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ORIGINAL ARTICLE

Identification of salt tolerant sugarcane cultivars through phenotypic, physiological and biochemical studies under abiotic stress

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Abstract Sugarcane is one of the typical glycophyte grass plant which can poorly thrive in saline soil profiles of tropics and subtropics globally. Salt stress is a major physiological constrain drastically influencing plant growth and development. Identification of salt-tolerant cultivars can make a substantial contribution to greater productivity of sugarcane in salt stress prone areas. Based upon descriptive phenotypes 38 sugarcane cultivars were included in the present study. Cultivars evaluated in pots at formative and grand growth stages of development under 8 dSm^{-1} levels of salts ($NaCl$, Na_2SO_4, $CaCl_2{\cdot}2H_2O$; 1:2:1 ratio) during two consecutive cropping seasons. Key morphological, physiological and biochemical traits were measured under different levels of salt stress. Recorded data was converted into relative salt tolerance indices (RSTI) for comparative study among genotypes for salt tolerance with multiple agronomic traits. Significant variations were observed between the cultivars at the both growth stages. RSTI for all the studied traits varied considerably such as; for proline contents it was calculated lowest (102.7) in Co 0239 and highest (287.2) in Co 7717 cultivar. Considering the salt tolerance indices derived from morphological, physiological, and biochemical observations indicated that 13 sugarcane cultivars were tolerant, while 13 moderately tolerant and rest 12 cultivars were not capable to grow optimally in salinity and showed susceptibility to salt stress. The tolerance rank of an individual cultivar was based on genotype rank (GR) determined with RSTI and ward's minimum variance of studied parameters. GR ranged from 1 to 3, wherein GR 1 denotes tolerant, GR 2 moderate and GR 3 for susceptible to salt stress. To conclude, salt tolerant cultivars identified and salt tolerance-associated traits can be exploited in breeding programs to improve sugarcane production in saline areas.

Keywords Salt stress tolerance · Morphological characters · Physiological parameters · Biochemical analysis · Nitrate reductase activity · Relative salt tolerance indices (RSTI)

Introduction

Sugarcane is a major agriculture-based feedstock for sugar and ethanol production in tropical and subtropical regions of the world. Several minor industries are depends upon sugarcane for their raw material to produce khandsari, jaggery, paper, plywood, acetic acid, butanol, and pharmaceutical compounds (Solomon, 2016; Singh et al., 2019). Renewable source of bio-energy can limit the dependence on fossil fuels and overcome emission of greenhouse gases (Manners & Casu, 2011). Sugarcane contributes $\sim$ 1.1% to the Indian GDP in agriculture sector, significant considering that the crop is planted only in 2.57% of the gross agriculture land (Solomon, 2016). Indian sugar industry plays a key role to support livelihood of millions rural people and socio-economic growth of the

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country (Singh et al., 2020; Solomon, 2016). Instead of such an important cash crop, sugarcane production has been hampered by the different biotic and abiotic stresses around the globe (Singh et al., 2011, 2012).

Among the several constrains, salt stress is a major abiotic factor affecting sustainability of agriculture, mainly for high water demanding crops like sugarcane over a vast area in the world. It has been estimated that $\sim$ 20% of total cultivated lands and 33% of irrigated arable land is afflicted with high salinity worldwide (Tanji, 1990). In India, 3.77 million ha area is sodic and 2.96 million ha is saline soil and every year more and more land becomes non-productive because of salt accumulation. Human population is on the rise and projected to reach 9.1 billion by 2050. With the available sugarcane genetic resources, it become challenging to meet the sugar demands of the burgeoning population, in particular when additional lands are becoming unusable for agriculture due to climate change and urbanization (Beddington et al., 2012). Sugarcane exhibit stunted growth under saline conditions with yield falling to $\sim$ 50% or less than its inherent potential depending upon the degree of salt stress and genetic constitution of the genotype (Azevedo et al., 2011; Cha-um et al., 2012; Patade et al., 2011).

The impact of soil salinity on sugarcane growth, stalk yield and quality may be due to physiological drought and ion toxicity leading to metabolic toxicity, membrane dis-organization and generation of reactive oxygen species ROS (Hasegawa et al., 2000). Increasing exposure of soil salinity to sugarcane plants leads to cascades of responses at morph-physiological and molecular levels due to salt-induced osmotic and ionic stress. Plants have developed certain defense mechanisms to cope with biotic and abiotic stresses such as; ion homeostasis, osmoregulation, antioxidant biosynthesis and accumulation of plant growth regulators facilitating halophytic plant species to adapt and defense in salt and metal excess (Azevedo et al., 2011; Cha-um et al., 2012). Glycophyte plant species like sugarcane is sensitive to high salt contents and symptoms are appeared in the form of reduced leaf margins, pigment level, chlorophyll contents which leads to lethal effects viz; wilting, chlorosis and necrosis, leaf drying, and senescence (Devi et al., 2017). Cumulatively these attributes ultimately leads to reduced yield and sucrose accumulation (Patade et al., 2011).

Achieving a projected sugarcane yields using marginal agriculture areas needs salt tolerant sugarcane lines which can thrive well in adverse soil environments. Breeding and cultivation of salt tolerant and high yielding cultivars is one of the feasible strategies for sustainable sugarcane production over saline areas. In vitro and in vivo screening processes using proteins as a biochemical marker could be used for ranking the genotypes for salinity tolerance and selection of salt tolerant lines (Azevedo et al., 2011; Cha-um et al., 2012). Considerable efforts have been made by different research groups globally to identify salt tolerant sugarcane genotypes from existing germplasm collections through multiple techniques of phenotypic, physiological and biochemical studies (Errabii et al., 2007; Gomathi & Thandapani, 2005; Mahajan et al., 2013; Plaut et al., 2000; Saxena et al., 2010). Most of these studies for identification of salt-tolerant lines were based field trials under uncontrolled environmental conditions. Additionally, these strategies have also been used and evaluated for stress tolerant traits in other plant species including sorghum (Kausar et al., 2012), rice (Ali et al., 2014), wheat (Al-Ashkar et al., 2019), and barley (Allel et al., 2019). Response of plant species to salinity induced oxidative stress in terms of growth and yield are the ultimate expression of several interacting physiological and biochemical mechanisms. Because of the complex nature of salt-tolerance and the difficulties in maintaining long-term growth experiments, physiological parameters as selection criteria have recommended for screening (Munns & James, 2003; Noble & Rogers, 1992). Hence, authors hypothesized that morphological, physiological, and biochemical attributes are the key selection criteria for salt tolerance in sugarcane (Azevedo et al., 2011; Cha-um et al., 2012). Present study was aimed to identify salt tolerant sugarcane cultivars from available germplasm collections using these potential approaches.

Materials and methods

Plant materials and experimental layout

A total of thirty eight genotypes of sugarcane comprising of released varieties from different parts of agro-climatic zones of sub-tropical and tropical India were included for this study (Table S1). The germplasm accessions were collected from Regional Centre, ICAR-Sugarcane Breeding Institute, Karnal; Sugarcane Research Station, Muzaffarnagar; Sugarcane Research Institute, Shahjahanpur; and Department of Agronomy, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, India. All genotypes were planted under normal (N) and salt stress (S) treatments under rain-off centre at Experimental Field Station, Faculty of Biotechnology, SVPUA&T (28°57′ to 29°02′ N and 77°40′ to 77°45′ E), in two successive seasons 2012–13 and 2013–14. Pot experiment was laid out to standardize the level of salinity which affects the growth attribute of sugarcane plant. The experimental soil was sandy loam with initial pH 7.2 and EC_e (electrical conductivity of the extract of a saturated soil paste) 1.39 dSm^{-1}. We created level of salinity up to 8 dSm^{-1} by mixing estimated amount of NaCl, Na_2SO_4, $CaCl_2.2H_2O$ (1:2:1 ratio) thoroughly into the soil before filling in pot (Vasantha, 2010 and Saxena et al., 2010). Four single budded cane sets of each accession were planted in each pot.

