Screening Salinity Tolerant Sugarcane Varieties Considering Yield, Quality and Economic Parameters in Southern Region of Bangladesh

KS Alam[1] MS Islam[2] GMA Hossain[3] and KM Alam[4]

Present address
[1]SSO and In-charge Sub-Station, BSRI Rahmatpur, Barisal
[2]SO and In-charge, Sub-Station, BSRI, Joypurhat
[3]PSO and Head, Soils and Nutrition Division BSRI Ishurdi, Pabna [4]SSO and In-charge, Sub-Station, BSRI, Jamalpur, Barisal

Correspondence*
hossaingma@yahoo.com

Accepted
15 March, 2018

Abstract

Sugarcane is considered to be a moderately sensitive crop to salinity stress. The degree of this sensitivity varies from crop to crop and varieties to varieties, even grown in a same condition. To realise this problems a field experiment was conducted during 2013-14 cropping season at Kalapara of Patuakhali district under southern region of Bangladesh to screen the salinity tolerant sugarcane varieties. The experiment was laid out in Randomized Complete Block Design (RCBD) having three replications. Five sugarcane varieties such as Isd 37, Isd 38, Isd 39, Isd 40 and VMC-86-550 were taken as treatments. The results demonstrate that there were significant differential responses among the evaluated sugarcane varieties in respect of yield, quality and economic parameters in saline condition. Maximum number of tillers (144.50×10^3 ha^{-1}) and millable cane (117.67×10^3 ha^{-1}), and maximum values in brix (20.0%) and goor yield (9.23 tha^{-1}) were observed in variety Isd 39. However, the variety Isd 40 scored the first position regarding cane yield (102.90 tha^{-1}) and benefit cost ratio (2.14). The possible reason behind the differential performances of the varieties might be the respective degree of genetic potentiality to overcome the salinity stress. The sugarcane varieties Isd 40 and Isd 39 showed more tolerance behavior to salinity among the five varieties in the southern region of Bangladesh.

Key words: Salinity tolerant, sugarcane varieties, southern region

Introduction

The coastal area of the southern region of Bangladesh is characterized by tides and salinity from the Bay of Bengal. Salinity intrusion due to a reduction of fresh water flow from upstream, salinization of groundwater and fluctuation of soil salinity are the major concern of the coastal area of the country (IWM, 2014).

More than 30% of the cultivable land in Bangladesh is in the coastal area and about 1.056 million ha of arable lands of coastal and off-shore area (2.86 million hectares) are affected by varying degrees of salinity. Farmers mostly cultivate low yielding, traditional rice varieties during wet season. Most of the land remains fallow in the dry season (January-May) because of soil salinity, lack of good quality irrigation water and late draining condition (Karim *et al*., 1990; and SRDI, 2001). Salinity is one of the major abiotic stresses that adversely affect crop quality and productivity. It inhibits plant growth by ion toxicity, nutritional imbalances, osmotic effect and oxidative stress (Leigh and Wyn Jones, 1984; Zhu, 2001; Chinnusamy *et al.*, 2005). High Na^+ concentration in the external solution cause a decrease in both K^+ and Ca^{2+} concentrations in plant tissues (Hu and Schmidhalter, 2005) due to the antagonism of Na^+ and K^+ at uptake site in the roots, the effect of Na^+ on K^+ transport into the xylem (Lynch and Lauchli, 1984) or the inhibition of uptake processes (Suhayda *et al.*, 1990). Excess of Na^+ in plant tissues increases the utilization of energy that the plants must use to acquire water from the soil and to make biochemical adjustments. This energy is diverted from processes that lead to growth and yield (Yeo, 1983), which consequently resulted in reduced plant growth. Sugarcane is a typical glycophyte exhibiting stunted growth or no growth under salinity (Subbarao and Shaw, 1985). Salinity in the root zone of sugarcane decreases sucrose yield, through its effect on both, biomass and juice quality (Lingle and Wiegand, 1996). Saline soil reduces millable stalks per hectare, stalk length, and stalk weight (Wiegand *et al.*, 1996). The decrease in yield is 0% at EC 1.7, 10% at 3.3, 25% at 6, 50% at 10.4 and 100% at 18.6 dSm^{-1} (Blackburn, 1984). However, Rozeff (1995) suggested that a steep decline in growth may take place once the EC rises above 3 dSm^{-1}, although plants may survive up to 10-15

dSm^{-1} depending upon genotypes. Various approaches like engineering techniques and the use of amendments as well as mineral nutrients are advocated to improve plant survival under salt stress (Marschner, 1995). Nevertheless, plant species and their genotypes differ genetically in their adaptation to salt stress environment (Rozeff, 1995; Wahid *et al.,* 1997). Characteristics like dry matter production, Na" accumulation and K+/Na+ ratio have been considered useful guide to assess plants for salt tolerance. Selection of crop genotypes on this basis is an important strategy to minimize yield losses in saline soils (Santa-Maria and Epstein, 2001). Tolerant plants have adopted certain strategies of ion regulation at root (Wahid *et al.*, 1999), stem (Wolf *et al.,*1992) or leaf level (Kumar *et al.*, 1994). Proper evaluation of the crop varieties against salinity may prove highly fruitful venture for its successful cultivation in problem soils. Considering the above facts and situations the experiment was conducted in the southern region of Bangladesh.

