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Influence of Sodium Chloride Induce Salinity on Growth, Yield and Juice Quality of Promising Sugarcane Genotypes

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A B S T R A C T

The experiment was conducted to study the effect of salinity levels (ECe value 0, 2.5 and 5.0 dSm^{-1}) on sugarcane genotypes (CoP 9702, CoP 112, BO 154, BO 153 and CoP 9301) under NaCl induced salt stress condition in glasshouse at Sugarcane Research Institute, Pusa, Bihar. The increasing salinity levels from 0 to 5 dSm^{-1} ECe significantly decreased germination, plant height and plant population indicating stunting of growth under salt stress condition. The ECe value of 5.0 dS m^{-1} leads to overall reduction in germination (30.28%), cane weight (25.72%) cane yield (28.05 %) and sugar yield (33.25%) over control. Among sugarcane genotypes, BO154 followed by CoP112 recorded significantly superior as compared to rest of the genotypes in terms of growth parameters and yield. The genotypes, BO154 attained maximum germination, plant height and cane yield followed by CoP 112 and lowest in COP 9301. The reduction in cane yield among the genotypes were in order of BO154 > CoP112 > CoP 9702 > BO153> CoP 9301. The value of brix, pol and juice recovery significantly decreased with increasing level of salinity, however purity coefficient remains unaffected. The mean sugar yield increased by 9.66 % in BO 154 and 5.44 % in CoP 112 over BO 153. Sugar yield, a function of cane yield and exhibited similar trend of cane yield. The salt stress caused increased concentration and uptake of Na^+ and Na+/K+ ratio in sugarcane leaf. BO 154 and CoP 112 performed better by maintaining lower Na^+/K^+ ratio. The increase in Na^+/K^+ ratio was observed in salt sensitive genotypes viz. CoP 9301 and BO 153. The pH and EC of post soil increased while organic carbon of soil decreased significantly with increasing level of salinity. The Cl^- content of soil varied significantly (16.54 - 26.67 mel^{-1}) due to salinity. Among sugarcane genotypes BO154, followed by CoP112 performed well in terms of sugar and cane yield under influence of salt stress and it may be grown as salt tolerant genotype in agro-climatic conditions of North Bihar.

Introduction

Sugarcane is grown extensively in tropical and sub-tropical regions of India and plays a pivotal role in both agricultural and industrial economy of the country. In India, area under sugarcane hovers around 5.0 million hectares, which is around 3% of the gross cultivable area in India with an annual production of 366.80 million tonnes and productivity of 63.7 tonnes per hectare. The sugarcane productivity remained low, primarily due to the cultivation of cane in to relatively less fertile marginal soils, which are characterized by various stresses occurring during the crop growth. Soil salinity limits the sugarcane production in considerable area of Bihar. The problem of salinity in combination of other abiotic stresses is known to influence the cane yield in both tropical and subtropical climate. The growth and yield components of sugarcane were reduced under saline stress as compared to the respective attributes in normal soil (Thakur *et al.,* 2010 and Singh *et al.,* 2015). Salt affected soils exist across the length and breadth of India covering 16 States/ Union Territories with a total area of 7.0 mha. In Indo-gangatic alluvial plains, about 2.5 million ha are salt affected, out of which a sizeable area lies under salinity. In absence of detailed soil survey, Bihar is having 4 lakh ha of sodic soil, which either produce very low crop yield or no yield.

The salt affected soil in the state of Bihar is widespread in the northern flood plain of the Ganges covering parts of East and West Champaran, Muzaffarpur, Gopalganj, Siwan and Chhapra districts. Area of such land is increasing year by year due to faulty irrigation management, high water table and drainage problems. These soils have pH of saturation paste (pHS) less than 8.5, ESP less than 15, and ECe more than 4 dS m^{-1} at $25^{o}C$. However, based on the Indian experience, saline soils having pHs less than 8.2, ECe more than 4 dS m^{-1} and preponderance of chlorides and sulphates of Na, Ca, and Mg. Excess amount of salt in the soil adversely affects plant growth and development. High salt concentration decreases the potential of soil solution creating a water stress in plants that also causes severe toxicity, salt stress and dehydration stress. Under saline soil conditions, sugarcane plants are unable to absorb water and minerals from the soil because of osmotic imbalance. A high degree of salinity results in to physiological, biochemical, molecular and genetical effects (Yusuf *et al.,* 2010).