Phenotypic observation

Plant height (cm) was measured from the base of the plant to the top fully opened leaf of the main shoot at formative (120–150 days) stage (S-1) and grand growth (220–250 days) stage (S-2). Measurements were taken from the main shoots in each treatment tagged earlier and average height of the single plant was calculated which expressed in cm. Leaf area (cm^2) was calculated using index leaf method of Stickler et al. (1961) as given below;

$$\text{Leaf area}\left(\text{cm}^2\right) = \text{L} \times \text{W} \times \text{F}$$

where, L = Maximum length (cm), W = Maximum width (cm), F = Factor (0.76). Number of tillers (NT) per plant was counted by taking the average of three plants grown in pots. Length of middle internode (LI) was measured with the help of scale which expressed in cm.

Physio-biochemical observations

The inverse of specific leaf weight is the specific leaf area (cm^2 mg^{-1}) and was calculated by using the following formula; SLA =

$$\frac{\text{Leaf area (dm2)}}{\text{Leaf dry weight (g)}}\text{dm}^2\text{g}^{-1}$$

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Relative water content (RWC) was determined in recently matured leaves following the method devised by Barrs and Wheatherly (1962). RWC % was calculated by the following formula;

$$\text{RWC}(\%) = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Turgid weight} - \text{Dry weight}} \times 100$$

In order to estimate leaf sheath moisture content (%), fresh leaves were collected from the main plants of each treatment in three replications and leaf sheaths were separated from the leaves. Fresh weight of the leaf sheath was taken and the samples were oven dried at 80 °C and the dry weight of the sample was weighed. Percent leaf sheath moisture was calculated by using the following formula;

$$\text{Leaf sheath moisture}(\%) = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Dry weight}} \times 100$$

Membrane stability index (MSI) was estimated according following protocol devised by Sairam (1994). MSI was calculated by the following expression; MSI = [1 − (C1/C2)] × 100. The measurement of photosynthetic rate (μmol CO_2 m^{-2} sec^{-1}) was accomplished at flag leaf stage by using Infrared Gas Analyzer (IRGA) (LI-7500 model, LI-COR Biomet System, USA) as proposed by Long and Bernachhi (2003). Chlorophyll estimation (mg g^{-1} fresh wt) was performed by the method proposed by Arnon (1949). About 250 mg fresh leaves were excised and extracted with 10 ml of 80% acetone and centrifuge (Sigma- 3-30KS, Germany) for 10 min at 12,000 rpm. The final volume of the extract was made upto 25 ml. Absorbance of the extract was measured at 645 and 663 nm using spectrophotometer (LAMBDA 25, PerkinElmer, USA). The total chlorophyll, chlorophyll 'a' and chlorophyll 'b' contents were calculated using the following formulae;

$$\text{Total chlorophyll(CH)} = \frac{(20.2 \times \text{ A645}) + (8.02 \times \text{ A663})}{\text{a} \times 1000\text{ XW}} \times \text{V mg g}^{-1}\text{fresh wt.}$$

$$\text{Chlorophyll }'\text{a}'\text{ (CHA)} = \frac{(12.7 \times \text{ A645}) - (2.69 \times \text{ A663})}{\text{a} \times 1000\text{ X W}} \times \text{Vmg g}^{-1}\text{fresh wt.}$$

$$\text{Chlorophyll }'\text{b}'\text{(CHB)} = \frac{(22.9 \times \text{ A645}) - (4.68 \times \text{ A663})}{\text{a} \times 1000 \times \text{ W}} \times \text{Vmg g}^{-1}\text{fresh wt.}$$

Where; A_{645} = absorbance at 645 nm; A_{663} = absorbance at 663 nm; a = path length of light in the cuvette (1 cm); V = volume of the extract (25 ml); W = fresh weight of the sample (0.25 g).

Proline content (PR) was estimated using the method devised by Bates et al. (1973). About 500 mg of fresh leaves were homogenized in 10 ml of aqueous sulfosalicylic acid (3%; Sigma-Aldrich, USA) and then centrifuged at 4,000 rpm for 20 min. The 2 ml of this aliquot was transferred into test tube and 2 ml of acid ninhydrin reagent (Sigma-Aldrich, USA) added in each test tube. The mixture was heated on boiling water bath for 1 h, after that reaction was terminated by placing test tubes in ice box. Thereafter, the reaction mixture was shaken vigorously with 4 ml toluene and kept for 1 h to make two layers. Chromatophore was extracted in toluene phase and separated out followed by absorbance measured at 520 nm using spectrophotometer (LAMBDA 25, PerkinElmer, USA). L-Proline standard was used for quantification and the proline content in the sample was calculated using the formula;

$$\text{Proline content }(\mu\text{mole/g}) = \frac{36.2311 \times \text{ O.D.} \times \text{ V}}{2\text{ W}}$$

where; W = fresh weight of leaf in mg, O. D. = optical density at 520 nm, and V = total volume of extract, 2 = volume of aliquot taken for proline estimation.

Total protein content (PTN) was estimated in green leaves using method devised by Lowery et al. (1951). About 100 mg of leaves were homogenized in 2.0 ml of ice cold 0.1 M phosphate buffer (pH 7.0) containing 0.01 mM EDTA (Sigma-Aldrich, USA), 1.0% PVP in pre-chilled mortar-pestle. Each homogenate was transferred to centrifuge tubes and was centrifuged (Sigma- 3-30KS, Germany) at 15,000 rpm for 15 min at 4 °C. The supernatant was used for protein estimation using Lowry method with bovine serum albumin as standard. A 0.5 ml aliquot was taken in test tube and mixed with 5.0 ml of reagent (C) solution allowed to stand for 10 min. Thereafter, 0.5 ml of reagent (D) was added with instant mixing. After 30 min, absorbance was recorded at 570 nm by spectrophotometer (LAMBDA 25, PerkinElmer, USA).

$$\text{Protein (mg/gm)} = \frac{\text{G.F. X O.D.} \times \text{V}}{\text{W} \times \text{Aliquote taken (ml)} \times 1000}$$

where; G.F. = gross factor obtain from BSA curve, V = total volume (ml), W = weight of sample (gm).

Plant samples were analyzed for total phosphorus (P), potassium (K) and sodium (Na) percent. P was determined by Vanadomolybidosphosphoric yellow colour method (Jackson, 1973) while, K and Na (%) by flame photometer (Jackson, 1973). For estimation of P, K and Na (%) in leaf samples di-acid digestion method was used. The mixture of concentrate $HClO_4$ and HNO_3 (Sigma-Aldrich, USA) was used in the ratio of (1:2). Transferred 0.5 g of dried fine powdered leaves sample to a 200 ml of test tube containing 10 ml of di-acid mixture and shifted test tube on hot plate and heated at 180–200 °C for 8 h for complete digestion until the dense white fumes are evolved. Cooled and make the volume upto 100 ml by adding double distilled water in flask and filtered through Whatmann filter paper. Finally the filtrate was used for analysis.

For the estimation of potassium (K) %, the known quantity of leaf digest in 100 ml volumetric flask has the dilution factor (0.5 ml made upto 100 ml gives 200 times dilution factor). It was calculated using the formula;

$$\text{K}(\%) = \frac{\text{ppm conc. of K}}{10^6} \times \frac{\text{volume of digest}}{\text{wt of sample (gm)}} \times \text{dilution factor} \times 100$$

In order to estimate sodium (Na) %, the known quantity of plant digest in 100 ml volumetric flask was taken and absorbance recorded using flame photometer (FP 8400, Kruss, Germany) at zero with 0 ppm and with 20, 40, 60, 80, and 100 ppm NaCl solution (K standard solution). The Na % was calculated using the formula;

$$\text{Na} (\%) = \frac{\text{ppm conc of Na}}{10^6} \times \frac{\text{volume of digest}}{\text{wt of sample (gm)}} \times \text{dilution factor} \times 100$$

Similarly, to estimate phosphorus (P) %, the known quantities of plant digest in 100 ml volumetric flask having dilution factor (0.5 ml made upto 100 ml gives 200 times dilution factor) were taken. About, 5 ml volumes of plant digest was made upto 25 ml by subsequent dilution with Vanadate-molybdate reagents HNO_3 (Sigma-Aldrich, USA). Mixed well and absorbance recorded at 420 nm. Standard curve was prepared by plotting P concentration on X axis and % transmission/colorimeter on Y axis with the standard P solution (KH_2PO_4).

