Bangladesh J. Sugarcane, 17: 23-30 *July, 1995*

Germination Responses of Six Sugarcane Genotypes to Osmotically-induced Water Stress

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Received on 12.5.94

ABSTRACT

A screen house study was conducted at the Unilorin Sugar Research Institute (USRI), Nigeria to investigate the effects of osmotically-induced water stress on seed cane germination of six sugarcane genotypes namely CO 957, CO 997, BD 83/019, BD 83/035, IB 85/43 and USRI 86/25. Sodium Chloride (NaCl) of various concentrations was added to the germinating medium to creat osmotic potentials ranging from 0 to -1.2 MPa. Both the rate and total germination of all genotypes declined with increasing osmotic potential. The extent of such reduction varied considerably among the tested genotypes, suggesting differential genotypic response to water stress. The order of genotypes with respect to drought tolerance at germination was USRI 86/25 BD 83/019 BD 83/035 CO 957 = CO 997 IB 85/43. The results of the study susquested that seed cane germination in high osmotic potential is an effective method in distinguising between drought tolerant and susceptible genotypes. Hence, a promising technique in mass screening of sugarcane genotypes for drought tolerance.

INTRODUCTION

Seed germination and vigour are prerequisite for the success of stand establishment of crop plants especially in sugarcane. However, germination rates have been reported to decrease at low available water and the rate of decline found to vary with crop species and cultivars. The differential ability of each species to germinate at low moisture content is found to be heritable and is now being used as a basic criterion for selecting for drought tolerance in various crops (Helmerick and Pfeifer, 1954; Ashraf and Abu-Shakra, 1978; Lafond and Baker. 1986; Winter *et al.*, 1988; Abayomi, 1992). Similarly, dissolved salts wether derived from saline soils or from fertilizer, have been found to reduce the availability of water to seeds by increasing the osmotic potential of the soil solution (Dubetz *et al.*, 1959). Theoretically, it has been suggested that the matric and osmotic components of soil are equivalent and their effects on plant water uptake are additive provided there is no entry of solutes (Sharma, 1973). Based on this assumption, in studies on the effect of drought on seed germination, water stress are usually simulated by addition of various osmotic substrates such as D-mannitol (Ashraf and Abu-Shakra, 1978: Abayomi, 1992), polyethylene glycol (PEG) (Saint-Clair, 1976; Smith *et al.*, 1989), sodium chloride (NaCl) (Sharma, 1973, Gerald *et al.* 1985) etc. to the germinating media. Thus, many workers have concluded that seed germination in high osmotic potentials is a rapid and efficient technique for screening a large population of plant material (Gul and Allen, 1976; Ashraf and Abu-Shakra, 1978; Abayomi, 1992), although others found the technique less effective (Winter *et al.*, 1988).

Although drought tolerance capacity of sugarcane varieties have been earlier evaluated by few workers using different methods (Singh, 1964; Tanimoto and Nickell, 1965; Rao and Asokan, 1978; Gerald *et al.*, 1985), information on the efficacy of seed cane germination in high osmotic potential as a technique for screening for drought tolerance in sugarcane genotypes are scanty and works on drought tolerance evaluation on sugarcane are especially lacking in Nigeria. It was therefore the objective of the present study to investigate the effects of osmotically-induced water stress on seed cane germination and to evaluate the effectiveness of the technique in distinguishing between drought tolerant and susceptible genotypes.

MATERIALS AND METHODS

The study was conducted in a screen house at the Unilorin Sugar Research Institute. The seed canes were germinated in 10 litre pots filled with sterilized top soil. The experiment was designed and laid out as a 6 x 5 factorial as a completely randomized block with three replicates. Two commercial varieties namely CO 957 and CO 997 and four advanced breeding lines (BD 83/019, BD 83/035, IB85/43 and USRI 86/25) from the Nationally Coordinated Research Project on Sugarcane currently on yield testing at the USRI farm were used for the study. Whole stalks of each variety of line were collected from the research farm of the Unilorin Sugar Research Institute, and were cut into single-budded setts.

