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Stability assessment of different sugarcane clones under flood stress condition

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ABSTRACT

An experiment was carried out in flood-prone areas in farmers' fields at Chunarughat and Pakshy (Ishurdi) of Bangladesh during the cropping season 2017-2018. For this study, nine selected clones and one BSRI Released variety viz: I 103-11, I 7-11, I 111-11, I 230-11, I 36-12, I 143-12, I 146-12, GT-11, G -17 and Isd 39 (standard) were planted following RCB design with three replications. The trial was conducted to screen flood stress tolerant clones. Significant differences were observed for all parameters of tested sugarcane in both locations. At Chunarughat location, the highest cane yield (107.34 tha^{-1}) was found in GT-11, which was followed by I 111-11 and GT-17. At Pakshy (Ishurdi) location, the highest cane yield (136.37 tha^{-1}) was found in GT-17, followed by I111-11. At Chunarughat location, the highest brix % (21.73) was found in I 111-11 that, followed by I 146-12 and GT-17. At Pakshy (Ishurdi) location, the highest brix% (21.03) was found from GT -17, followed by I 111-11, I 146-12 and GT-17. The clones I 111-11, GT-17 and GT-11 might be considered highly tolerant under flood stress conditions showed highly tolerant reaction, having tolerance rating of 1 in both locations. This screening program will help the breeders for selecting suitable varieties for flood situations.

***Key Words**: Sugarcane, Clone, Yield, Brix %, Intolerant and Tolerant.*

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I. Introduction

Sugarcane (*Saccharum officinarum* L.) is a vegetative propagated perennial crop. It is a cash crop, main source of white sugar and jaggary (locally called gur) in Bangladesh. It is a commercially important crop that accounts for approximately 65% of global sugar production (Deho et al., 2002). Besides

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sugar production, it also produces numerous valuable by-products like alcohol, used in pharmaceutical products; ethanol, used as a fuel; bagasse, used for paper and chipboard manufacturing and used as a rich source of organic matter as well as nutrients for sustainable crop production (Majid, 2007). It is one of the most important sugar producing crops in tropical and sub-tropical countries (Mehareb, 2015). It is mainly grown in high and medium high land under rainfed conditions, mainly in the north-west and south-west regions of the country. Farmers can harvest the potential cane and sugar yield in sugarcane growing countries. The soil and climate of Bangladesh are very much congenial to sugarcane production, but the cane yield is around 46 tha^{-1}, which is relatively low compared to other sugarcane growing countries (Islam et al., 2017). Yield of sugarcane is inferior due to various reasons; among them, vulnerability of sugarcane to water stress such as flood, water-logging, drought and non availability of promising varieties are most important in Bangladesh (Begum et al., 2008; Naich et al., 2006).

Flooding (waterlogged/ponded/saturated/submerged soil) is one of the crucial stress factors that has an appreciable effect on crop growth, ultimately leading to reduced yield and production of different crop plants (Normile, 2008). In Bangladesh, about one-third of sugarcane is now growing in the lowlands, where the plants remain under floodwater during summer for a considerable long time (Hasan et al., 2003). Generally, the extent of damage caused by flooding on sugarcane differs between the genotypes, environmental conditions, growth stage and stress duration (Gomathi et al. 2014). However, because of the rising global temperature accompanied by changes in weather and climate, which results in more frequent and more severe flooding, negative effects on sugarcane are often observed, particularly during the rainy season. Cane and sugar yield decreased because of decreasing photosynthesis, root development, tiller production, stalk height and sucrose yield (Gomathi et al., 2014; Viator et al., 2012). Sugarcane production and yield could never be improved until and unless promising varieties and technologies are adopted on large scale (Glaz, 2000). Some sugarcane genotypes highly adapt to flooding by developing adventitious roots with well-developed aerenchyma to assist in the maintenance of root activity and the supply of required oxygen and also contribute to higher dry matter accumulation (Jaiphong et al., 2016; Gomathi et al., 2014). Therefore, this experiment was conducted in flood-prone areas of Chunarughat and Ishurdi to collect information on adaptability, yield and quality of different sugarcane genotypes under flood stress conditions.