Nitrate reductase activity (µmol.NO_2.g.FW^{-1} h^{-1}) was measured using in vivo experiments (Srivastava, 1974). About 1.0 g fresh leaves were excised into tiny pieces, and incubated in assay mixture containing 8.0 ml of 0.1 M phosphate buffer (pH 7.4), 1 ml of 0.2 M $KNO_{3,}$ and 1.0 ml of 25% (v/v) propanol (Sigma-Aldrich, USA) in 10 ml of black tapped air tight vials. The incubation mixture was first evacuated and then the vials were incubated in dark at 30 °C for 30 min. Nitrite produced thereafter was estimated colorimetrically. For this to 2.0 ml of incubation medium, 2.0 ml sulphanilamide (1.5% w/v in 1.5 N HCl), and 2.0 ml napthylethylene diamine dihydrochloride (0.02% w/v; Sigma-Aldrich, USA) were added. The intensity of pink color so obtained was measured after 15 min at 540 nm using spectrophotometer (LAMBDA 25, PerkinElmer, USA). The amount of nitrite was calculated using a standard curve of KNO_2.

Statistical analysis

The data was subjected to statistical analysis using OPSTAT-1, ED and SPSS (version 19.02) computer software. Means for each trait under stress and non-stress conditions were separated by the least significant difference (LSD) at $P \leq 0.05$ and $P \leq 0.01$. Relative salt tolerant trait indices (RSTI) for each of the studied trait were calculated according to the formula of Ali et al. (2007).

$$\text{RSTI} = \frac{\text{Value of trait under stress condtion}}{\text{Value of trait under control condtion}} \times 100$$

Results

In the present investigation, the impact of salinity stress on key morphological, physiological and biochemical traits was studied in sugarcane elite cultivars at maturity stage. In total nineteen traits were undertaken in this study include; four morhpological (PH; plant height, LA; leaf area, NT;

number of tillers plant^{-1}, and LI; length of internode), five physiological (SLA; specific leaf area, RWC %; relative water content, LSM; leaf sheath moisture LSM), MSI; membrane stability index, and PHR; photosynthetic rate), and ten biochemical (CHA; chlorophyll a, CHB; chlorophyll b, CH; total chlorophyll, PR; proline content, PTN; protein content, K^+; potassium ion, Na^+; sodium ion, Na^+/K^+; potassium/sodium ion ratio, P; phosphorus, and NR; nitrate reductase activity using standard protocols. Data recorded for each trait during two cropping season (2012–13 and 2013–14) was showed that salinity significantly affect all the morphological and physiological traits along with biochemical parameters studied for crop season 2012–13 (Tables 1, 2, 3 and 4) and 2013–2014 (Tables 5, 6, 7 and 8).

All the data was converted into salt tolerance indices (STI) to allow comparisons among genotypes for salt tolerance using multiple agronomic and biochemical traits. A salt tolerance index was defined as the observation at salinity divided by the average of the control genotype salinity resistance ranking numbers can be assigned to cluster groups based on cluster means, and were used to score genotypes. Relative salt tolerant trait indices (RSTI) for each studied trait showed a wide ranges during 2012–13 and 2013–14 cropping season (Table S2a, b, c, d).

Morphological characterization of sugarcane

Data was recorded for key morphological traits including; plant height, leaf area, number of tillers plant -1, and length of internode at stage I (120–150 day) and stage II (220–240 day) during crop season 2012–13 (Table 1) and 2013–2014 (Table 5) under salt stress.

Plant height (cm)

The studied genotypes showed a wide range of RSTI for plant height ranged from 49.1 (CoSe 98,231) to 98.6 (BO 91) with a mean of 75.0 at plant stage 1 (S-1) and 48.5 (CoSe 98,231) to 97.6 (BO 91) with a mean of 73.4 at stage 2 (S-2) during 2012–13 (Table S2a). During 2013–14, RSTI values were ranged from 60.0 (CoJ 64) to 96.7 (BO 91) with a mean of 77.9 in salinity at S-1, and 47.7 (CoSe 98,231) to 96.9 (BO 91) with a mean of 72.9 in salinity at S-2 (Table S2a).

Leaf area (cm^2)

The RSTI revealed a wide range of leaf area (cm^2) varied from 33.7 (CoS 88,230) to 88.5 (CoS 95,255) with a mean of 78.8 in salinity at S-1 and 40.3 (CoS 88,230) to 85.3 (CoC671) with a mean of 84.1 at S-2 in 2012–13 (Table S2a). While in 2013–14 it ranged from 45.8 (CoS 08,279) to 88.2 (CoS95255) with a mean of 66.1 S-1 and 39.3 (CoS 88,230) to 84.8 (CoC671) with a mean of 63.4 at S-2 (Table S2a).

Number of tiller

The RSTI was revealed a wide range of number of tiller per plant ranged from 73.7 (CoS 03,234) to 100.0 (Co 0237) with a mean of 93.8 in salinity at S-1 and 62.7 (CoJ 64) to 99.8 (CoS 6287) with a mean of 83.9 at S-2 in 2012–13 (Table S2a), while in 2013–14 it ranged from 74.0 (CoS 3234) to 99.2 (BO 91) with a mean of 92.8 at S-1 and 61.4 (CoJ 64) to 99.4 (CoS 8276) with a mean value of 82.6 at S-2 (Table S2a).

Length of internode

The RSTI revealed a wide range of length of internode (cm) from 73.6 (CoS 8272) to 99.2 (CoS 7250) with a mean value of 94.5 in salinity at S-1 and 78.2 (CoS 8272) to 97.9 (BO 91) with a mean of 89.8 at S-2 in 2012–13 (Table S2a), while in 2013–14 it ranged from 74.0 (CoS 3234) to 99.2 (BO 91) with a mean of 92.8 at S-1 and 78.5 (CoS 8272) to 97.8 (BO 91) with a mean value of 89.5 at S-2 (Table S2a).

Physiological characterization of sugarcane

Data was recorded for key physiological traits including; specific leaf area (cm^2mg^{-1}) (Tables 1 and 2), RWC %, leaf sheath moisture (%), membrane stability index (MSI), and photosynthetic rate (µmol CO_2 m^{-2} sec^{-1}) at stage I (120–150 day) and stage II (220–240 day) during crop season 2012–13 (Table 2) and 2013–2014 (Table 6) under salt stress.

Specific leaf area (cm^2 mg^{-1})

The RSTI revealed a wide range of specific leaf area ranged from 45.8 (CoS 88,230) to 99.1 (Co 1158) with a mean of value 93.8 in salinity at S-1 and 45.0 (UP 05,125) to 98.9 (BO 91) with a mean of 83.9 at S-2 in 2012–13 (Table S2a), while in 2013–14 it ranged from 51.4 (Co 0240) to 98.8 (BO 91) with a mean of 74.1 at S-1 and 38.3 (UP 05,125) to 97.6 (BO 91) with a mean of 68.2 at S-2 (Table S2a).

