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Influence of Salinity Stress on Growth Parameters and Yield of Sugarcane

R.Gomathi And P.Thandapani
Department of Plant Physiology, Sugarcane Breeding Institute (ICAR), Coimbatore-7

Abstract: *A pot culture experiment was conducted to study the influence of salt stress on growth and yield component of four sugarcane varieties viz., C 92038, Co 85004, Si 94050 and Co 85036. The result of the study reveals that the growth parameter viz., LAI, LAD and CGR, RGR and SGR indicated that the derivation of LAI, CGR and SGR are the reliable growth parameters for assessing the genotypes for salt tolerance, as resistant genotypes Co 85004 and C 92038 performed better because of higher CGR, and SGR in present study. The important yield parameters viz., number of stalk per^{-1}, stalk length, number of inter nodes, inter nodal length, cane diameter and single cane weight were found to be affected under salt stress condition, which leads in overall yield reduction of 38.56 per cent in T_2. However the extent of reduction was less in GA_3 treated plants (18.50 %). Under salinity condition, the reduction in yield was less in C 92038 and Co 85004 (29.81 and 28.00 %) and it was found to be maximum in Co 85036 and Si 94050 (47.82 and 47.36 %). Irrespective of the genotypes, supplementing GA_3 (150 ppm) as sett treatment and foliar application play role on imparting salt tolerance in terms of getting better growth and cane yield.*
Keywords: *Sugarcane salinity, CGR, RGR, SGR, GA_3, resistant and susceptible.*

I. Introduction

Salinity stress decreased the leaf development and plant height much earlier than any other morphological parameters (Srivastva *et al*., 1998). Reduction in green leaf production for photosynthetic process was observed in sugarcane genotypes at soil EC 4.5 (Naik and Joshi, 1981). In sugarcane, reduction of leaf area with increase in soil EC from 5 to 20 dsm^{-1} was reported by Anon (1996). Kumar *et al.* (1994) stated that the leaf number and size were significantly affected by soil salinity at the level of 8 dsm^{-1} in sugarcane. Muniaswamy (1998) reported that the reduction in leaf area index due to salt stress varied from 2.6 per cent (resistant genotype) to 27.9 per cent (susceptible genotype). In chickpea, number of affected leaves was more than salt tolerant genotype and the symptom of yellowing of leaves increased linearly with day of salinization in both the genotypes, however, the start of symptom was early in sensitive genotype compared to tolerant genotype (Dua, 1998). In India, several authors have noted increased cane length by the GA_3 application at normal condition (Singh, 1976 and Kanwar and Kanwar, 1986). Studies from Thaiwan (Yang *et al*., 1981) have also demonstrated increased cane growth particularly in terms of cane elongation and increased cane yield by the application of GA_3.According to Thirupal,(1988) and Bhasker ,(1990) foliar application of 300 ppm of GA_3 was effective technique for increasing yield and quality of short duration sugarcane genotypes at Coimbatore condition. Keeping with above background, a pot culture experiment was conduced to study the impact of salt on growth and yield of selected sugarcane genotypes and influence of GA_3 on imparting salt tolerance.

II. Materials and Methods

A pot culture experiment was conducted by using three treatments viz., T_1 (control), T_2 (soil Ec 7dsm-^{1}) and T_3 (salt + 150 ppm GA_3 as sett treatment and foliar spray at formative phase) and four genotypes viz., C 92038, Co 85004, Si 94050 and Co 85036. Soil EC in the treated pots were monitored at fortnightly interval and salinization pots was done by NaCl salt (1 %) and there by soil EC was maintained between 6-8 d sm^{-1}. The LAI was worked out by the method suggested by William, (1946). LAD was determined by the method suggested by Kvet *et al*., (1971) and the values expressed in days. The main shoot height was recorded at weakly intervals by tagging 3 plants from each variety and each treatment at random during 120 to 180 days of age. The mean shoot growth rate was calculated using the formula.

$$\text{Shoot growth rate (SGR)} = \frac{\text{Main shoot height at time } T_2 - \text{Main shoot height at time } T_1}{T_2 - T_1}$$

Where, T_1 and T_2 are the duration in weeks and expressed (cm week^{-1}). CGR was worked out by the method suggested by Watson, (1952) and expressed in g g^{-2} d^{-1}. RGR was determined by the formula given by Williams,

(1946) and expressed in g g^{-1} day^{-1}. The yield and yield components was recorded at 12^{th} month after planting. All the data analyzed statistically to test the significance of the parameters.