Materials and Methods

The field experiment was conducted at Hazipur of Kalapara upazila in Patuakhali district during 2013-14 cropping season to screen the salinity tolerant sugarcane varieties using yield, quality and economic parameters. The soil pH of the experimental field was 7.8 with organic carbon-0.56%, N-0.05%, P-6.8 ppm, K-0.11 meq% and S-14 ppm. The experiment was laid out in Randomized Complete Block Design (RCBD) having three replications. Five sugarcane varieties such as Isd 37, Isd 38, Isd 39, Isd 40 and VMC-86-550 were included as treatments. Two eyed soil bed seedling was used for plantation. Line to line and seedling to seedling spacing was maintained 1 M and 50 cm, respectively. Uniform application of recommended rates of N, P, K, S, Mg, B and Zn @ 165, 55, 120, 30, 10, 2 and 2.5 kg ha^{-1} was done. Cowdung was applied @ 12.5 tha^{-1} in the plot prior seven days of planting and mix well with the soil. The seedlings were planted on 19 December 2013. Necessary intercultural operations were done throughout the cropping season for proper growth and development of the crop. Data on number of tillers were taken at 150 days after planting (DAP) whereas data on number of millable cane and total soluble solids or brix (%) were recorded at proper maturity. Brix% in juice samples were determined using hand refractometer. Crops were harvested on 11 December 2014 and data on cane yield were taken. The harvested sugarcane samples from each variety were crushed using power crusher and goor preparation was done. The prepared goor was tested by organoleptic taste method. Collected data were compiled and tabulated in proper form and were subjected to statistical analysis by using the computer package Statistix 10 program for Windows Version. Computation was done by the use of Microsoft Excel 2003 program. The cost and return analysis were done to evaluate the sugarcane varieties.

Results and Discussion

Yield parameters

The results pertaining to number of tiller, millable cane and cane yield showed significant variation among the tested sugarcane varieties in saline condition (Table 1).

Number of tillers

There was a significant variation in tillering potentials among the sugarcane varieties grown in saline condition. Maximum number of tillers of 144.50×10^3 ha^{-1} was observed in Isd 39, followed by Isd 38 (131.33×10^3 ha^{-1}) and Isd 37 (129.33×10^3 ha^{-1}). Whereas the minimum number of tillers (123.21×10^3 and 126.17×10^3 ha^{-1}) were recorded from Isd 40 and VMC-86-550, respectively. The findings of the experiment are in combination with Nadeem *et al* (2009) who reported significant differences among the varieties for number of tillers $plant^{-1}$.

Number of millable cane

A significant variation was also observed in case of number of millable cane among the evaluated varieties. The highest number of millable cane of 117.67×10^3 ha^{-1} was recorded from Isd 39 which was statistically similar with Isd 40 (117.33×10^3 ha^{-1}) but different from other varieties. The variation among the varieties in this trait may be due to their gene make-up. Similar results were reported by Ahmed *et al.* (2014).

Cane yield

The yield data presented in Table 1 indicate significant difference among the sugarcane varieties. The variety Isd 40 scored the first position with the yield of 102.90 tha^{-1} which was

statistically similar with Isd 37 (102.21 tha^{-1}). The variety VMC 86-550 and Isd 38 gave significantly lower yield compared to other varieties indicating lower tolerance potentiality in saline condition. Similar trend was found by Majeedano *et al.* (2003).

Table 1: Yield parameters of the sugarcane varieties in saline condition

Varieties	No. of tiller (10^3 ha^{-1})	No. of millable cane (10^3 ha^{-1})	Cane yield (t ha^{-1})
Isd 37	129.33bc	101.67b	102.21a
Isd 38	131.33b	105.50b	92.50c
Isd 39	144.50a	117.67a	98.40b
Isd 40	123.21d	117.33a	102.90a
VMC-86-550	126.17d	103.33b	94.00c
$LSD_{0.05}$	13.17	12.17	3.81

Figures in different columns accompanied by similar letters do not differ significantly as per DMRT at 0.05 levels.