Relative water content (RWC)

The RSTI revealed a wide range of RWC which varied from 45.8 (UP 05,125) to 99.1 (Co1158) with a mean of 73.3 in salinity at S-1 and 63.0 (CoSe 98,239) to 97.6 (CoC671) with a mean of 85.42 at S-2 during 2012–13

Table 1 Data recorded for morphological traits viz, plant height, leaf area, number of tillers plant $^{-1}$, length of internode and specific leaf area at stage I (120–150 day) and stage II (220–240 day) during crop season 2012–13 under salt stress

Genotypes	Plant height (cm)				Leaf area (cm^2)				No. of tillers plant $^{-1}$				Length of internode (cm)				Specific leaf area ($dm^2\ g^{-1}$)			
	I		II		I		II		I		II		I		II		I		II	
	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S
CoC 671	84.27	81.83	174.80	168.27	221.91	188.97	367.37	313.26	5.03	5.00	6.00	5.87	4.37	4.23	10.40	10.10	0.15	0.15	0.15	0.14
Co 7717	70.73	67.24	180.30	168.67	210.63	175.23	298.63	229.43	4.03	4.00	4.07	3.53	3.70	3.63	10.20	9.80	0.14	0.14	0.18	0.16
CoS 08,272	82.40	64.23	175.60	131.77	179.47	102.67	269.77	155.17	5.03	3.90	6.00	4.33	4.17	3.07	8.70	6.80	0.14	0.09	0.13	0.08
CoS 03,234	57.70	41.93	197.30	140.17	138.10	95.67	216.63	114.90	4.03	2.97	4.90	4.00	3.83	3.73	9.40	8.30	0.14	0.10	0.14	0.10
Co 0238	72.23	57.97	194.77	127.53	218.50	153.33	375.47	251.31	6.03	5.73	5.93	5.00	4.23	4.13	10.20	9.80	0.15	0.11	0.14	0.10
CoJ 64	52.67	31.27	145.40	88.97	174.27	101.53	264.17	154.90	5.03	5.00	5.00	3.13	3.93	3.83	9.70	8.30	0.13	0.07	0.13	0.06
CoS 95,255	61.30	46.17	154.40	115.23	159.30	141.40	267.53	188.40	4.03	4.00	4.00	3.43	4.13	3.97	10.30	9.40	0.15	0.13	0.14	0.12
Co 0118	67.30	48.47	170.70	119.77	154.17	98.30	289.37	158.67	6.03	5.70	6.40	5.00	4.37	4.13	8.80	7.60	0.15	0.10	0.14	0.09
CoSe 98,239	54.47	36.37	145.20	95.57	165.63	90.67	317.13	170.23	4.03	4.00	5.00	4.90	3.27	3.17	8.30	7.50	0.14	0.09	0.13	0.09
CoS 8436	63.47	45.27	162.40	140.09	164.33	102.31	298.77	183.27	3.97	3.83	5.00	3.67	3.93	3.83	8.40	7.60	0.12	0.08	0.12	0.07
Co 98,014	55.47	40.23	170.40	121.27	146.97	94.90	213.63	107.33	5.03	5.00	6.00	4.90	4.03	3.83	8.60	8.10	0.14	0.10	0.14	0.10
Co 1148	50.47	44.17	150.80	128.27	146.33	110.90	221.20	165.10	4.03	4.00	5.03	3.70	3.63	3.53	10.60	9.70	0.13	0.12	0.13	0.12
Co 0239	64.50	45.67	145.32	98.23	151.97	98.37	255.63	165.77	4.97	4.60	5.00	3.43	4.23	4.13	10.20	8.90	0.15	0.09	0.14	0.08
CoS 96,268	66.80	46.23	155.70	105.23	176.03	113.37	248.46	150.47	3.97	3.67	4.00	3.30	3.43	3.37	9.10	7.80	0.14	0.09	0.13	0.08
Co 05,011	57.63	36.40	149.20	93.23	155.37	96.46	218.93	141.22	3.97	3.63	4.30	3.20	3.53	3.17	8.50	7.10	0.15	0.09	0.14	0.08
CoSe 92,423	50.77	45.53	180.10	158.00	109.53	91.23	268.43	208.27	4.93	4.77	5.83	5.47	4.53	4.43	8.60	8.10	0.14	0.13	0.14	0.13
CoS 96,275	63.40	43.17	143.90	97.37	167.30	104.57	287.40	158.37	2.97	2.80	4.00	3.00	4.17	4.07	10.30	8.70	0.12	0.10	0.12	0.09
CoS 01,434	51.20	32.07	157.50	97.43	167.47	113.93	257.23	185.97	5.03	4.10	6.00	4.40	3.17	2.90	9.40	8.50	0.13	0.09	0.13	0.08
UP 49	71.17	61.03	175.70	145.80	187.77	139.26	315.80	220.67	3.97	3.70	5.00	4.07	4.23	4.10	10.60	9.40	0.13	0.11	0.12	0.10
CoS 8432	64.20	41.67	154.70	98.47	191.27	110.20	297.27	158.60	4.97	4.67	5.00	5.00	3.80	3.77	8.40	7.50	0.14	0.10	0.13	0.10
CoSe 8231	46.40	22.80	167.20	81.17	107.43	57.07	214.83	112.83	3.97	3.67	6.00	4.37	3.53	3.33	8.20	7.30	0.14	0.10	0.13	0.08
Co 0237	71.27	49.13	158.40	107.57	149.57	85.43	286.73	176.67	2.97	2.97	6.00	5.00	4.57	4.27	9.10	8.20	0.13	0.07	0.12	0.06
Co 0240	69.10	46.17	164.70	108.23	157.17	87.80	289.33	150.53	4.07	3.60	5.00	5.10	3.53	3.33	9.30	8.20	0.14	0.07	0.13	0.06
Co 0241	67.40	46.33	157.20	104.33	185.53	117.27	328.23	189.26	4.97	4.60	5.97	4.97	4.43	4.23	8.20	7.10	0.14	0.09	0.14	0.08
CoS 6287	52.00	32.93	148.60	93.30	153.97	99.28	245.53	157.30	4.03	3.67	4.00	5.00	3.47	3.17	10.40	8.80	0.14	0.07	0.13	0.07
CoS 8276	64.60	41.23	153.40	94.23	167.03	103.53	308.13	197.34	3.03	3.00	4.00	5.20	3.57	3.47	9.40	8.10	0.13	0.07	0.13	0.07
BO 91	72.00	70.97	169.20	165.07	176.23	151.73	267.40	217.73	3.97	3.67	5.10	5.17	4.57	4.33	9.70	9.50	0.15	0.14	0.14	0.14
Co 1158	70.40	62.23	158.70	136.17	224.90	171.60	367.73	264.51	4.97	4.93	5.00	4.40	3.77	3.63	8.40	7.90	0.13	0.12	0.13	0.11
CoSe 1424	55.40	43.97	151.40	117.13	193.07	139.20	358.10	261.66	4.97	4.80	6.03	4.93	4.70	4.53	9.30	8.50	0.14	0.12	0.14	0.11
ISH 135	60.20	44.97	153.70	113.47	180.27	130.20	274.37	198.43	3.03	2.77	5.00	4.10	3.53	3.37	8.60	7.80	0.15	0.13	0.14	0.13
ISH 148	62.40	49.27	157.50	119.17	246.80	184.93	161.76	94.73	3.97	3.60	5.33	5.00	4.13	3.57	8.40	7.80	0.13	0.10	0.13	0.09
UP 05,125	64.20	45.27	158.40	110.27	157.97	88.20	267.27	149.26	2.97	2.83	4.00	3.20	4.23	3.67	10.10	8.90	0.13	0.06	0.12	0.06