II. Materials and Methods

An experiment was carried out at flood-prone areas in farmers' fields at Chunarughat and Pakshy (Ishurdi) locations of Bangladesh during the cropping season 2021-22. For this study, nine selected clones and one BSRI Released variety viz: I 103-11, I 7-11, I 111-11,I 230-11, I 36-12, I 143-12, I 146-12, GT-11, GT-17 and Isd 39 (standard) were planted following Randomized Complete Block Design with three replications. The unit plot size was 6 m × 6 m, conventional two budded setts were used in the experiment. Row to row distance was 90 cm and sett placement was end to end. The setts were planted on 25thNovember, 2021 and harvested 15th December, 2022. Fertilizers were applied following the recommended rate from fertilizer recommendation guide (BARC, 2012). Intercultural operations like weeding, mulching, irrigation, earthling up, tying etc. were done accordingly in proper time. The experimental field was inundated up to 90 cm by flood water and keep up to 90 days (Miah et al., 1993). Tiller was counted before the flood stress condition, but mill able cane, cane yield, brix (%) and tolerance rating scale during flood stress condition were recorded at harvest. Tolerance rating scale was recorded based on greenness of leaves and visually looks fresh. Fisher's analysis of variance (ANOVA) was used for statistical analysis of collected data and for comparison of differences among treatment means. Least significant difference (LSD) test was done at a 5% level of probability (Steel et al., 1996). Statistics 10 (Tallahassee FL 32317) was used to determine statistical differences.

III. Results and Discussion

Tiller Population

The highest number of tiller production (198.33 × 10^3 ha^{-1} and 146.47 × 10^3 ha^{-1}) was counted in Isd 39 at both locations, which were statistically similar with 230-11 at Chunarughat location but statistically similar with GT-17, I 143-12, I 103-10 and GT-11 at Pakshy (Ishurdi) location. The lowest tiller production of 106.67×10^3 ha^{-1} was counted in I 143-12 at Chunarughat location, which was statistically similar to I 143-12 whereas at Pakshy (Ishurdi) location, the lowest number of tiller

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(117.65× 10^3) was counted in I 230-11 which was statistically similar with clone I 111-11, I 146-12 and I 36-12 (Table 01). Variation in tiller production among the different clones/varieties was reported by Miah et al. (1994). They reported that the highest tiller was found from LJC (137.6× 10^3 ha^{-1}) and lowest tiller production from (I-2226/83) among the ten tested clones/variety.

Millable cane

The number of millable cane directly influences cane yield. The number of millable canes produced varied significantly with varying clones of sugarcane. The highest number of millable cane was found from the variety Isd 39 (109.34 × 10^3) at Chunarughat location, which was statistically similar to GT-11, I 111-11, I 103-10 and GT-17 (Table 01). At Pakshy (Ishurdi) location, the highest number of millable cane (125.10 × 10^3) was found from GT -17, which was statistically similar to Isd 39, I 143-12, I 103-10 and I 7-11 (Table 02). The lowest number of millable cane 65.00 × 10^3 ha^{-1} was found from I 143-12 at Chunarughat location, which was statistically similar to I 36-12 and I146-12. At Pakshy (ishurdi) location, the lowest number of millable cane (99.41 × 10^3) was found from the clone I 146-12, which was statistically similar to GT-11 (Table 02). These findings were in close agreement with the findings of Islam et al. (2013). They found variations of millable cane of different sugarcane clones at different locations under waterlogging stress conditions and the highest number of millable cane was found in I 231-03 (141.9 × 10^3) at Jamalpur location and lowest number of millable cane was found from I 07-07 (93.9 × 10^3) clone at Sirajganj location.

Stalk diameter

Stalk diameter is a vital yield-contributing trait and use of large stalk diameter would enhance the acceptability of varieties from the commercial point of view (Rashid, 2017). The highest stalk diameter (2.32 cm and 2.41cm) was observed in GT-17 at both locations, which was statistically similar with the clone I GT-11, I 143-12, I 111-11, Isd 39 and I 7-11 at Chunarughat location (Table 01) but statistically similar with I 111-11, GT-11 and I 143-12 at Pakshy (Ishurdi) location (Table 02). The lowest stalk diameter (1.82 cm and 2.10 cm) was observed in I 146-12 at both locations, which was statistically similar to I I 103-10 at Chunarughat location, whereas statistically similar to I 103-10, I 230-11, Isd 39, I 7-11 and I 36-12 at Pakshy (Ishurdi) location (Table 02).