Quality parameters

Total soluble solids (Brix%)

Figure 1 demonstrates that differential responses of the tested sugarcane varieties were found in case of accumulating total soluble solids or brix (%) in saline soil. Maximum value in brix (%) reading was obtained from Isd 39 (20.0%) which is statistically same with Isd 37 (19.25) but superior from other varieties. However the lowest amount of total soluble solids was recorded from Isd 40 (18.50%). These results are in accordance with those reported by Khaiyam *et al.* (2018).

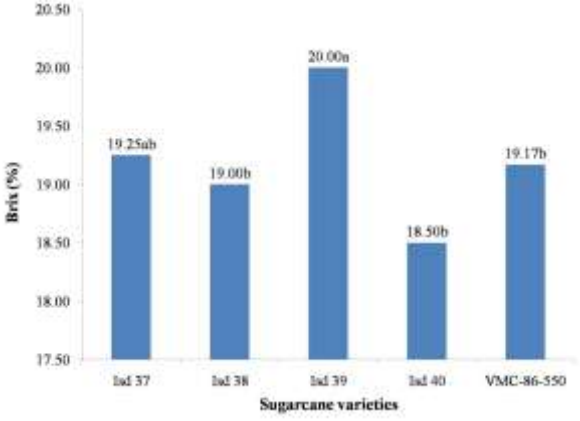

Figure 1: Brix (%) of the sugarcane varieties in saline condition

Goor preparation and taste of goor

The salinity level in the studied area ranged 4.1-8.1 dSm^{-1} throughout the whole cropping season. The highest value in salinity level was found in the month of April (8.1 dSm^{-1}) and the lowest in December (4.1 dSm^{-1}). There was no adverse effect of this level of salinity on goor preparation process. No salty nature of goor was found by organoleptic taste method.

Goor yield

Figure 2 indicates that the evaluated sugarcane varieties varied significantly in case of goor yield. The maximum amount of goor was produced by Isd 39 (9.23 tha^{-1}) which was followed by Isd 40 (8.83 tha^{-1}). The lowest amount of goor was obtained from Isd 38 (8.17 tha^{-1}).

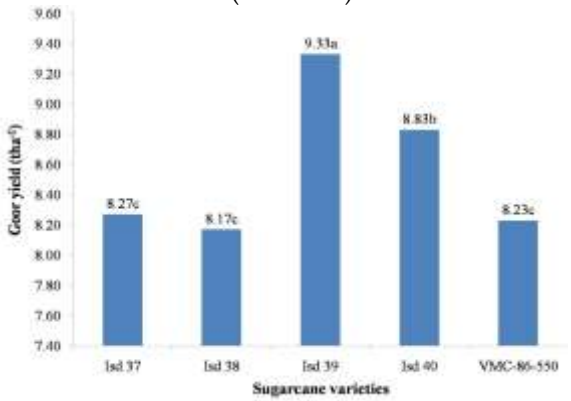

Figure 2: Goor yield of the sugarcane varieties in saline condition

Economic parameter

Table 2 represents the cost and return performance of the sugarcane varieties grown in saline condition. The maximum gross return (257250Tk. ha^{-1}), gross margin (137250 Tk. ha^{-1}) and benefit cost ratio (2.14) were obtained from Isd 40 followed by Isd 37 and Isd 39. The lowest economic return was obtained from Isd 38 followed by VMC 86-550. Therefore, the varieties Isd 40, Isd 37 and Isd 39 were found economically superior to others in saline condition. Khaiyam *et al*. (2018) also observed variation in economic performances among sugarcane varieties.

Table 2. Cost and return analysis of the sugarcane varieties during 2013-14 cropping season

Varieties	Total production cost (Tk. ha^{-1})	Cane yield (t ha^{-1})	Gross return (Tk.ha^{-1})	Gross margin (Tk.ha^{-1})	Benefit cost ratio (BCR)
Isd 37	120000	102.21	255525	135525	2.13
Isd 38	120000	92.50	231250	111250	1.93
Isd 39	120000	98.40	246000	126000	2.05
Isd 40	120000	102.90	257250	137250	2.14
VMC-86-550	120000	94.00	235000	115000	1.96

Price of sugarcane: 2500.00 Tk. t^{-1}

Conclusion

From the above results and discussions, it is evident that there were significant differential responses among the evaluated sugarcane varieties in respect of yield, quality and economic parameters in saline condition. The possible reason behind the differential performances of the varieties might be the respective degree of genetic potentiality to overcome the salinity stress. Maximum number of tillers (144.50×10^3 ha^{-1}) and millable cane (117.67×10^3 ha^{-1}), and maximum values in brix (20.0%) and goor yield (9.23 tha^{-1}) were observed in variety Isd 39. However, the variety Isd 40 scored the first position regarding cane yield (102.90 tha^{-1}) and benefit cost ratio (2.14). The sugarcane varieties Isd 40 and Isd 39 showed more tolerance behavior to salinity among the five varieties in the southern region of Bangladesh.