Table 1 continued

Genotypes	Plant height (cm)				Leaf area (cm^2)				No. of tillers plant $^{-1}$				Length of internode (cm)				Specific leaf area ($dm^2\ g^{-1}$)			
	I		II		I		II		I		II		I		II		I		II	
	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S
CoS 88,230	74.30	53.47	168.40	119.27	164.63	55.53	269.07	108.59	4.97	4.67	6.07	5.07	4.87	4.63	8.30	7.10	0.14	0.09	0.14	0.08
CoS 08,279	57.20	34.97	151.20	92.07	145.77	68.40	258.27	175.46	4.03	4.00	5.00	5.00	3.83	3.23	9.40	8.50	0.12	0.08	0.13	0.08
Co 86,032	69.80	64.07	174.80	152.37	198.56	167.81	401.43	337.20	5.97	5.60	6.03	4.83	3.47	3.33	10.20	9.80	0.14	0.13	0.13	0.12
CoS 767	68.40	60.67	171.40	143.37	159.30	116.25	254.27	179.93	3.97	3.90	5.00	4.37	4.57	4.17	11.10	10.20	0.14	0.13	0.15	0.14
UP 9530	55.00	43.73	158.10	119.97	122.73	83.65	245.27	140.66	3.03	2.67	5.93	4.87	3.93	3.73	8.60	7.50	0.15	0.12	0.14	0.11
CoS 7250	76.00	63.04	166.20	134.83	178.70	134.28	312.50	222.60	4.03	3.83	5.87	4.47	4.07	4.03	9.40	8.80	0.15	0.12	0.14	0.11
G. Mean	63.64	48.21	162.44	119.77	169.89	114.88	280.50	182.00	4.32	4.05	5.21	4.43	3.99	3.76	9.34	8.39	0.14	0.10	0.14	0.10
SE(m)/CD for T	0.5098/1.4276		0.5262/1.4734		0.5507/1.5422		0.5687/1.5926		0.0834/.2335		0.0886/0.2481		0.0651/N.S		0.2062/0.6031		0.0018/N.S		0.018/0.040	
SE(m)/CD for V	1.9744/5.5291		2.0378/5.7066		2.1329/5.9729		2.2025/6.1680		0.3229/0.9043		0.3432/0.9610		0.2521/N.S		0.7984/2.0125		0.07/=0.195		0.06/=0.0195	
SE(m)/CD for T x V	2.7922/7.819		2.8818/8.070		5.9729/8.447		3.1148/8.723		0.4567/1.279		0.4853/1.359		0.3565/0.998		1.192/3.641		0.0098/=0.028		0.092/0.023	

C—Normal soil (control); **S**— Salinity level (EC_e = 8.0 dSm^{-1}); C. D.— Critical difference is significant at the 5% level

(Table S2b), while in 2013–14 it ranged from 72.4 (CoS 08,279) to 98.6 (CoC671) with a mean of value of 84.7 at S-1 and 61.3 (CoSe 98,239) to 95.8 (CoC671) with a mean of value 83.2 at S-2 (Table S2b).

Leaf sheath moisture (%)

The RSTI was revealed a wide variation in leaf sheath moisture percent ranged from 69.1 (CoS 08,279) to94.2 (BO 91) with a mean of 84.9 in salinity at S-1 and 66.7 (CoS 6287) to 92.3 (BO 91) with a mean of 80.23 at S-2 in 2012–13 (Table S2b). While in 2013–14 varied from 64.0 (CoS 6287) to 94.0 (CoC671) with a mean value of 78.7 at S-1 and 68.2 (CoS 08,279) to 97.0 (CoC671) with a mean value of 83.2 at S-2 (Table S2b).

Membrane stability index (MSI)

The RSTI was showed a wide range of membrane stability index percent ranged from 48.6 (CoS 08,279) to 93.1 (BO 91) with a mean of 66.2 at S-1 and 66.3 (CoS 8276) to 92.4 (BO 91) with a mean value of 80.23 at S-2 in 2012–13 (Table S2b). While in 2013–14 it ranged from 52.0 (CoS 96,268) to 92.2 (CoSe 92,423) with a mean of 68.2 at S-1 and 47.5 (CoS 08,279) to 95.3 (BO 911) with a mean of 65.4 at S-2 (Table S2b).

Photosynthetic rate (PR)

The RSTI was exhibited a wide range of photosynthetic rate (μmol $CO_2\ m^{-2}\ sec^{-1}$) which ranged from 62.2 (CoJ64) to 98.8 (CoC671) with a mean of 81.5 at S-1 and 54.9 (CoJ64) to 97.1 (CoC671) with a mean value of 77.95 at S-2 in 2012–13 (Table S2b), while in 2013–14 it varied from 67.0 (UP 05,125) to 99.0 (BO 91) with a mean value of 82.1 at S-1 and 60.5 (UP 05,125) to 97.5 (BO 91) with a mean of 76.5 at S-2 (Table S2b).

Biochemical characterization of sugarcane

Data was recorded for key physiological traits including; chlorophyll a (mg g^{-1}fresh wt) (Tables 2 and 6), chlorophyll b (mg g^{-1}), total chlorophyll (mg g^{-1}), proline content (μmole/g), protein content (mg/g), K^+ %, (Tables 3 and 7), Na^+ %, K + /Na + ratio, phosphorus (%), and nitrate reductase activity (μ moles $NO_2\ h^{-1}\ g^{-1}$) at stage I (120–150 day) and stage II (220–240 day) during crop season 2012–13 (Table 4) and 2013–2014 (Table 8) under salt stress.

Table 2 Data recorded for physio-biochemical traits viz, relative water content, leaf sheath moisture, membrane stability index, photosynthetic rate and chlorophyll a at stage I (120–150 day) and stage II (220–250 day) during crop season 2012–13 under salt stress