Each experimental unit consisted of 10 litre pot containing 10 single budded setts. The setts were evenly arranged in the pot and covered with 4-5 cm soil. All pots were slightly watered after planting. Water stress was simulated in this study using sodium chloride (NaCl) applied as granules. There were five osmotic potentials (0, -0.3, -0.6, -0.9 and -1.2 MPa corresponding to No, Low, Moderate, High and Severe stress respectively). The salt granule of the appropriate weight calculated from the expressions used by Ashraf and Abu-Shakra (1978) was applied directly to the soil medium according to the method developed in Hawaii (Tanimoto and Nickell, 1965) and later used by Gerald *et al.*, 1985). Thereafter, water was applied slowly to dissolve the salt taking care that no salt is lost either by way of overflowing or drainage from the perforated bottom. Similarly, the soil was kept moist with daily watering.

There were germination counts at 4 d intervals starting from 7 d after planting (DAP) unit 35 DAP when counting was terminated. Germination data are presented as percent germination at the end of a specified period. However, it has been observed that two seed lots may have the same final germination percentage which may be arrived at through two distinct germination curves and this difference may have important agronomic implication (Nichol, 1965). Thus, Lafond and Baker (1986) suggested that a proper analysis of germination curves requires a measure of the median of time required for germination or a measure of speed of germination in addition to the total amount of germination.

Hence, in this study the cumulative germination-time curves were plotted as described by Abayomi (1992) and the speed of germination was calculated as Median Germination Time (MGT) using the method of moments described by Hole (1966) in addition to total germination at the end of stress period (E%). All data including the germination counts, and median germination time were subjected to variance analysis and mean differences were separated by LSD (0.05).

RESULTS AND DISCUSSION

The analysis of variance show that both the two main effects and their interactions are significant from 11 DAP until the last measurement date. The significant osmotic X genotype interactions implies that the effects of osmotically-induced water stress were not the same for all the genotypes considered in this study, thereby suggesting genotypic difference in water stress tolerance. Since the interaction effects are significant throughout the study period only the results of interaction effects are presented and discussed. The analyses of variance on median germination time (MGT) and total germination at the end of stress period show that two main effects were significant for MGT and E%. However, none of the interactions were significant.

The comparative response of the genotypes to various osmotic potential are shown in the Figures 1 - 5. Figure 1 shows the germinability of genotypes at 0 MPa. Both commercial varieties CO 957 and CO 997 recorded higher germination than all four advanced breeding lines. Nevertheless, germination advantages of both varieties were not significantly better than in line BD 83/019 which also has significantly better germination than lines BD 83/035 and IB 85/45. At -0.3 MPa advanced lines BD 83/019 and USRI 86/25 have better germination percentages than CO 957, CO 997, BD 83/035 and IB 85/43 (Figure 2). The best and the worst germination percentages were recorded in lines BD 83/019 and IB 85/43 respectively. BD 83/035 showed lower germination percentage than commercial varieties upto 19 DAP. Thereafter, germination in the line was similar to or better than in the two commercial varieties.

Both advanced lines BD 83/019 and USRI 86/25 showed similar germination percentages upto 15 DAP. Therefore, germination was slightly better in USRI 86/25 at -0.6 MPa (Figure 3). Nevertheless, both lines showed better germination than commercial varieties CO 957 and CO 997 as well as other lines, BD 83/035 and IB 85/43. Figure 4 shows that lines BD 83/019 and USRI 86/25 and BD 83/035 had better germination than IB 85/43, CO 957 and CO 997 at -0.9 MPa. After an initial delay in germination upto 14 DAP, USRI 86/25 showed relatively better germination from 23 DAP upto 35 DAP at -1.2 MPa (Figure 5). At this stress level CO 997 recorded a low germination after a delay of 24 d while there was no germination at all in CO 957. Water stress tolerance is said to be related to cell protoplasm, and indicates ability of cell to survive under suboptimal water supply (Gerald *et al.*, 1985). The results of this study thus indicated that genotypes USRI 86/25, BD 83/019 and BD 83/035 showed capacity to survive and germinate better than others under comparatively suboptimal water conditions, thereby suggesting that these are promising clones for drought prone areas of the country.

