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Effects of Drought Stress on some Physiological Parameters of Sugarcane

S. Ali, M.A.S. Miah, M.A.H. Khan[1] and M.M. Rahman[2]
Bangladesh Sugarcane Research Institute,
Ishurdi, Pabna, Bangladesh.

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ABSTRACT

Effects of drought stress on some physiological parameters of six sugarcane varieties/clone such as Isd 20, Isd 24, Isd 2-54, I 291-87, Isd 16 and Isd 18 were investigated at Bangladesh Sugarcane Research Institute (BSRI) Farm. Three drought stress conditions, viz. no application of water and Polyethylene Glycol 6000 (PEG), application of 1% PEG and 2% PEG were tested and data were collected on % pH drop, CSI and Brix of cane. Drought stressed plants produced less Brix than unstressed plants of all varieties except Isd 20. The lowest chlorophyll stability index (CSI) level was recorded in the varieties Isd 20 and Isd 24, while Isd 16 and Isd 18 showed the highest CSI level indicating that the varieties Isd 20 and Isd 24 are more drought tolerant. Varieties Isd 20 and Isd 24 showed above 3% fall in pH identified as resistant, whereas varieties Isd 16 and Isd 18 showed a fall below 1.7% and identified as sensitive to drought stress. From this investigation it is suggested that the different physiological parameters used here can be recommended to screen sugarcane clones against tolerance to drought.

INTRODUCTION

Sugarcane is a food cum-cash crop of Bangladesh and cultivated in nearly 0.19 million hectares of land under wide ranges of agro-ecological condition (Anon, 1993). It is generally cultivated in low rainfall belt of (below 1500 mm) south-west and north west part of Bangladesh. In Bangladesh, cane yield is around 45 tones per hectare (Anon-1993) and average recovery of sugar is around 8.5 percent. These figures are quite low compared to those of the advanced sugarcane growing countries. Various factors are responsible for low yield of cane and sugar in Bangladesh. Among them, drought is one of the important factors causing lower yield in Bangladesh. Drought affects sugarcane growth during early growth and tillering phases. Estimates shows that about 30% sugarcane are planted on high lands where no irrigation facilities are available which results in poor cane yield (Ali *et al.* 1989). In the recent past, screening of sugarcane clones for drought tolerance has received higher research attention at BSRI and carried out lots of experiment on screening and drought management (Anon, 1990; 1992; 1993; 1994; 1995). Research on drought have also been carried out (Rao and Reddy, 1975, Tanimoto and Nickell, 1985; Singh, 1973; Heinz, 1971; Bates *et al.* 1973). It may be mentioned that plants tolerant to water stress have some distinct physiological features which enables them to overcome the injurious affects of water stress (Heinz, 1971;

1 & 2. Professor & Associate Professor, Department of crop Botany, BAU, Mymensingh.

Parthasarathy, 1972; Singh, 1973, Rao and Reddy, 1975; Rahman, 1983; Malik, 1992). In view of the facts the present investivation was undertaken to study the effects of drought on some physiological characters viz. pH drop, CSI value and Brix of five important commercial varieties and one advanced clone of sugarcane for identifiying characters for screening of drought tolerant varieties.

MATERIALS AND METHODS

The experiment was conducted in pots (PVC pipe) at Bangladesh Sugarcane Research Institute (BSRI), Ishurdi, Pabna. Sugarcane cultivars used in this investigation were Isd 2/54, Isd 16, Isd 18, Isd 20, Isd 22 and I 290-87 at test crops.