The Sugarcane Research Institute, Pusa developed several promising genotypes of sugarcane. The evaluation of genotypes is necessary for its performance in saline soil to increase sugarcane productivity in agro climatic condition of Bihar. Adoption of tolerant sugarcane genotype would be one of the best ways to reduce the loss in cane productivity in salt affected soils. Reclamation of saline soils is time consuming and costly affair. Therefore, it is important to evaluate the affect of salinity and screening of sugarcane genotypes to break the existing plateau of cane productivity fom such marginal lands. The tolerant genotypes are being used to counteract salinization effects and to improve productivity of such marginal lands. These considerations prompted to undertake the present investigation.

Materials and Methods

Experimental Site

The present investigation was undertaken with an aim to study the effect of salinity levels on productivity and juice quality of sugarcane genotypes during 2016-17, at Sugarcane Research Institute, RPCAU, Pusa, Bihar. The site has hot and humid summers and too cold winters with average rainfall of 1200 mm of which 75% received during the monsoon period (mid June - mid September). The mean annual temperature is $24.5^{o}C$ with maximum $38.6^{o}C$ during April and minimum $7.4^{o}C$ in January.

Experimental Soil

The soil of the experimental site belongs to order Entisol, suborder Fluvents and great group Ustifluvent. The experimental soil was sandy loam in texture with moderately alkaline pH (8.18), low in organic carbon (0.45%), SAR (9.0) and EC (0.27dSm^{-1}) and low in available N-P-K (234.3- 18.1-114.6 kg/ha).The Fe, Zn Cu and Mn content of initial soil was 8.79, 0.79, 1.02 and 4.62 mg kg^{-1} respectively.

Experimental design and application of treatments

The pot experiment was conducted with treatment consisted of three salinity levels (0, 2.5 and 5.0 dSm-1) and five sugarcane genotypes developed by SRI, Pusa (CoP 9702, CoP 112, B.O. 154, B.O 153 and CoP 9301) with three replication in CRD. Soil sample (0-15cm) was collected from crop research farm, Pusa from medium upland and having uniform topography for filling of pot. The bulk samples were grouped in three separate parts for salinity development. The desired salinity levels were developed by mixing the suitable amount of NaCl in soil before filling the pot. The electrical conductivity of soil saturation extract (ECe) of 2.5 dSm^{-1} and 5.0 dSm^{-1} was developed after one week of incubation. The sugarcane genotypes were planted in cemented pit having capacity of 100 kg soil. NPK was applied as per recommendations (150-85-60). The one budded setts were planted after setts treatment. The salinity was maintained in salt treated pots during the experiment. Half of N was top dressed in two equal splits. The first top dressing was done after 60 days after planting and second at the time of earthing-up. All the standard agronomical practices were followed.

Experimental observations and procedure

The growth contributing characters and cane yield for each treatment were recorded. The leaf samples collected after harvest were analysed for Na and K using standard procedure. Soil samples (0-15 cm) were collected before initiation and after harvest of crop. The soil samples were analysed for pH and EC (Jackson 1973), organic carbon (Walklay and Black., 1934) and chloride in soil saturation extract (Richard 1954). The cane juice quality was determined using procedure outlined by Spencer and Meade (1964) and sugar yield was calculated. The data were analysed statistically.

Results and Discussion

Effect on growth parameters

Germination

The mean germination varied significantly and ranges from 41.61 -54.21 % due to salinity (Table 1). Maximum (30.28%) reduction in germination was recorded at ECe 5.0 dSm^{-1} levels of salinity as compared to control. The germination was delayed for a month due to salinity. The genotype BO 154 recorded significantly highest germination percentage (53.84%) followed by CoP112 (50.53%) as compared to CoP 9301 (42.35%) and CoP 9702 (45.02%). The genotypes BO 154 followed by CoP 112 establish better under saline soil condition and produces maximum plant population. There was inhibitory effect on germination of sugarcane genotypes at high salt concentration. Singh *et al.,* (2003) and Wahid (2004) reported similar findings.