Across all genotypes, median germination time (Table 1) significantly increased with increased osmotic potential while total germination significantly decreased (Table 2). Tables 1 and 2 also show that across all osmotic potentials, BD 83/019 and USRI 86/25 advanced lines have significantly lower MGT (i.e. higher rate of germination) and a higher E% than commercial varieties CO 957 and CO 997 and other two advanced lines, BD 83/035 and IB85/43. In sugarcane cultivaion, ultimate yield mostly depends upon successful germination of seed cane buds. Faster rate and higher percentage of germination of USRI and BD 83/019 suggest that both genotypes will give higher yield than others in comparatively low soil moisture content by minimizing gaps and maximizing plant population (Miah *et al.*, 1988).

Table 1. Effects of osmotically-induced water stress on median germination time (MGT) (in days) of six sugarcane genotypes.

Osmotic potentials	Sugarcane genotypes							
	BD 83/019	BD83/035	CO 957	CO 997	IB 85/43	USRI 86/25	Mean	LSD
0 MPa.	11.4	20.5	13.2	9.6	19.6	14.0	14.7	
-0.3 MPa	14.5	18.2	18.5	18.8	16.8	10.9	16.3	
-0.6 MPa	13.7	23.3	26.1	24.4	30.7	13.5	21.9	4.10
-0.9 MPa	15.3	21.2	28.2	29.3	20.2	16.3	21.8	
-1.2 MPa	20.5	21.0	32.0	29.7	32.0	20.4	25.9	
Mean	15.1	20.8	23.6	22.4	23.8	15.0	-	
$LSD_{0.05}$				4.49				

S.E.D. for Genotype X Osmotic potential = 5.07

Table 2. Effects of osmotically-induced water stress on total germination at the end of stress period (E%).

Osmotic potentials	Sugarcane genotypes							
	BD 83/019	BD83/035	CO 957	CO 997	IB 85/43	USRI 86/25	Mean	LSD
0 MPa.	73.3	53.3	96.7	93.3	53.3	63.3	72.2	
-0.3 MPa	66.7	50.0	30.0	30.0	20.0	53.3	41.7	
-0.6 MPa	33.3	36.7	10.0	13.3	3.3	46.7	23.9	12.79
-0.9 MPa	23.3	23.3	10.0	3.3	10.0	20.0	15.0	
-1.2 MPa	23.3	13.3	0.0	3.3	3.3	26.7	11.7	
Mean	11.0	35.3	29.3	28.7	18.0	42.0	-	
$LSD_{0.05}$				11.68				

S.E.D for Genotype X Osmotic potential = 14.44

Several workers have earlier concluded from studies with other crops that seed germination in high osmotic potential is a rapid and efficient technique for screening a large population of plant materials (Gul & Allen, 1978; Ashraf & Abu-Shakra, 1978; Abayomi, 1992), although the technique was found less effective in screening for drought tolerance in winter wheat (Winter *et al.*, 1988). Results of the present study showed clear genotypic difference in seed cane germination at high osmotic potentials, thereby supporting the views of earlier workers who found the method effective. The results showed that drought tolerance was better in lines BD 83/019 and USRI 86/25 than in commercial varieties CO 957 and CO 997 and other selected lines. The inferiority of commercial varieties in terms of drought tolerance capacity might be due to fact that these varieties were not selected against drought tolerance in their country of origin. This is evident in their outstanding performances at optimal moistre (Figure 1). This may also explain why the two varieties performed badly under severe drought conditions in the field. Hence, the need to breed and select for locally adapted varieties.

The results of speed of germination (Table 1) and total germination (Table 2) show that rate of and total germination decreased with increased osmotic potential. These results are similar to those reported earlier for other crops (Lafond & Baker, 1986; Smith *et al.*, 1989; Abayomi, 1992). The decrease in germination rate and consequently in total