III. Results and Discussion

The photosynthetic rate depends upon LAI and canopy structure, which in turn is related to dry matter production. In present study, LAI was reduced by salt stress, however GA_3 treated plants (T_3) showed higher LAI than untreated plants (T_2) (Table1). Under salinity conditions (T_2), Co 85004 had a higher LAI with lesser reduction of 32.52 per cent followed by C 92038 (37.10 %), implying that this genotype can photosynthesis in larger amount compared to other genotypes indicating its tolerant nature. Similar genotypic differences in LAI were reported by Djanaguiraman (2000) in rice and Abdul Whahid *et al.*, (1997) in sunflower.

Irrespective of the treatments and genotypes, LAD increased up to 180-270 days and declined at 270-330 days (Table 1). In all the conditions, C 92038 and Co 85004 recorded higher LAD, there by showing the resistant nature of the genotypes to ionic stress. Since salt stress induces the early senescence of susceptible genotypes (Si 94050 and Co 85036), it comparatively recorded lesser LAD there by showing the susceptible nature. However the influence of GA_3 was found to be on LAD was more in susceptible genotypes.

Significant reduction in CGR was due to salinity (40.00 %). Among the genotypes, greater CGR was observed in C 92038 with minimum reduction of 19.53 per cent, followed by Co 85004 (27.77 %). The lesser reduction in CGR under salinity conditions indicates its relative tolerant nature, which results in higher TDMP (Muniaswamy, 1998). In T_3, influence of GA_3 was less in C 92038 and Co 85004 by 27.00 and 32.00 per cent over T_2 and it had more influence in Si 94050 (58.00 %) followed by Co 85036 (47.00 %) over $T_{2.}$

Relative growth rate is an index of the amount of growing material per unit of dry weight of the plant (Table1). Though there was apparent reduction in RGR in the genotypes due to salt stress, the genotype, C 92038 and Co 85004 were showed its efficiency in recording higher RGR with lesser reduction (28 .66 and 28.57 per cent) over control and expressed the tolerant nature. Muniaswamy (1998) and Ayman (1995) reported such less reduction in RGR values in tolerant genotypes. According to them, genotypic variation in RGR under salinity conditions indicating the relative capacity of genotype on dry matter production and it was more sensitive to salt stress. The genotypes Si 94050 and Co 85036 were recorded maximum reduction of 69.23 and 57.14 per cent respectively, which showed its susceptible nature to salt stress.

Since, stem is an economic part of sugarcane, derivation of SGR (shoot growth rate) is a reliable parameter for assessing the genotypes for salt tolerance under stress situation. In present study, an overall 40.00 per cent reduction in SGR was observed under salinity conditions, however the reduction was minimized in GA_3 treated plants (T_3) by 25.50 per cent over control. In all the conditions, Co 85004 showed its superiority in recording higher SGR even under salinity conditions (T_2 and T_3) and this was followed by C 92038(Table1). Among the genotypes, maximum reduction in SGR was noticed in Co 85036 (58.80 %) followed by Si 94050 (46.00 %). The report of Muniaswamy (1998) also indicated the similar variation in SGR in resistant and susceptible genotypes (17.50 and 40.00 per cent respectively) under salinity conditions (EC 8 dsm^{-1}), which confirms the present findings. Among the growth parameters studied, LAI, CGR, and SGR had much influence in governing the yielding ability of the genotypes and it can be greatly modified by environmental fluctuations. In present study, the reduction in SGR is more than that of reduction in RGR and CGR. It is primarily due to the fact that besides reducing total biomass, salinity stress also affects the sink growth.

Result of correlation study also indicates that the CGR, LAI and SGR were highly correlated to yield when compared to RGR and LAD (Table3). The resistant genotypes *viz*., Co 85004 and C 92038 performed better because of high CGR, LAI and SGR. It is in accordance with Ayman (1995) Muniaswamy (1998) and Nasir *et al*. (1999).