Plant height

The increasing salinity levels significantly decreased plant height (Table 1) indicating stunting of growth under salt stress condition. The sugarcane genotype BO154 attained maximum plant height followed by CoP 112 and CoP 9702 at both the stages of plant growth. The sugarcane genotypes BO 154 followed by CoP 112 performing well under saline condition up to ECe 5.0 dSm^{-1} levels of salinity. The lowest plant height was recorded in genotype V_5 (CoP 9301) at both the stages of plant growth. The performance of genotype CoP 9301 and BO 153 was significantly inferior and found at par at both the stages of plant growth. The data clearly indicated that sugarcane genotypes BO154 followed by Cp112 and CoP 9702 performing well under saline condition. Plant height is an important characteristic for assimilation of organic constituents.

The sugarcane genotypes attended the maximum height in saline soil indicated the adaptability and sustainability. The variation in plant height in different sugarcane genotypes might be because of injury to plant roots in rhizosphere by built of toxic ions and than their gradual accumulation in aerial parts cause damage to plant metabolism and reducing growth. Singh *et al.,* (2002) and Singh *et al.,* (2003) recorded similar observations. The salinity reduces growth through osmotic stress, increases cellular Na and Cl contents and exerts negative imbalance of K, Ca and NO_3 nutrition depending upon the stress severity (Flowers and Colmer, 2008).

Effect on yield attributes and yield

Single cane weight

The reduction in mean cane weight (Table 2) due to salinity at 2.5 dS/m and 5.0 dSm^{-1} levels of salinity over control was to the extent of 12.64 % and 25.72 %, respectively. The ECe value of 5.0 dS m^{-1} leads to overall reduction to the extent of 25.72 % in single cane weight over control.

The highest cane weight was recorded in genotypes BO154 followed by CoP 112 and minimum in CoP 9301.The sugarcane genotype BO154 was found at par with CoP 112 and performance of these genotypes were superior over rest of the genotypes. Under salt stress condition reduction in cane weight in susceptible genotypes associated with more reduction in growth rate of sugarcane. Gomathi *et al.*, (2014) and Singh *et al*., *(*2002) reported similar findings.

Cane yield

The cane yield (Table 2) of sugarcane significantly decreased with increasing level of salinity from 2.5 to 5.0 dSm^{-1}. The reduction in yield due to salinity at 2.5 dSm^{-1} and 5.0 dSm^{-1} over control was to the extent of 14.69 % and 28.08 %, respectively. The mean cane yield varied from 3.17- 4.06 Kg pot^{-1} due to salinity. Among genotypes mean cane yield varied significantly from 3.36 - 3.83 kg pot^{-1}. The genotype BO154, CoP 112 and CoP 9702 increased cane yield significantly as compared to BO153 and Cop 9301. The highest cane yield was recorded in genotype BO154 followed by CoP 112 and minimum in CoP 9301. The sugarcane genotype BO154 was found at par with CoP 112. The mean cane yield increased by 14.00 % and 10.12 % in genotypes BO 154 and CoP 112, respectively over CoP 9301.

The ECe value of 5.0 dSm^{-1} leads to overall reduction in germination (30.28%), single cane weight (25.72%) and cane yield (28.05 %) over control. Excess salts adversely affect the growth and development of sugarcane crop which ultimate results in poor crop growth and cane yield. Unlike other crops, yield of sugarcane is directly related the vegetative growth which is main components for yield. The lower yield at salinity might be because of sugarcane shows a decline in growth and yield attributing characteristics. Akthar *et al.,* (2003) reported that excess of soluble salts in root zone was inevitably taken up, which accumulate in the aerial parts and reduce growth and yield. Thakur *et al.,* (2010) and Gomathi *et al.,* (2014) reported varietal difference in terms of cane yield. Singh *et al.*, (2015) also recorded similar findings.

Table.1 Effect of salt stress on growth parameters of promising Sugarcane Genotypes