Single budded polybag settlings were raised following method described by Ali *et al.* (1989). Six weeks old settlings were transplanted singly in each 60 x 10 cm PVC (Poly vinyl chloried) pipe filled with a mixture of soil and pressmud in 3:2 ratio. In each pipe, three tillers were allowed to grow from each plant up to 120 d of transplanting. After 120 d i.e., in the month of March when natural drought prevails, four different treatments were applied to 6 varieties/clone with 3 replications (each PVC pipe represented one replication). In Ist treatment (T_1), no water and PEG (Polyethylene glycol 6000) osmoticum was applied in the PVC pipe. In the 2nd treatment (T_2) 1% PEG osmoticum and in 3rd treatment (T_3) 2% PEG osmoticum were applied in the plants in the piped soil up to 30d at an interval of 3 days. In control pots (T_0) irrigation was applied in each PVC pipe as and when necessary. Data on the following physiological parameters were recorded during water stress.

a) Chlorophyll stability index (CSI)

For CSI determination 3rd leaves (counted basipetally) were used and collected randomly from 5-6 months old plants from each PVC pipe. The collected leaves were kept in a polythene bag and brought immediate to the laboratory, washed with tap water, rinsed with distilled water and wiped with filter paper. Middle laminar portions of leaves were taken after removing the mid ribs and small pieces were made by chopping. Middle portions of leaves excluding the mid ribs, apical and collar regions were used for CSI estimation following the method described by Kilen and Andrew[2] (1969). The two samples (Heated and unheated) with three replications from each pipe were placed in separate 125 ml flasks with 20 ml 80% acetone. Heated sample was placed in temperature controlled water bath at 60±1°C for 120 minutes. Leaf tissue of both heated and unheated samples was removed from acetone, blotted dry, transferred to a mortar. Both the sample were homogenized in a morter by pestle with 5 ml of 80% acetone separately. Supernatant was decanted off and filtered through a funnel containing Watman No. 1. The filtrates were pooled and then volume was made to 100 ml with distilled water in a volumetric flask. The optical density of heated and unheated solutions were measured in Spectrophotometer (Model - Spectronic-1201, USA). The difference between the two readings was recorded as chlorophyll stability index (CSI).

b) pH of leaves

pH was estimated following the method described by Dwivedi *et al.* (1988). The four fresh TVD (top visible dewlap) leaves from each variety were collected and sampled in triplicate between 10.30 and 11.30 a.m. After collection they were brought immediately to the laboratory. From the lamina apical one third were taken and chopped to small pieces. One gram chopped sample were placed in 20 ml 0.025M EDTA disodium salt and ground with a glass homogenizer for 30 seconds. The extract was decanted and volume was made to 20ml with 0.025 M EDTA disodium salt. The pH of this extract was measured by single electrode pH meter. The pH reading of 0.025M EDTA disodium salt was used as check. The formula used for pH declined (%) measurement are as follows.

$$\text{pH decline \%} = \frac{(\text{pH of 0.025M EDTA} - \text{pH of extract}) \times 100}{\text{pH 0f 0.025M EDTA}}$$

c) Brix percent in juice

Direct brix reading in percentage were recorded with the help of hand refractometer from middle portion of each canes from each pipe.

RESULTS AND DISCUSSION

Effects on chlorophyll stability index (CSI)

Effects of drought stress on physiological parameters of sugarcane have been presented in the Figure 1. In respect to CSI, highly significant varietal differences was recorded while treatmental differences as well as variety and treatment interactions showed insignificant differences (Tables 1 & 2). It is revealed from figures that several folds higher CSI was recorded in varieties Isd 16 and Isd 18 compared to varieties/clones Isd 20, Isd 2-54, Isd 24 whereas the lowest CSI was observed in Isd 20. Among the treatments CSI varied independently from each other. In all the varieties, CSI of unstressed plants lower than stressed plant. Killen and Andrew (1969) stated that higher the CSI, lower the tolerance against drought. According to Killen and Andrew, varieties tested in this experiment have been divided into three groups :-

Isd 16 and Isd 18	:	Drought intolerant.
Isd 2-54 and I 129-87	:	Drought tolerant.
Isd 20 and Isd 24	:	Highly drought tolerant.