References

Ahmed ZA, Ahmed AM and El-Soghier KS. 2014. Evaluation of three sugarcane varieties grown under different number of irrigations. *Egypt. J. Agric. Res*., 92(2): 765-778.

Blackburn. 1984. Sugarcane. Longman. London, UK. pp.47-52.

Chinnusamy, Jagendorf VA and Zhu JK. 2005. Understanding and improving salt tolerance in plants. *Crop Sci*. 45, 437-448.

Hu Y and Schmidhalter U. 2005. Drought and Salinity: a comparison of their effects on mineral nutrition of plants. *J. Plant Nutr. Soil Sci*. 168, 541-549.

IWM. 2014. Salinity in the South West Region of Bangladesh. Institute of Water Modeling, Bangladesh.

Karim Z, Hussain SG and Ahmed M. 1990. Salinity problems and crop intensification in the coastal regions of Bangladesh. Soils publication no.8, BARC, p 33.

Khaiyam MO, Islam MS, Ganapati RK, Uddin MJ, Hossain MI. 2018. Suitability of newly released sugarcane varieties in farmers field condition under High Ganges River Floodplain of Bangladesh. Int J Plant Biol Res 6(2): 1086.

Kumar S, Naidu KM and Sehtiya HL. 1994. Causes of growth reduction in elongating and expanding leaf tissue of sugarcane under saline conditions. *Australian J. Plant Physiol*. 21: 79–83.

Leigh RA and Wyn Jones RG. 1984. A hypothesis relating critical potassium concentrations for growth to the distribution and functions of this ion in the plant cell. *New Phytol*. 97, 1-13.

Lingle SE and Wiegand CL. 1996. Growth and yield responses of sugarcane to saline soil: Sucrose biochemistry in individual internodes. Proc. Inter American Sugarcane Seminars. pp: 93-102.

Lynch J and Lauchli A. 1984. Potassium transport in salt-stressed barley roots. *Planta,* 161, 295-301.

Majeedano HI, Baloch FM, Tunio SD and Jarwar AD. 2003. Yield response of different sugarcane varieties in agro-ecological conditions of Tandojam. *Pak. Sugar Jour*. 18(1): 20-23.

Marschner H. 1995. Mineral Nutrition of Higher Plants. *Academic Press Inc*., San Diego, CA, USA.

Nadeem MA, Sarwar MA, Ahmed F, Hussain F, Ghaffar A and Chatta AA. 2009. Evaluation of some sugarcane clones at Faisalabad. *Pak. Sugar Jour*. 21(2): 2-5.

Rozeff N. 1995. Sugarcane and salinity-a review paper. *Sugarcane*, 5, 8-19.

Santa-Maria GE and Epstein E. 2001. Potassium/sodium selectivity in wheat and the amphiploid cross wheat×*Lophopyrum elongatum*. *Plant Sci*. 160, 523-534.

SRDI. 2001. Soil Resources in Bangladesh: assessment and utilization.p-105.

Subbarao M and Shaw MAE. 1985. A review of research on sugarcane soils of Jamaica. *Proc. Meeting West Indies Sugar Technol*., 2: 343–55.

Suhayda CG, Giannini JL, Briskin DP and Shannon MC. 1990. Electrostatic changes in *Lycopersicon esculentum* root plasma membrane resulting from salt stress. *Plant Physiol*. 93, 471-478.

Wahid A, Masood I, Javed I and Rasul E. 1999. Phenotypic flexibility as marker of sodium chloride tolerance in sunflower genotypes. *Environ. Exp. Bot*. 42: 85–94.

Wahid A, Rao AR and Rasul E. 1997. Identification of salt tolerant traits in sugarcane lines. *Field Crops Res*. 54, 9-17.

Wiegand CL, Escobar DE and Lingle SE. 1996. Growth and yield responses of sugarcane to saline soils: Sensing and mapping using aerial videography. *Proc. Inter American Sugarcane Semi*. pp. 15-17.

Wolf O, Tonnet ML and Jeschke WD, 1992. Role of stem in the partitioning of Na^+ and K^+ in salt stressed barley. *J. Expt. Bot.* 42: 697–704.

Yeo AR. 1983. Salinity resistance:Physiologies and prices. *Physiologia Plantarum*. 58, 214-22.

Zhu JK. 2001. Plant salt tolerance. *Trends Plant Sci*. 6, 66-71.