clone I 80-00 was found to be tolerant to water-logging stress having tolerance rating 2. Clones I 24-00 and I 124-00 were found to be moderately tolerant to water-logging stress having tolerance rating scale 3 against natural water-logging stress condition. Islam *et al*. [30] also observed similar result while they studied tolerance rating scale under water-logging stress condition. BSRI [16] and BSRI [17] also reported that same results under water-logging stress condition.

CONCLUSIONS

From the study it may be concluded that clones I 1 133-00 and I 149-00 proved that highly tolerant potential under natural water-logging stress condition in respect of cane yield, sugar yield, juice quality.

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