Kaloyereas (1958) reported a new method of using Chlorophyll stability for measuring relative drought resistance. He used chlorophyll stability index (CSI) which is the difference between the cholorimetric reading of chlorophyll extract from heated and unheated extracts of leaf sample. In pine (Kaloyereas, 1958), rice (Murthy and Majumder, 1962) and Corn (Kilen and Andrew, 1969) high correlations between CSI and field drought tolerance were reported elsewhere.

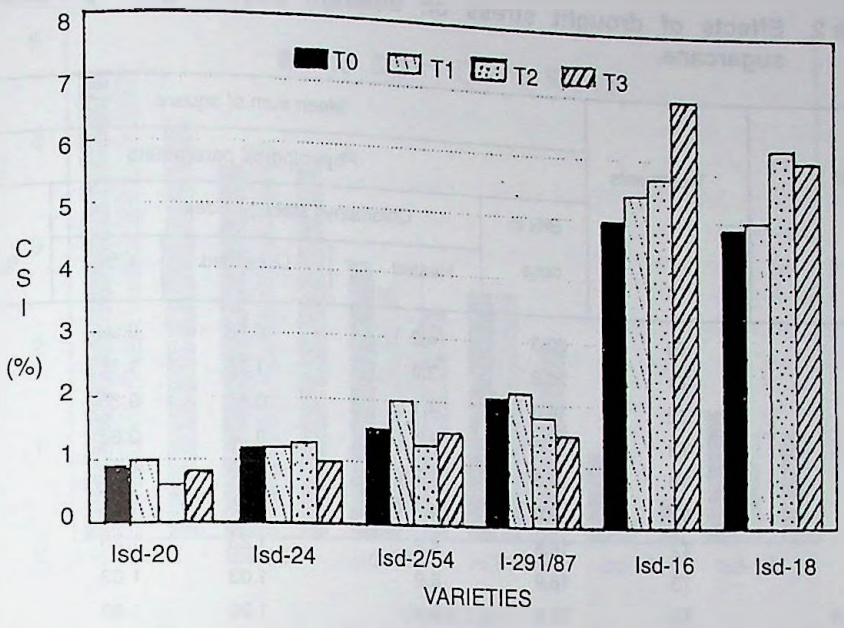

Figure 1. Effects of drought stress on CSI in different treatments of different varieties/clone of sugarcane.

Table 1. Analysis of variance of data on physiological parameters of sugarcane under drought stress condition.

Source of variance	Degree of freedom	Mean sum of square				
		Physiological parameters				
		Brix in cane	Chlorophyll stability index			% pH drop
			Heated	Unheated	CSI	
Replication	2	1.843	6.40	20.882	6.068	0.000
Variety	5	96.353**	646.717*	344.048*	66.121**	0.052**
Treatment	3	11.785**	0.759	1.350	0.255	0.000
Variety x Treatment	15	0.899	1.473	1.758	0.566	0.000
Error	46	1.084	4.16	3.112	3.057	0.000

* Significant at 0.05 level.

** Significant at 0.01 level.

Table 2. Effects of drought stress on different physiological parameters of sugarcane.