Genotypes	Relative water content (%)				Leaf sheath moisture (%)				Membrane stability index				Photosynthetic rate (µmol CO_2 m^{-2} s^{-1})				Chlorophyll a (mg g^{-1})			
	I		II		I		II		I		II		I		II		I		II	
	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S
CoC671	84.25	83.13	81.24	79.29	66.50	62.39	65.01	59.58	38.27	32.24	42.18	35.32	21.23	20.82	22.21	21.56	1.94	1.79	1.87	1.74
Co 7717	81.21	79.16	77.40	74.98	54.00	49.83	53.46	47.78	27.29	22.32	32.43	26.05	15.33	14.63	17.18	16.24	1.33	1.25	1.28	1.19
CoS08272	78.92	68.73	77.78	65.86	61.21	49.94	57.23	45.93	28.66	18.87	34.00	21.22	21.55	17.35	18.17	13.69	1.73	1.15	1.69	1.04
CoS03234	59.93	51.81	54.24	46.25	60.80	52.33	58.53	48.33	32.05	21.71	38.66	25.46	18.97	15.23	16.97	13.11	1.60	1.06	1.58	0.98
Co 0238	69.51	62.59	68.45	60.29	64.60	56.42	63.28	53.44	37.91	26.12	42.54	28.15	22.27	19.15	19.17	15.72	1.84	1.21	1.72	1.17
CoJ 64	87.36	76.03	84.96	72.66	66.24	50.73	62.43	45.83	25.23	17.44	36.40	23.46	14.54	9.05	13.43	7.37	2.04	1.37	1.94	1.21
CoS95255	69.63	63.53	66.55	59.92	55.00	48.45	54.11	47.08	29.00	20.12	36.03	24.46	20.67	18.24	21.67	18.78	1.75	1.37	1.72	1.49
Co 0118	68.38	55.85	66.69	52.65	62.30	48.08	60.37	44.60	26.69	15.68	39.29	22.34	19.70	14.12	17.29	11.40	1.86	1.23	1.85	1.20
CoSe98239	73.92	64.07	73.14	46.04	53.76	43.13	51.90	40.27	36.82	22.74	32.21	18.33	15.05	10.78	14.51	10.13	1.97	1.33	1.93	1.20
CoS 8436	75.41	64.13	72.87	59.49	50.40	36.17	48.70	32.86	34.63	20.23	40.26	23.08	18.43	13.05	16.21	10.69	1.48	1.01	1.42	0.94
Co 98,014	81.16	72.92	79.22	56.63	56.47	47.78	54.44	43.97	34.88	18.54	42.90	21.41	17.53	13.70	15.57	11.51	1.67	1.13	1.58	1.02
Co 1148	76.99	72.47	74.49	69.94	58.00	52.51	56.73	49.95	38.15	29.95	42.74	32.52	16.44	14.95	15.17	13.35	1.47	1.22	1.45	1.24
Co 0239	81.74	70.21	79.17	65.10	61.23	47.63	60.53	44.46	29.42	15.48	36.86	18.61	21.19	15.51	19.54	13.59	2.16	1.57	2.03	1.34
CoS 96,268	76.40	65.93	74.17	62.93	60.40	49.63	58.49	45.05	27.53	14.00	32.39	14.93	18.17	14.03	17.57	12.83	1.68	1.17	1.51	1.07
Co 05,011	79.25	68.12	75.28	63.04	56.32	45.49	55.38	42.54	29.16	16.74	38.25	21.72	22.17	17.83	19.29	14.67	1.76	1.36	1.64	1.17
CoSe92423	68.75	66.11	65.35	62.19	56.00	51.30	53.04	47.29	35.76	31.01	39.79	33.66	15.37	14.73	16.68	15.02	1.62	1.46	1.60	1.38
CoS 96,275	78.17	61.52	76.23	59.11	61.33	48.11	58.53	42.84	34.63	20.23	41.44	23.63	19.54	15.46	17.97	13.44	1.58	1.12	1.54	1.06
CoS 01,434	76.32	67.25	74.27	63.58	62.50	53.89	59.30	48.12	25.23	17.44	46.21	31.75	20.96	17.01	19.57	15.21	2.35	1.64	2.14	1.38
UP 49	84.40	79.67	81.41	70.40	60.70	54.03	52.08	44.66	34.29	23.47	40.34	26.82	19.54	17.96	18.37	16.73	1.81	1.59	1.79	1.53
CoS 8432	78.24	67.26	77.33	64.43	60.48	48.89	56.44	43.00	25.23	17.44	33.72	22.30	21.38	17.21	19.67	14.82	1.63	1.11	1.62	1.03
CoSe 8231	68.17	58.61	65.26	54.89	55.74	45.54	53.26	41.84	30.15	17.09	37.72	21.09	18.37	14.33	16.67	12.06	1.76	1.10	1.72	1.01
Co 0237	67.25	51.45	64.19	48.05	59.20	48.14	58.90	44.17	32.26	19.44	41.79	23.80	14.17	9.93	15.73	11.25	1.46	1.12	1.41	1.03
Co 0240	64.26	51.60	62.93	48.91	49.30	37.52	48.34	34.40	28.49	17.27	37.43	21.60	16.33	12.18	14.82	10.24	1.91	1.43	1.89	1.31
Co 0241	79.29	68.07	76.76	63.27	55.68	43.85	50.23	36.15	32.25	22.37	46.30	31.46	18.17	13.92	17.47	12.69	1.70	1.04	1.66	0.97
CoS 6287	67.31	52.30	65.26	49.65	50.60	37.79	46.38	30.95	35.35	26.95	42.11	31.04	19.63	14.31	18.21	12.45	1.69	1.23	1.57	1.04
CoS 8276	78.76	64.01	75.19	60.25	64.20	51.95	61.42	47.06	28.13	14.53	35.16	17.38	15.05	12.39	14.55	11.26	1.64	1.19	1.59	1.21
BO 91	69.28	67.37	65.10	63.09	64.80	61.05	62.74	57.92	32.40	30.17	39.76	36.01	18.87	18.65	20.17	19.54	1.36	1.36	1.39	1.37
Co 1158	78.07	72.43	74.87	69.00	56.74	50.17	55.00	47.70	29.76	20.17	38.83	24.76	19.74	17.41	17.47	14.75	2.03	1.74	1.88	1.58
CoSe 1424	71.30	66.35	68.43	62.22	60.50	53.64	58.64	50.49	34.51	23.07	46.29	29.24	18.37	15.79	19.45	16.20	1.95	1.44	1.91	1.86
ISH 135	80.26	75.56	78.23	73.22	53.02	46.54	52.51	45.67	25.26	17.44	46.30	31.46	14.29	12.46	13.53	11.42	1.60	1.16	1.58	1.39
ISH 148	72.67	66.36	69.14	62.38	57.08	49.23	54.24	44.34	32.25	22.37	41.76	28.55	12.04	9.09	12.43	9.27	1.89	1.36	1.83	1.24

Table 2 continued

Genotypes	Relative water content (%)				Leaf sheath moisture (%)				Membrane stability index				Photosynthetic rate (μmol CO_2 m^{-2} s^{-1})				Chlorophyll a (mg g^{-1})			
	I		II		I		II		I		II		I		II		I		II	
	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S
UP 05,125	69.13	55.19	64.19	48.76	61.43	49.02	55.26	40.55	27.18	14.30	36.34	18.05	17.32	12.47	15.42	10.17	1.68	1.24	1.61	1.12
CoS 88,230	71.15	60.07	69.04	56.88	58.31	45.78	52.18	37.68	36.77	18.09	46.42	22.74	18.97	13.55	17.63	11.66	1.96	1.21	1.87	1.11
CoS 08,279	81.37	68.70	78.29	65.70	65.04	44.97	61.50	46.57	29.68	14.42	38.51	18.47	20.97	15.96	18.82	13.36	1.62	1.07	1.59	1.04
Co 86,032	71.95	67.99	69.64	63.85	57.52	52.24	50.05	43.78	38.43	31.69	46.21	37.80	16.18	14.72	17.73	16.20	2.62	2.27	1.58	1.35
CoS 767	67.29	64.12	66.38	62.55	57.30	50.87	54.35	47.57	42.37	32.64	45.24	33.32	18.17	16.38	16.81	14.86	1.69	1.53	1.64	1.47
UP 9530	69.29	63.95	64.26	58.75	58.05	50.63	57.27	49.10	32.25	22.37	46.28	31.26	19.57	16.96	15.69	12.71	1.87	1.33	1.82	1.27
CoS 7250	77.28	70.67	75.18	68.54	55.24	47.44	53.12	44.53	38.25	25.30	44.07	28.75	23.03	20.13	19.43	16.31	2.05	1.78	1.87	1.59
G. Mean	74.58	65.93	71.91	61.44	58.63	49.03	55.93	44.95	32.01	21.35	40.14	25.84	18.40	15.04	17.32	13.59	1.78	1.33	1.69	1.25
SE(m)/CD for T	0.5871/ 0.6441		0.5755/ 1.6117		0.5006/1.421		0.5336/ 1.4944		0.3883/0.856		0.3589/ 1.0050		0.3502/1.042		0.0131/N.S		0.013/ 0.0424		0.0133/ 0.0371	
SE(m)/CD for V	2.2738/ 6.3676		0.2291/6.242		1.9389/ 5.4296		2.0667/ 5.7877		1.5039/ 4.2117		1.3900/ 3.8925		1.3564/3.7984		0.0507/0.1419		0.0507/ 0.1419		0.0513/ 0.1437	
SE(m)/CD for T x V	3.2157/9.005		3.1524/8.828		2.7420/7.679		2.9228/8.185		2.1269/5.956		1.9657/5.505		1.9182/5.372		0.0716/0.201		0.0716/ 0.201		0.0726/ 0.203	

C—Normal soil (control); S—Salinity level (ECe = 8.0 dSm^{-1}); C. D.—Critical difference is significant at the 5% level

Table 3 Data recorded for physio-biochemical traits viz, chlorophyll b, total chlorophyll, proline content, protein content andpotassium at stage I (120–150 day) and stage II (220–250 day) during crop season 2012–13 under salt stress