Table 01. Productivity of sugarcane clones/variety under flood stress conditions at Chunarughat location

Clones/Variety	Tiller (×10^3 ha^{-1})	Millable cane (×10^3 ha^{-1})	Stalk diameter (cm)	Cane yield (tha^{-1})	Brix (%)
I 103-10	180.00 bc	93.16 ab	1.88 d	59.63 de	19.00 bc
I 7-11	171.00 bc	83.34 b	2.16 abc	68.34 cd	15.67 e
I 111-11	176.67 bc	98.00 ab	2.24 abc	98.80 a	21.73 a
I 230-11	186.33 ab	85.50 b	2.13 bc	70.11 bcd	17.03 de
I 36-12	146.67 d	69.00 c	2.10 c	49.68 f	17.10 de
I 143-12	116.67 e	75.00 c	2.27 abc	79.60 b	16.57 de
I 146-12	113.00 e	81.16 bc	1.82 d	50.33 ef	21.63 a
GT-11	176.67 bc	107.34 a	2.30 ab	107.34 a	19.00 bc
GT-17	163.33 cd	90.33 ab	2.32 a	91.30 ab	20.00 ab
Isd 39	198.33 a	109.34 a	2.17 abc	78.22 bc	17.67 cd
Lsd (0.05)	17.24	5.84	0.18	11.90	1.88

Cane yield

In flood stress conditions at both locations, all clones/varieties significantly affected cane yield. The highest cane yield 107.34 tha^{-1} was obtained from clone GT-11, which was statically similar to I 111-11 and GT-17 at Chunarughat (Table 01), while the highest cane yield 136.37 $tha^{-1}$was obtained in GT-17 at Pakshy (Ishurdi), location which was statistically similar with I 111-11 (Table 02). The lowest cane yield was obtained from clone I 36-12 (49.68 tha^{-1}), which was statistically similar to I 146-12 at Chunarughat location (Table 01), whereas at Pakshy (Ishurdi) location, the lowest cane yield (77.54 tha^{-1}) was obtained from I 146-12 which was statistically similar with I 230-11. The result agreed with Islam et al. (2013), which showed that different sugarcane varieties/promising clones show different cane yield trends per unit area. They observed the highest cane yield in Isd 39 (99.7 tha^{-1}) at Jamalpur location and the lowest cane yield (60.4 tha^{-1}) at Natore location.

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Brix (%)

Brix reading significantly differed among the clones/variety. The highest brix% of 21.73 was recorded from clone I 111-11, which was statically similar to I 146-12 and GT-17 at Chunarughat while highest brix% (21.03) was obtained in GT-17 at Pakshy (Ishurdi) location, which was statically similar with I 111-11, I 146-12, I 103-10 and GT-11 (Table 02). The lowest brix%15.67 was recorded from clone I 7-11 which was statically similar to I 143-12, I 230-11 and I 36-12 at Chunarughat (Table 01), whereas at Pakshy (Ishurdi) location, the lowest brix% 16.27 was recorded from I 230-11 which was statically similar with I 36-12, I 7-11 and I 143-12 (Table 02). A similar result was found by (Islam et al., 2011; Begum et al., 2013; Rashid et al., 2017). They studied several sugarcane clones/varieties and found different levels of Brix percent.

Table 02. Productivity of sugarcane clones/variety under flood stress conditions at Pakshy (Ishurdi) location

Clones/Variety	Tiller ($\times 10^3$ ha^{-1})	Millable cane ($\times 10^3$ ha^{-1})	Stalk diameter (cm)	Cane yield (tha^{-1})	Brix (%)
I 103-10	142.35 ab	116.86 a	2.12 d	100.50 de	20.17 ab
I 7-11	139.74 abc	112.54 a	2.23 bcd	108.04 cd	17.20 cd
I 111-11	125.29 de	99.41 b	2.35 ab	121.34 ab	20.45 ab
I 230-11	117.65 e	98.43 b	2.17 cd	80.72 f	16.27 d
I 36-12	130.00 b-e	110.40 b	2.23 bcd	99.36 e	16.77 d
I 143-12	142.94 ab	120.39 a	2.31 abc	107.15 cde	17.67 cd
I 146-12	127.65 cde	99.41 c	2.10 d	77.54 f	20.42 ab
GT-11	138.24 a-d	105.49 bc	2.33 ab	108.65 bc	19.33 abc
GT-17	145.29 a	125.10 a	2.41a	136.37 a	21.03 a
Isd 39	146.47 a	122.55 a	2.20 bcd	116.42 b	19.27 abc
Lsd (0.05)	13.25	4.44	0.16	8.14	2.23