Treatments	Germination (%)			Mean	Plant height (cm) 120 DAP			Mean	Plant height (cm) 240 DAP			Mean
	Salinity level (dSm^{-1})				Salinity level (dSm^{-1})				Salinity level (dSm^{-1})			
Genotypes	Control	2.5	5.0		Control	2.5	5.0		Control	2.5	5.0	
CoP 9702	49.83	43.53	41.70	45.02	102.66	91.66	92.8	95.70	221.00	212.00	170.00	201.22
CoP 112	55.70	50.50	45.34	50.53	103.33	94.30	90.33	95.98	215.00	198.66	190.00	201.22
BO 154	66.50	50.83	44.20	53.84	106.30	96.30	94.33	98.97	233.33	201.33	185.00	206.55
BO 153	50.20	42.83	38.60	43.87	98.33	93.66	85.26	92.41	222.66	192.66	180.00	198.44
CoP 9301	48.83	41.11	38.25	42.73	95.33	90.66	82.20	89.39	208.00	188.66	178.00	191.55
Mean	54.21	45.76	41.61		101.19	93.36	88.94		219.99	198.66	180.60	
Source	S	G	SXG	CV%	S	G	SXG	CV%	S	G	SXG	CV%
LSD $_{(0.05)}$	2.71	3.50	NS	7.71	3.06	3.95	NS	4.35	6.16	7.96	NS	4.14

Note S-Salinity level, G-genotypes

Table.2 Effect of salt stress on yield attributes and yields of promising sugarcane genotypes

Parameters	Single Cane weight (g)				Cane yield (kg pot^{-1})			Mean	Sugar yield (kg pot^{-1})			Mean
Treatments	Salinity level (dSm^{-1})			Mean	Salinity level (dSm^{-1})				Salinity level (dSm^{-1})			
Genotypes	Control	2.5	5.0		Control	2.5	5.0		Control	2.5	5.0	
CoP 9702	975	882	766	874.33	4.12	3.52	3.06	3.56	447.41	376.80	324.32	382.84
CoP 112	1001	920	852	924.33	4.02	3.68	3.40	3.70	440.22	397.89	360.49	399.53
BO 154	1078	972	830	960.00	4.30	3.88	3.32	3.83	469.83	421.94	354.76	415.51
BO 153	990	853	783	875.33	3.95	3.40	3.12	3.49	439.76	366.58	330.46	378.93
CoP 9301	946	805	738	829.66	3.92	3.22	2.95	3.36	455.03	365.56	320.22	380.27
Mean	998	886	793.80		4.06	3.54	3.17		450.45	385.754	338.05	
Source	S	G	SXG	CV%	S	G	SXG	CV%	S	G	SXG	CV%
LSD $_{(0.05)}$	35.34	45.62	NS	5.30	0.13	0.17	NS	5.02	16.31	21.06	NS	5.59

Note S-Salinity level, G-genotypes

Table.3 Effect of salt stress on juice quality of promising sugarcane genotypes

Parameters	Brix (%)				Pol (%)			Mean	Purity (%)			Mean
Treatments	Salinity level (dSm^{-1})			Mean	Salinity level (dSm^{-1})				Salinity level (dSm^{-1})			
Genotypes	Control	2.5	5.0		Control	2.5	5.0		Control	2.5	5.0	
CoP 9702	18.20	17.93	18.00	18.04	15.83	15.60	15.52	15.65	86.96	87.03	87.30	87.09
CoP 112	18.30	18.16	17.83	18.09	15.93	15.76	15.46	15.71	87.06	86.76	86.90	86.90
BO 154	18.50	18.26	18.00	18.25	15.98	15.86	15.60	15.81	86.36	86.80	86.66	86.60
BO 153	18.46	18.16	17.80	18.14	16.17	15.73	15.45	15.78	87.60	86.50	86.80	86.96
CoP 9301	19.00	18.80	18.43	18.74	16.78	16.47	15.89	16.38	88.30	87.60	86.23	87.37
Mean	18.49	18.26	18.01		16.13	15.88	15.58		87.25	86.93	86.77	
Source	S	G	SXG	CV%	S	G	SXG	CV%	S	G	SXG	CV%
LSD $_{(0.05)}$	0.22	0.28	NS	1.61	0.18	0.24	NS	1.56	NS	NS	1.05	0.69

Note S-Salinity level, G-genotypes

Table.4 Effect of salt stress on Na concentration, its uptake and Na/K ratio in leaf of promising sugarcane genotypes