Genotypes	Chlorophyll b (mg g^{-1})				Total chlorophyll mg g^{-1})				Proline content (µmoles/g)				Protein content (mg/g)				K^+ (%)			
	I		II		I		II		I		II		I		II		I		II	
	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S
CoC671	0.81	0.79	0.79	0.76	2.75	2.53	2.28	1.92	0.32	0.80	0.32	0.53	296.42	393.00	243.05	305.67	1.65	1.59	1.62	1.43
Co 7717	0.46	0.43	0.57	0.52	1.79	1.68	1.67	1.51	0.25	0.71	0.26	0.40	246.45	337.79	256.36	307.57	1.54	1.53	1.42	1.32
CoS08272	0.69	0.44	0.64	0.40	2.42	1.91	1.94	1.51	0.30	0.33	0.30	0.32	272.16	261.58	276.68	256.29	1.62	1.09	1.54	1.20
CoS03234	0.51	0.35	0.49	0.34	2.11	1.41	2.07	1.44	0.20	0.25	0.21	0.24	255.29	284.35	263.76	267.31	1.67	1.42	1.51	1.35
Co 0238	0.67	0.56	0.46	0.38	2.51	1.63	2.36	1.49	0.27	0.32	0.27	0.30	319.65	353.23	322.59	347.25	2.07	1.61	1.86	1.58
CoJ 64	0.89	0.45	0.76	0.41	2.93	1.82	2.70	1.62	0.11	0.22	0.13	0.12	240.27	238.61	243.50	231.85	1.44	0.75	1.34	0.75
CoS95255	0.69	0.37	0.68	0.33	2.44	1.74	2.40	1.62	0.30	0.40	0.31	0.36	314.06	356.14	320.19	341.11	1.48	1.38	1.36	1.18
Co 0118	0.71	0.40	0.69	0.37	2.57	1.57	2.54	1.57	0.18	0.21	0.19	0.20	298.35	312.27	300.04	287.28	1.67	1.00	1.47	0.92
CoSe98239	0.67	0.41	0.82	0.35	2.82	1.74	2.76	1.55	0.24	0.28	0.26	0.28	265.58	248.35	272.30	240.66	1.56	1.10	1.42	1.10
CoS 8436	0.76	0.47	0.71	0.41	2.24	1.48	2.13	1.35	0.18	0.20	0.25	0.26	243.07	238.39	246.88	205.24	1.96	1.23	1.80	1.15
Co 98,014	0.62	0.41	0.61	0.35	2.29	1.54	2.19	1.37	0.21	0.26	0.23	0.26	204.41	231.25	211.70	210.40	1.69	1.26	1.52	1.24
Co 1148	0.52	0.35	0.48	0.31	1.99	1.55	1.93	1.82	0.23	0.59	0.24	0.35	252.25	234.56	264.06	229.31	1.53	1.45	1.41	1.23
Co 0239	0.43	0.31	0.41	0.24	2.59	1.88	2.44	1.58	0.22	0.23	0.32	0.23	276.09	280.74	282.97	210.88	1.68	1.06	1.58	0.96
CoS 96,268	0.68	0.49	0.64	0.45	2.36	1.66	2.15	1.52	0.33	0.36	0.33	0.35	199.72	214.59	208.90	189.73	1.74	1.24	1.54	1.22
Co 05,011	0.51	0.32	0.48	0.31	2.27	1.80	2.12	1.48	0.21	0.25	0.22	0.24	272.34	265.67	279.95	254.09	1.43	0.91	1.33	1.00
CoSe92423	0.65	0.51	0.64	0.42	2.27	1.97	2.24	2.09	0.25	0.67	0.26	0.39	304.24	393.69	315.09	363.58	1.36	1.29	1.27	1.10
CoS 96,275	0.61	0.47	0.55	0.43	2.19	1.59	2.09	1.49	0.20	0.22	0.20	0.20	263.17	248.87	268.80	224.32	1.54	0.91	1.50	0.85
CoS 01,434	0.95	0.69	0.87	0.62	3.30	2.33	3.01	2.00	0.22	0.26	0.23	0.25	275.43	289.31	279.12	281.22	1.88	1.44	1.71	1.42
UP 49	0.72	0.39	0.68	0.34	2.53	2.18	2.47	2.12	0.36	0.67	0.28	0.46	361.24	398.05	367.38	370.25	1.38	1.28	1.79	1.62
CoS 8432	0.49	0.38	0.41	0.31	2.12	1.49	2.03	1.39	0.31	0.34	0.32	0.34	188.37	203.24	192.40	174.05	1.31	0.77	1.24	0.90
CoSe 8231	0.87	0.51	0.85	0.46	2.64	1.61	2.56	1.47	0.23	0.27	0.24	0.26	286.37	262.10	290.04	255.31	1.47	1.02	1.34	1.04
Co 0237	0.53	0.44	0.52	0.41	1.99	1.56	1.93	1.44	0.19	0.23	0.19	0.22	231.62	234.76	238.22	194.29	1.24	0.61	1.13	0.80
Co 0240	0.86	0.69	0.84	0.61	2.77	2.12	2.73	1.91	0.25	0.28	0.26	0.27	243.11	225.63	251.77	210.88	1.78	1.23	1.44	1.06
Co 0241	0.68	0.46	0.63	0.41	2.38	1.50	2.30	1.38	0.12	0.15	0.13	0.14	218.37	209.29	222.32	182.33	1.68	1.11	1.58	1.22
CoS 6287	0.58	0.24	0.52	0.21	2.27	1.47	2.09	1.25	0.30	0.32	0.31	0.31	267.82	256.24	278.28	226.38	1.64	1.04	1.54	1.16
CoS 8276	0.78	0.34	0.71	0.31	2.42	1.66	2.30	1.51	0.29	0.31	0.29	0.30	245.32	216.34	251.55	211.27	1.35	0.78	1.24	0.85
BO 91	0.54	0.51	0.51	0.46	2.91	2.90	1.90	1.85	0.22	0.62	0.24	0.62	237.39	331.23	304.81	385.29	1.54	1.49	1.48	1.36
Co 1158	0.82	0.47	0.78	0.41	2.84	2.21	2.66	2.00	0.18	0.27	0.20	0.27	306.61	358.74	318.34	335.04	1.43	1.34	1.34	1.13
CoSe 1424	0.79	0.45	0.71	0.38	2.74	2.41	2.62	2.24	0.19	0.28	0.20	0.17	225.31	250.77	232.34	242.07	1.37	1.17	1.25	1.02
ISH 135	0.43	0.25	0.48	0.21	2.03	1.81	2.06	1.83	0.12	0.35	0.15	0.24	214.87	275.90	220.76	251.82	1.77	1.69	1.64	1.44
ISH 148	0.77	0.62	0.73	0.54	2.66	1.98	2.56	1.78	0.15	0.21	0.16	0.20	186.06	221.33	191.08	195.31	1.81	1.59	1.76	1.50
UP 05,125	0.74	0.46	0.61	0.41	2.42	1.70	2.22	1.53	0.21	0.24	0.23	0.23	268.05	253.27	271.26	212.59	1.62	1.00	1.57	1.19