Plant height

Figure 01 shows that the highest plant height 4.53m, was obtained from I 143-12 clone at Chunarughat location, which was statistically similar to I 111-11, GT-17 and I 230-11. At the Pakshy (Ishurdi) location, the highest plant height was 4.78 m, which was measured in the I 111-11 clone, which was statistically similar to I 143-12 and GT-17. The lowest plant height, 4.16m was measured from I 146-12 clone at Chunarughat location which was statistically similar to I 103-10, I 36-12, GT-11, I 7-11, Isd 39 and I 230where at Pakshy (Ishurdi) location the lowest plant height 4.29 m was obtained from I 103-10 clone which was statistically similar with I 7-11, I 146-12, GT-11 and I 36-12.

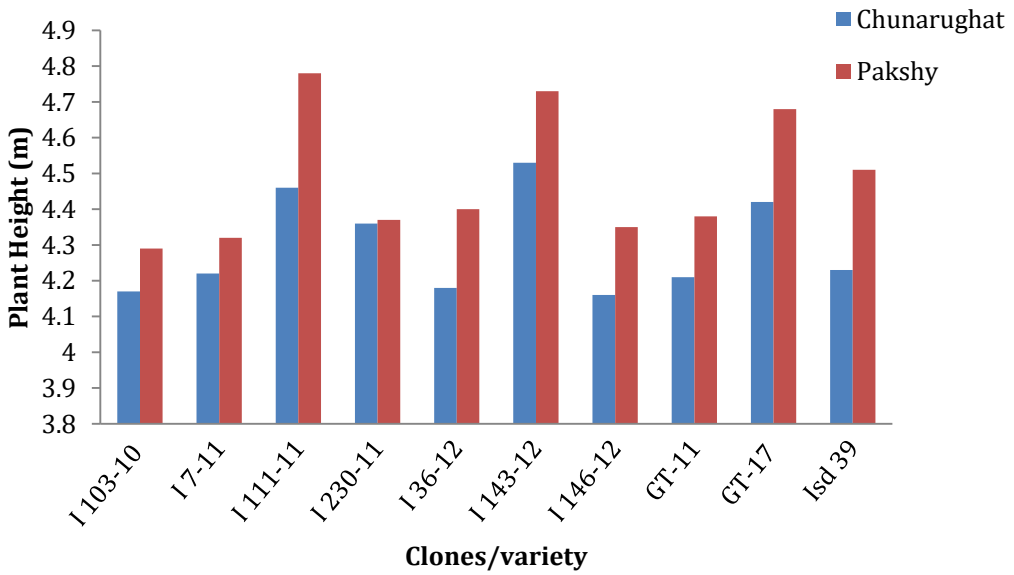

Figure 01. Plant heigh of sugarcane clones/variety at Chunarughat and Pakshy (Ishurdi) locations

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Stalk height

Figure 02 shows that the highest stalk height 3.29 m, was measured from I 143-12 at Chunarughat location, which was statistically similar to I 111-11, GT-17, Isd 39 and I 230-11. At Pakshy (Ishurdi) location highest stalk height, 3.43 m was measured at I 111-11, which was statistically similar to I 143-12 and GT-17 and Isd 39. The lowest plant height 2.93 m was measured in I 103-10 at Chunarughat location, which was statistically similar to I 146-12, I 36-12, I 7-11, GT-11, I 230-11 and Isd 39, whereas at Pakshy (Ishurdi) location, the lowest stalk height 2.88 m was measured in I 146-12 which was statistically similar with I 36-12, I 230-11I 7-11 and GT-11.