Yield and yield components in response to salt stress

Unlike other crops, yield of sugarcane is directly related the vegetative growth as the stalks are main components for yield, hence yield of sugarcane is determined by the number stalk per unit area, (NMC) stalk length, number of internode per stalk, internodal length, cane diameter and single cane weight, which are highly influenced by soil, genetic and environmental factors. Data on yield components indicates that there was overall reduction in cane length (42.37 %) cane diameter (38.88 %), number internodes (26.26 %), internodal length (330.82), single cane weight (44.30 %) and thus, 38.56 percent reduction yield due to salt stress (Table 2). While under GA_3 treatment, the reduction in yield and yield components due to salt stress was reduced by 13.21, 6.35, 18.27, 12.35, 7.07 and 16.66 per cent for cane length, diameter no of internodes, internodal length, single cane weight and yield over GA_3 untreated (T_2). Among the yield components, influence of GA_3 was more on number of internodes and stalk length there by enhances the yield by 16.66 % over T_2 as it evident from results of Moore *et al.* (1982), at normal conditions. When compared to the genotypes, Co 85004 and C 92038 performed better by recording higher stalk length than, more number of internodes, higher internodal length and single cane weight under both salt stress conditions (T_2 + T_3) suggesting their adaptation to the problem soils. Several studies have also shown that salt stress reduced the number of internodes, cane length and internodal length, which depends on genotypes (Ruzelf, 1995 and Dang *et al.,* 1998) who reported that the detrimental effects of excess salt on sugarcane are greater on the cane and sugar yields than sugar recovery.

Yield per pot was significantly decreased by 38.56 and 21.94 per cent due to T_2 and T_3. Under salinity condition (T_2), the reduction in yield was, 31.81, 28.00, 47.82 and 47.36 per cent over control of C 92038, Co 85004, Si 94050 and Co 85036 respectively (Table 2). However, influence of GA_3 was found to maximum in susceptible genotype viz., Co 85036 and Si 94050 by 44.00 and 40.00 per cent over T_2 respectively, while it was minimum in resistant genotype viz., Co 85004 and C 92038 by 8.8 and 20.00 per cent over T_2 respectively. The minimum reduction in cane yield as well as CCC % in resistant genotype (C 92038 and Co 85004) might be due more number of stalk per pot and cane length associated with better adaptability under saline condition. Similar varietal difference in cane yield under salinity was reported by various worker (Zerega *et al.,* 1991; Moore *et al.,* 1994; Dwivedi and Srivastava, 1995; Sundara, 1996; Sharma *et al.,* 1997; Dang *et al.,* 1998; Muniaswamy, 1998 and Nasir Ahmed, 1999).

Experiment conducted at sugarcane breeding institute, coimbatore, over the year have shown that soil salinity had reduced the single cane weight, cane length and cane diameter (Anon, 1996). Further, Thomas *et al.* (1981) found that under mild salt stress condition (4 dsm^{-1}), the individual cane weight was not affected in resistant variety NCO 310. However, Syed and El-Swaify (1972) observed a significant reduction in single cane weight, when the EC of irrigation water increased from 2.0 to 8.0 dsm^{-1}. This is in conformation with findings of present results.

IV. Conclusion

Among the growth parameters studied, derivation of LAI, CGR and SGR are the reliable parameters to judge the salt tolerance. Under salt stress condition, reduction in cane weight in susceptible genotypes is associated with more reduction in stem growth rate and CGR. Among the genotypes, C 92038 and Co 85004 are can be used for the breeding program for development of salt tolerant sugarcane genotypes with better growth and yield under saline environment. Supplementing of 150 ppm of GA_3 as sett treatment and foliar spray at tillering phase favors in better growth under salt stress condition, and thus enhanced the cane yield particularly in salt sensitive genotypes.