Variety	Treatments	Mean sum of square				
		Physiological parameters				
		Brix in cane	Chlorophyll stability index			% pH drop
			Heated	Unheated	CSI	
Isd 20	T0	20.3	4.2	0.93	0.93	4.28
	T1	20.8	3.9	1.16	1.16	4.28
	T2	19.0	4.1	0.86	0.86	4.28
	T3	9.6	4.0	0.83	0.83	4.28
Isd 24	T0	19.8	4.7	1.23	1.23	4.32
	T1	20.0	4.8	1.20	1.20	4.32
	T2	18.8	4.2	1.23	1.23	4.31
	T3	18.9	3.9	1.03	1.03	4.31
Isd 2-54	T0	17.4	3.1	1.30	1.30	4.35
	T1	15.6	3.1	2.00	2.00	4.36
	T2	15.9	3.2	1.26	1.26	4.36
	T3	15.0	2.9	1.50	1.50	4.37
I 291-87	T0	17.0	3.1	2.13	2.13	4.38
	T1	15.6	3.0	2.20	2.20	4.36
	T2	15.1	4.1	1.80	1.80	4.38
	T3	15.0	2.8	1.63	1.63	4.38
Isd 16	T0	14.8	16.3	6.00	6.00	4.44
	T1	12.4	17.7	5.56	5.56	4.47
	T2	12.8	18.6	5.70	5.70	4.46
	T3	12.6	15.4	7.13	7.13	4.46
Isd 18	T0	15.4	6.7	4.93	4.93	4.41
	T1	13.1	5.2	5.60	5.60	4.44
	T2	13.1	6.2	6.16	6.16	4.43
	T3	12.9	7.4	6.00	6.00	4.43
LSD (0.05)						
Among (VxT)		NS	NS	NS	NS	NS
Among Varieties (V)		0.85	1.67	1.44	1.43	0.01
Among treatments (T)		NS	NS	NS	NS	NS

T_0 : Control; T_1 : No water no PEG, T_2 : PEG 1% solution; T_3 : PEG 2% solution.

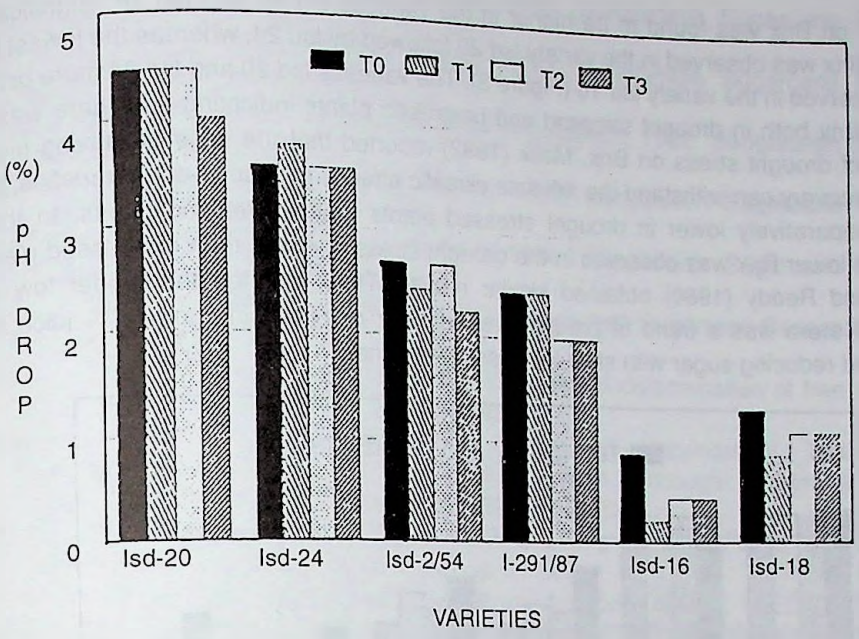

Figure 2. Effects of drought stress on pH drop in different treatments of different varieties/clone of sugarcane.

Effects on pH of the EDTA leaf extract

The significant varietal differences were found in respect to pH of the EDTA leaf extract while treatment differences as well as variety and treatment interactions showed insignificant differences (Tables 1 & 2). It was seen in the Figure 2, that the significant (higher percent) fall in pH of the EDTA leaf extract was obtained in lsd 20 followed by lsd 24 whereas significant (lowest percent) fall in pH of the EDTA leaf extract was recorded in lsd 16. The fall in pH of the EDTA leaf extract was moderate in veriety lsd 2-54 and clone I 291-87. This observation was in accordance with Dwivedi *et al.* (1988). According to them quantitatively the genotypes showed pH fall above 3% were identified as sensitvie to drought stress. Considering a 3% and above fall in pH of leaf extract may be treated as drought tolerant, and as such the varieties lsd 20 and lsd 24 may be categorized as drought resistant among the test varieties/clone. Other varieties/clone tested like lsd 2-54 and I 291-87 showed moderate fall in percent leaf extract pH, ranging above 2% but below 3% and may be categorized as moderately drought tolerant. On the other hand, pH fall around 1% or below may be treated as intolerant and as such varieties lsd 16 and lsd 18 may be categorized as intolerant to drought stress. This results is in agreement with the findings of Dwivedi *et al.* (1986; 1988).