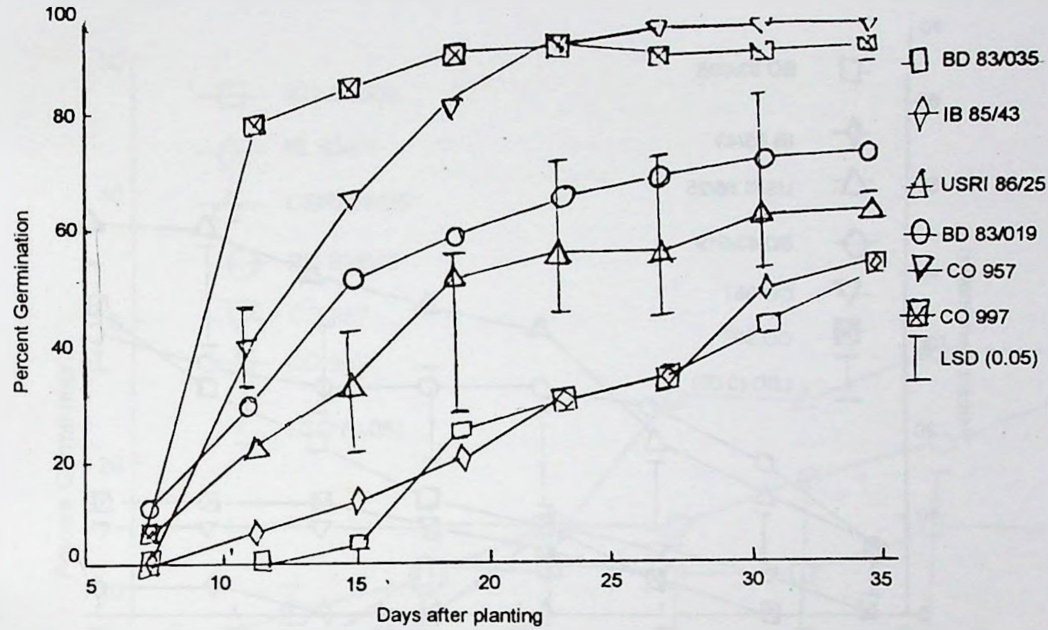

Figure 1. Germination response of six sugarcane genotypes to osmotically-induced water strees (No stress).

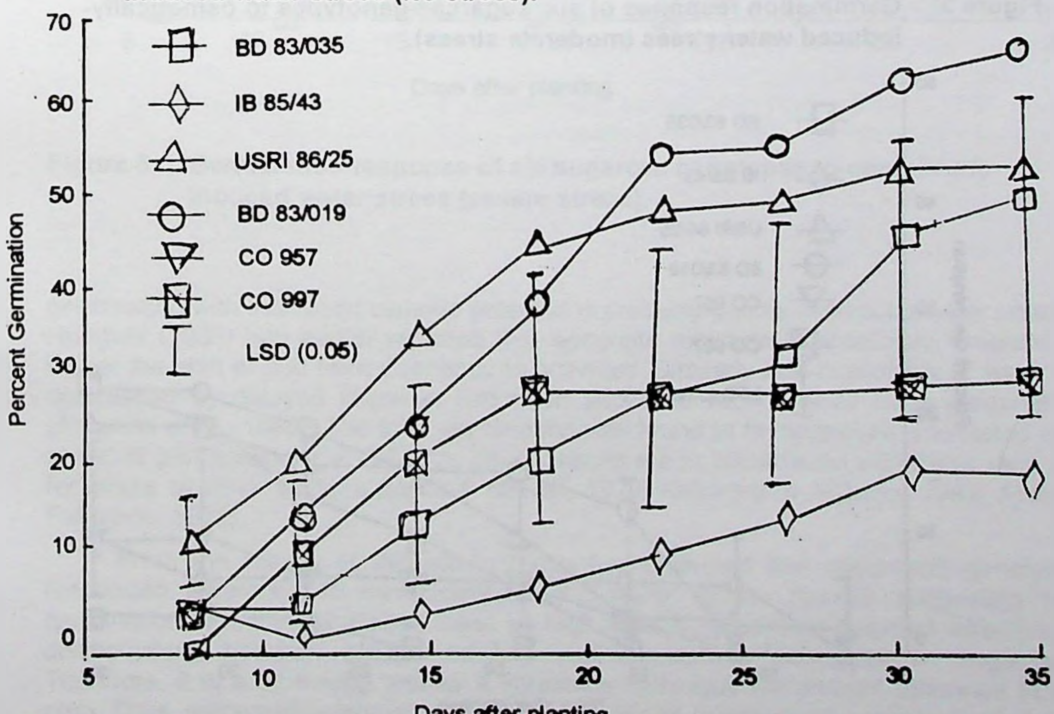

Figure 2. Germination response of six sugarcane genotypes to osmotically-induced water stress (low stress).