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Table:1. Salinity effect on growth parameters of sugarcane genotypes

Treatment	Genotypes	LAI	LAD (Days)	SGR (cm week^{-1}) 150 days	CGR (g m^{-2}day^{-1})	RGR (mg g^{-1}day^{-1}).
Control (T_1)	C 92038	4.07	404.25	7.00	4.49	0.040
	Co 85004	4.00	395.10	7.50	4.59	0.042
	Si 94050	3.07	380.88	6.50	3.76	0.037
	Co 85036	3.91	387.70	8.00	4.61	0.044
	Mean	**3.75**	**391.90**	**7.32**	**4.36**	**0.04**
Salt treated (T_2)	C 92038	2.35	228.16	5.20	3.06	0.031
	Co 85004	2.14	216.76	4.00	2.78	0.029
	Si 94050	1.86	261.91	2.80	2.17	0.021
	Co 85036	1.90	192.00	5.80	2.31	0.020
	Mean	**2.06**	**224.71**	**4.45**	**2.57**	**0.025**
Salt + GA_3 treated (T_3)	C 92038	2.90	282.75	5.90	3.81	0.034
	Co 85004	2.97	286.20	5.00	3.80	0.035
	Si 94050	2.51	243.15	4.20	3.44	0.033
	Co 85036	2.35	227.40	6.70	3.40	0.036
	Mean	**2.68**	259.88	**5.45**	3.61	**0.035**
Stage Mean		**2.83**	**292.16**	**5.75**	**3.51**	**0.030**

	CD	**CD**	**CD**	**CD**	**CD**
Treatments	0.16	11.16	0.009	0.068	0.002
Genotypes	0.18	14.24	0.012	0.14	0.005
Tx G	0.64	22.40	0.026	0.20	0.008

Note: LAI, LAD,CGR and RGR-Mean of three stages

Table: 2. Effect of salinity on yield and yield components of sugarcane genotypes

Treatments	Genotypes	No. of shoot pot^{-1}	Shoot length (cm)	Cane diameter (cm)	No.IN plant^{-1}	Int. N. length (cm)	Single cane wt (g)	Cane weight pot^{-1} (kg)
Control (T_1)	C 92038	8.20	178.40	2.20	26.10	7.00	0.800	2.20
	Co 85004	8.00	180.56	2.75	26.00	6.80	0.846	2.30
	Si 94050	7.40	150.36	2.60	23.70	7.21	0.710	2.50
	Co 85036	7.56	166.26	2.55	26.33	6.50	0.680	1.93
	Mean	**7.79**	**168.89**	**2.52**	**25.55**	**6.80**	**0.760**	**2.23**

Salt treated (T_2)	C 92038	7.00	112.11	1.80	21.08	5.70	0.501	1.50
	Co 85004	6.80	120.78	1.89	21.00	5.50	0.543	1.60
	Si 94050	4.50	90.58	1.33	17.51	4.17	0.366	1.09
	Co 85036	4.00	75.51	1.13	17.16	3.13	0.283	1.00
	Mean	**5.57**	**99.24**	**1.54**	**18.84**	**4.50**	**0.423**	**1.27**
Salt + GA_3 treated (T_3)	C 92038	7.50	142.48	1.92	24.00	6.00	0.596	1.96
	Co 85004	7.00	111.49	2.00	24.03	6.07	0.581	1.85
	Si 94050	5.80	125.61	1.55	21.83	4.93	0.396	1.60
	Co 85036	6.00	100.37	1.35	20.69	4.33	0.353	1.44
	Mean	**6.57**	**119.99**	**1.70**	**22.64**	**5.53**	**0.480**	**1.74**
Mean		7.04	121.37	1.95	22.67	5.63	0.580	1.72
		CD	CD	CD	CD	CD	CD	CD
Treatment		0.075	4.06	0.091	1.02	0.079	0.013	0.054
Variety		0.060	4.69	0.105	1018	0.092	0.015	0.061
Treatment X variety		0.125	8.12	0.183	2.05	0.159	0.025	0.107

Table 3: Association between growth parameters and yield of sugarcane under salinity stress

Parameters	**LAI (r value)**	**LAD (r value)**	**SGR (r value)**	**CGR (r value)**	**RGR (r value)**	**Yield (r value)**
LAI	1.00					
LAD	0.590*	1.00				
SGR	0.612*	0.812**	1.00			
CGR	0.720**	0.653*	0.740**	1.00		
RGR	0.523*	0.756**	0.670**	0.612*	1.00	
Yield	0.812**	0.680**	0.912**	0.860**	0.690**	1.00