Effects on Brix in cane

In the present investigation highly significant differences were obtained in Brix of cane between varieties and as well as between treatments (Tables 1 & 2). Drought stress

effects on Brix was found to be higher in the varieties Isd 16 and Isd 18. Significantly higher Brix was observed in the variety Isd 20 followed by Isd 24, whereas the lowest Brix was observed in the variety Isd 16 (Figure 3). The varieties Isd 20 and Isd 24 more or less similar Brix both in drought stressed and unstresed plants indicating that there was no effects of drought stress on Brix. Malik (1992) reported that the varieties having higher sugar recovery can withstand the adverse climatic effects. In case of other varieties, Brix was comparatively lower in drought stressed plants than unstressed plants. In these vareities lower Brix was observed in the drought stressed plants than unstressed plants. Singh and Reddy (1980) obtained similar results. They reported that under low soil moisture there was a trend of progressively greater reduction in sucrose % juice and increased reducing sugar with stalk thickness of a variety.

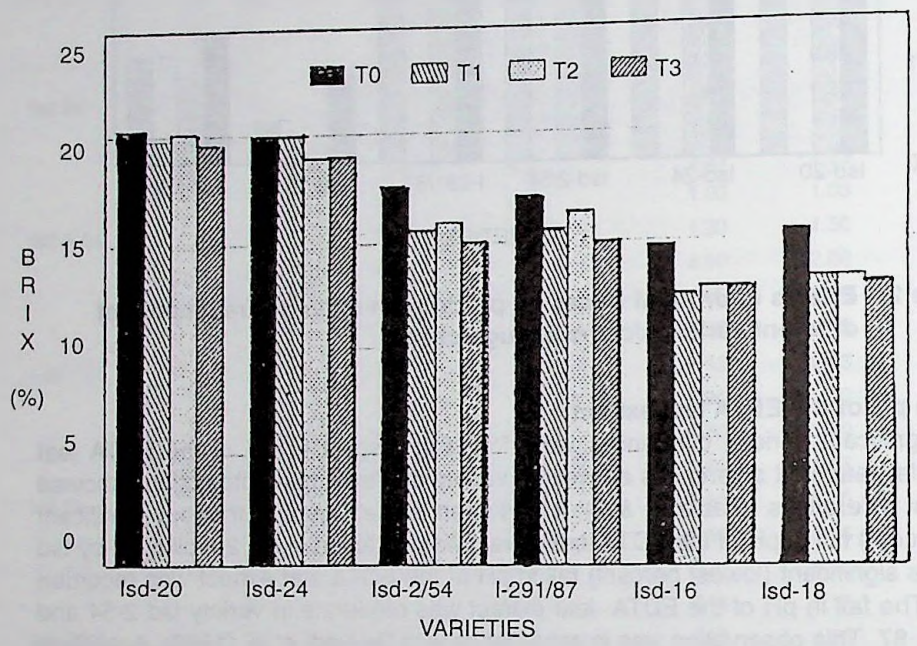

Figure 3. Effects of drought stress on Brix of cane in different varieties/clone of sugarcane.

From the results, it can be concluded that the varieties Isd 20 and Isd 24 are drought tolerant and may be recommended for commercial cultivation in the drought prone areas of Bangladesh. Since Brix of cane, CSI, pH etc of sugarcane were affected due to drought stress, so desired gene for stress tolerance need to be included to reduce drought stress damage. Chlorophyll stability index (CSI) and pH drop test may also be used to screen sugarcane varieties against dorught stress.

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