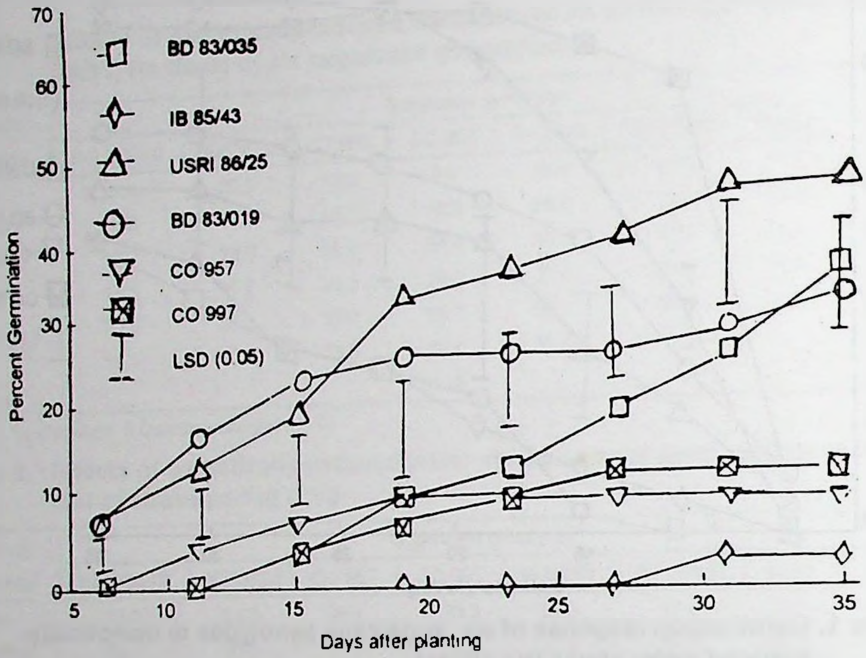

Figure 3. Germination response of six sugarcae genotypes to osmotically-induced water strees (moderate stress).

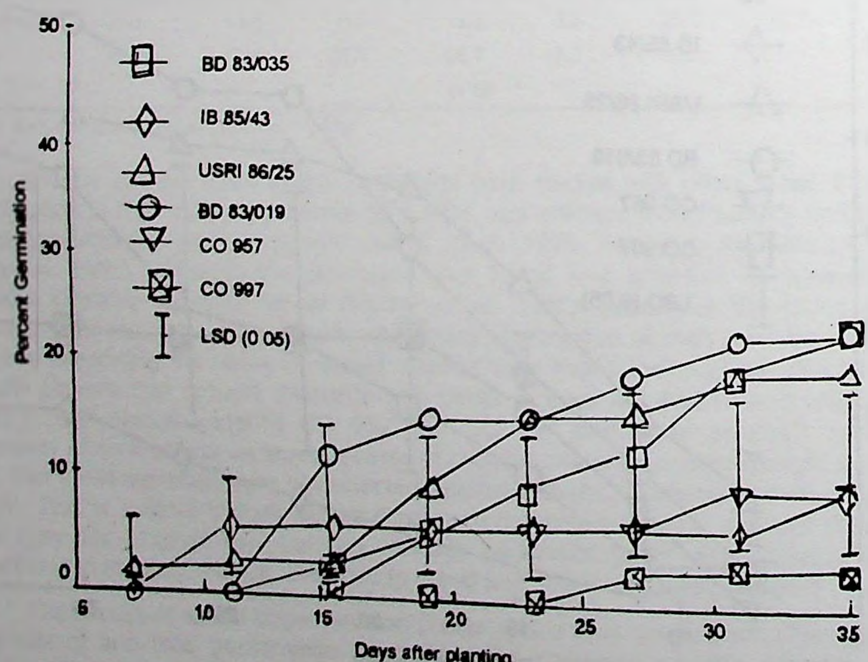

Figure 4. Germination response of six sugarcane genotypes to osmotically-induced water stress (high stress).