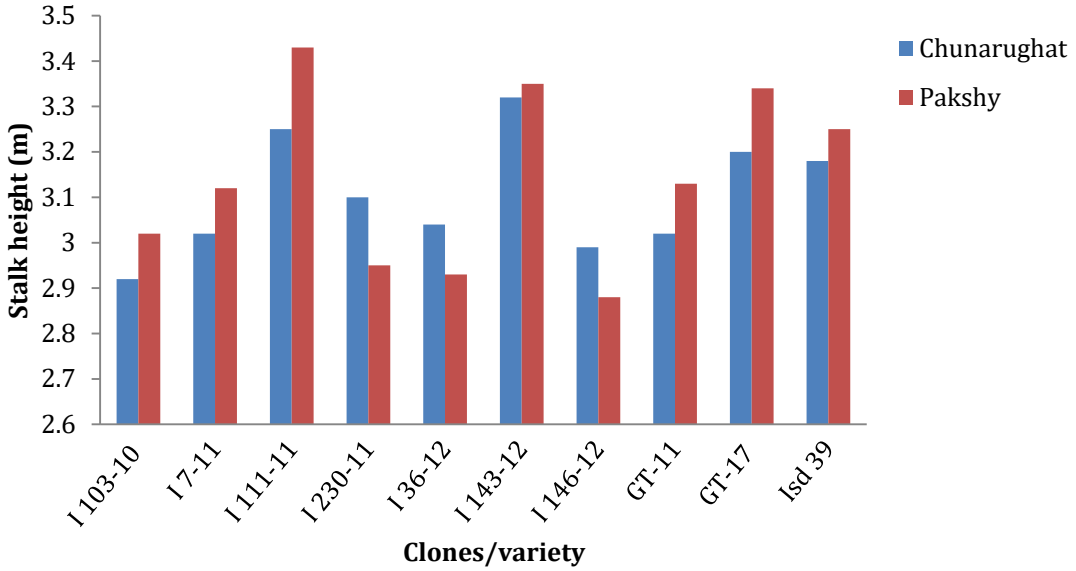

Figure 02. Stalk height of sugarcane clones/variety at Chunarughat and Pakshy (Ishurdi) location

Tolerance rating scale

Tolerance considered based on bear comparatively greener leaves and visually looking fresh may be selected as tolerant clones for flood stress. Tolerance rating scale was measured on the basis of tiller number, millable cane, cane yield, brix % (Islam et al. 2011). Among tested clones/variety I 230-11, GT-17, GT-11 and Isd 39 were highly tolerant with tolerance rating scale 1 and I 103-10,I 7-11 and I 111-11 were found to be tolerant to flood stress with a tolerance rating scale 2. The clone I 36-12, I 143-12 and I 146-12 were found to be moderately tolerant to flood stress, having tolerance rating of scale 3 at Chunarughat location, whereas at Pakshy (Ishurdi) location, the clones about all clones/variety to be highly tolerant except I 146-12. Colne 146-12 was moderately tolerant (Table 03). The results were reported by Islam et al. (2011). They observed that the tested clones/variety showed various flood tress tolerance characteristics.

Table 03. Tolerance Rating Scale of sugarcane clones/variety at Chunarughat and Pakshy (Ishurdi) location

Clones/Variety	Grading (1-5)*	
	Chunarughat	Pakshy (Ishurdi)
I 103-10	2	1
I 7-11	2	1
I 111-11	1	1
I 230-11	1	1
I 36-12	3	1
I 143-12	3	1
I 146-12	3	2
GT-11	1	1
GT-17	1	1
Isd 39	1	1

*Tolerance rating scale (1-5) is based on greenness of plants and other data collected, where, 1 = Highly tolerant, 2 = Tolerant, 3 = Moderately tolerant, 4 = Intolerant and 5 = Highly intolerant

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IV. Conclusion

Flood stress tolerance in sugarcane is often complex due to its long crop duration, nature and period of flooding, which vary with the place. Flood stress tolerance and all other economic traits of yield, quality and other stress resistance/tolerance in the desired variety will drastically increase the selection pressure to be applied for developing the variety. The overall result revealed that among nine tested clones and one check variety I 111-11 was given highest plant height, stalk height, salk diameter, highest cane yield, brix percentage (21.73 and 21.03) and tolerant rating scale at both locations, which followed by GT -17 and GT-11. It may be concluded that the clones clone I 111-11, GT -11 and GT-17 showed better performance under flood stress conditions might be considered highly tolerant based on greener leaves and visually look fresh, maximum tiller & mill able cane production ability, higher plant height, stalk height, cane yield and brix % under induced clones for flood stress condition.

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