Parameters	Na concentration (%)			Mean	Na/K ratio			Mean	Na uptake (g pot $^{-1}$)			Mean
Treatments	Salinity levels (dSm^{-1})				Salinity levels (dSm^{-1})				Salinity levels (dSm^{-1})			
Genotypes	Control	2.5	5.0		Control	2.5	5.0		Control	2.5	5.0	
CoP 9702	0.045	0.070	0.090	0.068	0.050	0.080	0.118	0.082	0.69	0.92	1.04	0.98
CoP 112	0.043	0.070	0.086	0.066	0.048	0.078	0.108	0.078	0.65	0.97	1.10	1.03
BO 154	0.041	0.065	0.085	0.063	0.044	0.075	0.108	0.075	0.66	0.95	1.06	1.00
BO 153	0.048	0.076	0.096	0.073	0.054	0.088	0.125	0.089	0.71	0.97	1.13	1.05
CoP 9301	0.046	0.079	0.098	0.074	0.053	0.093	0.133	0.093	0.68	0.95	1.09	1.02
Mean	0.045	0.072	0.091		0.050	0.083	0.12		0.68	0.95	1.08	
Source	S	G	SXG	CV%	S	G	SXG	CV%	S	G	SXG	CV%
LSD $_{(0.05)}$	0.002	0.003	NS	4.30	0.002	0.002	NS	3.25	0.026	0.034	NS	3.95

Note: S-Salinity level, G-genotypes

Table.5 Effect of salt stress on physic-chemical properties of soil after sugarcane harvest

Treatments / Genotypes	pH Salinity levels (ECe dSm^{-1})			Mean	ECe (dSm^{-1}) Salinity levels (ECe dSm^{-1})			Mean	Organic Carbon (%) Salinity levels (ECe dSm^{-1})			Mean	Cl^- content in soil saturation extract (me/l) Salinity levels (ECe dSm-1)			Mean
	Control	2.5	5.0		Control	2.5	5.0		Control	2.5	5.0		Control	2.5	5.0	
CoP 9702	8.20	8.23	8.32	8.25	0.27	1.49	2.95	1.57	0.46	0.44	0.40	0.43	16.80	21.50	26.40	21.56
CoP 112	8.17	8.27	8.38	8.27	0.34	1.73	3.11	1.72	0.49	0.43	0.38	0.43	16.50	21.83	26.90	21.74
BO 154	8.21	8.25	8.36	8.27	0.28	1.46	3.01	1.58	0.48	0.42	0.41	0.43	16.25	21.65	26.80	21.57
BO 153	8.12	8.19	8.32	8.21	0.32	1.55	2.88	1.58	0.46	0.44	0.37	0.42	16.45	21.80	26.74	21.66
CoP 9301	8.18	8.29	8.40	8.29	0.36	1.62	3.08	1.68	0.49	0.45	0.39	0.44	16.70	21.40	26.50	21.53
Mean	8.17	8.24	8.35		0.31	1.57	3.00		0.47	0.43	0.39		16.54	21.63	26.67	
Source	S	G	SXG	CV%	S	G	SXG	CV%	S	G	SXG	CV%	S	G	SXG	CV %
LSD $_{(0.05)}$	0.015	NS	NS	0.24	0.017	NS	NS	1.46	0.008	NS	NS	5.95	1.05	NS	NS	9.62

Note: S-Salinity level, G-genotypes

Sugar yield

The reduction in mean sugar yield (Table 2) by 16.75 % and 33.25 % was observed due to salinity level of 2.5 and 5.0 dSm^{-1}, respectively, over control. Among sugarcane, genotypes BO 154 recorded significantly highest sugar yield followed by CoP112 and lowest in BO 153. The mean sugar yield increased by 9.66 % in BO 154 and 5.44 % in CoP 112 over BO 153. Sugar yield, a function of cane yield and exhibited similar trend of cane yield. The higher cane yield resulted in higher sugar yield. Excess salts adversely affect the growth and development of sugarcane crop which ultimate results in poor sugar recovery. Gomathi *et al.*, (2014) reported similar findings.

Effect on brix, pol and purity coefficient

The data on juice quality parameters viz. brix, pol and purity coefficient has been presented in table 3. The value of brix in sugar cane juice significantly decreased with increasing level of salinity from 2.5 to 5.0 dSm^{-1}. The brix of cane juice was in order of control (18.49%) > 2.5 dSm^{-1} (18.26%) and 5.0 dSm^{-1}(18.01%) salinity. The brix of sugarcane genotypes CoP 9301 was significantly higher (18.74%) followed by the genotype BO154 (18.25%) than the rest of the sugarcane genotypes.