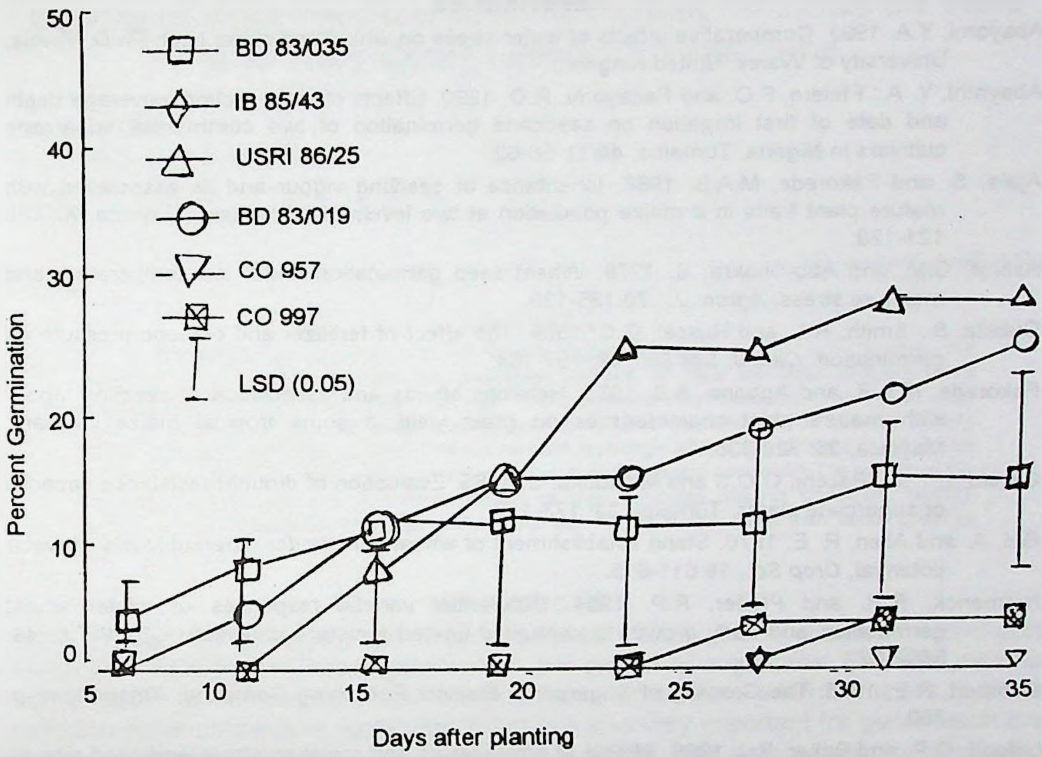

Figure 5. Germination response of six sugarcae genotypes to osmotically-induced water strees (severe stress).

germination with increased osmotic potential is probably due to decreased water uptake. Humbert (1968) had earlier reported that adequate moisture is absolutely essential to trigger the shift of bud from dormancy to activities. Similarly non-availability of water as occasioned by delayed irrigation had been shown to reduce seed cane germination (Abayomi *et al.*, 1990). The total germination was found to be negatively correlated with speed of germination ($r = -0.71^{***}$). These results are in accordance with those reported for miaze by other workers (Mock & McNeil, 1979; Fakorede & Agbana, 1983; Ajala & Fakorede, 1988).

From the results of this study it can be concluded that sugarcane genotypes responded differently to osmotically-induced water stress, thereby suggesting that germination test involving seed cane at high osmotic potentials seemed effective in distinguishing between drought tolerant and susceptible genotypes of sugarcane. Therefore, it is a promising tool as a screening technique for drought tolerance in the crop. Thus, comparative drought tolerance capacity of investigated genotypes are in the following order from best to worst USRI 86/25, BD 83/019, BD 83/035, CO 997, CO 957 and IB 85/43.

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