The osmotic component of NaCl mainly appeared to affect the transport of sucrose to stalks followed by stimulated sucrolytic activity in the internodes (Wahid 2004). Among salinity level maximum pol was recorded in control (16.14%) and it's decreased with increasing ECe at 2.5 dSm^{-1} (15.88%) and 5.0 dSm^{-1} (15.58%). Pol of sugarcane genotypes CoP 9301 was significantly higher (16.38%) than rest of the sugarcane genotypes. The genotypes BO153 (15.78%), CoP 112 (15.72%) and CoP 9702 were recorded lower sucrose content. Interaction between salinity level and genotypes was found non-significant. Similar findings were reported by Gomathi and Thandapani, (2005).

Na concentration, uptake and Na^+/K^+ ratio in plant

The Na concentration and its uptake by sugarcane plant at harvest stage significantly increased with increasing salinity being highest in 5.0 dSm^{-1} salinity as compared to control (Table 4). Among sugarcane genotypes, BO154 followed by CoP 112 and CoP 9702 recorded lower Na concentration as compared to other genotypes. The concentration of Na in cane leaf was significantly low in BO154 (0.063%), CoP 112 (0.066%) and CoP 9702 (0.068%) as compared to BO153 and CoP 9301. The result indicated that BO154 showed least accumulation of Na in the leaf at grand growth stage. The highest Na accumulation in cane leaf was observed in genotype CoP 9301 followed by BO 154 indicating susceptibility of these genotypes against toxic ions resulted in poor performance in terms of yield and quality. The mean uptake of Na varied (0.68-1.08 g/pot) significantly due to salinity.

Among sugarcane genotype BO 153 recorded highest Na uptake and lowest in Cop 9702. The higher concentration in plant leads to higher uptake of Na. Under salt stress Ca^{2+} promotes $K^{+,}$ and inhibits Na^+ uptake, thus maintaining high Na^+/K^+ ratios that counteract the reduction in plant growth caused by salinity stress. Salt induced accumulation of toxic elements viz., Na was enhanced in susceptible genotypes. The resistant genotypes viz. BO 154 and CoP 112 performed better by maintaining lower Na^+/K^+ ratio. The increase in Na^+/K^+ ratio was observed in sensitive genotypes viz. CoP 9301 and BO 153 (Gracia and Medina, 2013).

Effect on soil properties

The soil physico-chemical properties viz. pH, ECe and organic carbon content of post-harvest soil presented in table 5. The data indicated that pH and ECe of soil increased while organic carbon of soil decreased significantly with increasing level of salinity. The mean pH value varied from (8.18 to 8.36), ECe (0.33 to 3.01 dSm^{-1}) and organic carbon from (0.39 to 0.47 %) due to salinity. It was also observed that salinity of soil decreased at harvest stage over the initial value. Among genotypes the pH, EC and organic carbon were fond non-significant. The Cl^- content of saturation extract of soil varied significantly due to salinity and ranges from 16.54 - 26.67 mel^{-1}. The data indicated that increasing salinity increased Cl^- content of post-harvest soil. The salinity resulted in accumulation of these toxic ions in soil. The increased Cl^- ions due to salinity adversely affected the growth of sugarcane plant. The organic carbon content of soil reduced due to salinity to the extent of 20.51 % over control. The overall data indicated that salinity build up resulted in increased pH, electrical conductivity and Cl^- content of post-harvest soil. The addition of salt NaCl leads to reduction in organic carbon content and create unfavourable soil environment for plant growth. Saline soils are generally low in organic matter and adversely affect the solubility and availability of nutrients (Takkar and Mishra, 2004 and Hossain *et. al*., 2015).

Based on above findings it may be concluded that there was overall reduction in germination (30.28%), cane weight (25.72%) cane yield (28.05 %) and sugar yield (33.25%) at ECe value 5.0 dS/m over control. Among sugarcane genotypes, BO154 followed by CoP112 recorded significantly superior as compared to rest of the genotypes and maintained lower Na^+/K^+ ratio. The increase in Na^+/K^+ ratio was observed in salt sensitive genotypes viz. CoP 9301 and BO 153. The sugarcane genotypes BO154 produced highest cane and sugar yield at all salinity levels followed by CoP 112 as compared to other genotypes indicating that BO 154 and CoP 112 genotypes may be grown as moderately salt tolerant varieties under agro-climatic conditions of North Bihar.

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