Table 3 continued

Genotypes	Chlorophyll b (mg g^{-1})				Total chlorophyll mg g^{-1})				Proline content (μmoles/g)				Protein content (mg/g)				K^{+} (%)			
	I		II		I		II		I		II		I		II		I		II	
	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S
CoS 88,230	0.86	0.71	0.84	0.62	2.82	1.92	2.71	1.73	0.19	0.21	0.19	0.19	261.37	249.44	267.37	231.28	1.64	1.05	1.53	1.15
CoS 08,279	0.75	0.48	0.71	0.44	2.37	1.55	2.30	1.47	0.27	0.30	0.28	0.28	196.06	208.53	199.08	165.23	1.82	1.25	1.74	1.26
Co 86,032	0.72	0.56	0.58	0.42	3.34	2.56	2.16	1.57	0.12	0.27	0.13	0.25	289.36	376.15	290.79	331.36	1.81	1.74	1.79	1.62
CoS 767	0.67	0.47	0.43	0.30	2.36	1.78	2.25	1.68	0.23	0.57	0.24	0.34	211.38	276.49	218.15	250.38	1.43	1.25	1.36	1.16
UP 9530	0.71	0.45	0.68	0.41	2.58	2.12	2.50	1.98	0.20	0.27	0.22	0.28	264.26	274.57	264.37	259.26	1.79	1.58	1.58	1.35
CoS 7250	0.86	0.52	0.84	0.49	2.91	2.16	2.71	1.90	0.18	0.26	0.22	0.26	270.05	304.14	276.36	295.35	1.70	1.26	1.56	1.04
G. Mean	0.68	0.46	0.64	0.41	2.50	1.86	2.32	1.66	0.22	0.34	0.24	0.29	257.16	278.12	263.23	256.15	1.61	1.22	1.50	1.18
SE(m)/ CD for T	0.0140/N.S		0.0135/ =N.S		0.0592/N.S		0.0618/0.143		0.048/0.1031		0.047/0.1421		0.4169/1.1675		0.4052/1.1347		0.0017/0.0048		0.0017/0.0046	
SE(m)/ CD for V	0.0542/0.151		0.0524/0.146		0.2292/0.641		0.2392/0.669		0.184/0.516		0.184/0.515		1.6146/4.5216		1.5693/4.3948		0.0066/0.0185		0.0064/0.0179	
SE(m)/ CD for T x V	0.0766/0.215		0.0741/0.208		0.3242/0.846		0.3382/1.121		0.761/1.7364		0.460/1.63		2.2834/6.394		2.2194/6.215		0.0093/0.02 6		0.0090/0.025	

C—Normal soil (control); S—Salinity level (ECe = 8.0 dSm^{-1}); C. D.—Critical difference is significant at the 5% level

Chlorophyll a

The RSTI was showed a wide range of chlorophyll a (mg g^{-1}fresh wt) which ranged from 60.9 (CoJ64) to 99.8 (BO 91) with a mean of 75.0 S-1 and 58.1 (Co 0241) to 99.3 (BO 91) with a mean of 73.9 at S-2 in 2012–13 (Table S2b), whereas in 2013–14 it varied from 55.8 (CoS 88,230) to 97.5 (BO 91) with a mean of 72.5 at S-1 and 57.5 (Co 86,032) to 96.1 (BO 91) with a mean of 71.7 S-2 (Table S2b).

Chlorophyll b

The RSTI was exhibited a extensive range of chlorophyll b (mg g^{-1}fresh wt) ranged from 40.6 (CoS 6287) to 97.5 (CoC671) with a mean value of 68.3 at stage S-1 and 39.5 (CoS 6287) to 95.4 (CoC671) with a mean of 64.2 at S-2 in 2012–13 (Table S2c), at the same time as in 2013–14 varied from 73.2 (CoSe 98,231) to 99.4 (BO 91) with a mean of 87.0 at S-1 and 47.3 (CoJ 64) to 96.3 (BO 91) with a mean of 69.5 at S-2 (Table S2c).

Total chlorophyll

The RSTI showed a wide range of total chlorophyll ranged from 61.0 (CoSe 98,231) to 99.8 (BO 91) with a mean value of 74.4 at S-1 and 56.2 (CoSe 98,231) to 97.7 (BO 91) with a mean of 72.1 at S-2 in 2012–13 (Table S2c), while in 2013–14 ranged from 60.2 (Co 0118) to 97.6 (BO 91) with a mean of 77.6 at S-1 and 58.7 (CoSe 98,231) to 96.5 (BO 91) with a mean of 74.4 at S-2 (Table S2c).

Proline content

The RSTI was revealed a broad range of proline content (μmole/g) which ranged from 102.7 (Co 0239) to 287.2 (Co 7717) with a mean of 154.2 at S-1 and 70.9 (Co0239) to 260.1 (BO 91) with a mean of 121.6 at S-2 in 2012–13 (Table S2c). While in 2013–14 ranged from 101.6 (Co 0239) to271.4 (BO 91) with a mean of 149.1 at S-1 and 71.2 (Co 0239) to 250.5 (BO 91) with a mean of 119.3 atS-2 (Table S2c).

Total protein content

The RSTI revealed a wide range of total protein content (mg/g) which ranged from 88.2 (CoS 8276) to139.6 (BO 91) with a mean of 108.2 at S-1 and 74.5 (Co 0239) to126.4 (BO 91) with a mean of 96.94 at S-2 in 2012–13 (Table S2c), while in 2013–14 ranged from 70.2 (Co 98,014) to 139.3 (BO 91) with a mean of 102.0 at S-1 and 74.4 (Co 0239) to 126.6 (BO 91) with a mean of 94.9 at S-2 (Table S2c).

Table 4 Data for physio-biochemical traits viz, sodium, K^+/Na^+ratio, phosphorus and nitrate reductase activity at stage I (120–150 day) and stage II (220–250 day) during crop season 2012–13 under salt stress

Genotypes	Na^+ (%)				K^+/Na^+ ratio				Phosphorus (%)				Nitrate reductase activity (μ moles NO_2 h^{-1} g^{-1})			
	I		II		I		II		I		II		I		II	
	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S
CoC671	0.08	0.08	0.09	0.09	21.01	18.80	19.01	15.60	0.17	0.16	0.19	0.18	0.85	0.84	0.83	0.79
Co 7717	0.07	0.08	0.08	0.09	22.35	19.36	17.54	14.88	0.21	0.19	0.16	0.15	0.75	0.72	0.74	0.66
CoS08272	0.11	0.13	0.13	0.21	14.39	9.55	11.85	5.80	0.19	0.13	0.18	0.12	0.69	0.51	0.68	0.43
CoS03234	0.10	0.16	0.13	0.18	16.54	9.03	12.00	7.31	0.18	0.14	0.18	0.14	0.70	0.56	0.70	0.50
Co 0238	0.12	0.16	0.12	0.21	17.69	10.01	15.24	8.20	0.21	0.17	0.20	0.17	0.87	0.78	0.86	0.71
CoJ 64	0.19	0.27	0.19	0.27	7.53	3.54	7.17	3.89	0.17	0.08	0.16	0.07	0.57	0.35	0.56	0.28
CoS95255	0.10	0.13	0.09	0.13	14.58	11.08	14.20	9.34	0.18	0.16	0.18	0.16	0.65	0.54	0.64	0.57
Co 0118	0.22	0.29	0.21	0.28	7.69	3.47	5.30	3.23	0.16	0.09	0.17	0.08	0.81	0.63	0.79	0.54
CoSe98239	0.11	0.13	0.12	0.21	13.69	8.69	11.34	5.12	0.19	0.15	0.19	0.13	0.68	0.52	0.68	0.46
CoS 8436	0.15	0.26	0.17	0.24	8.22	3.23	6.51	4.32	0.18	0.12	0.18	0.11	0.71	0.52	0.71	0.42
Co 98,014	0.17	0.25	0.13	0.19	9.98	9.06	11.36	6.64	0.16	0.12	0.15	0.10	0.45	0.60	0.59	0.37
Co 1148	0.10	0.11	0.09	0.11	15.00	12.64	15.85	11.41	0.17	0.17	0.17	0.15	0.70	0.61	0.69	0.60
Co 0239	0.13	0.21	0.16	0.21	12.55	5.06	10.21	5.11	0.17	0.10	0.16	0.10	0.88	0.73	0.86	0.60
CoS 96,268	0.10	0.14	0.16	0.22	18.01	8.77	9.34	5.59	0.17	0.12	0.16	0.10	0.75	0.58	0.74	0.51
Co 05,011	0.15	0.19	0.15	0.22	9.79	4.89	8.64	4.62	0.17	0.12	0.17	0.12	0.66	0.49	0.65	0.42
CoSe92423	0.10	0.12	0.08	0.09	13.29	10.42	16.69	12.64	0.17	0.16	0.16	0.15	0.75	0.70	0.75	0.66
CoS 96,275	0.10	0.12	0.17	0.22	16.20	9.75	8.64	3.87	0.15	0.08	0.15	0.09	0.63	0.45	0.62	0.38
CoS 01,434	0.13	0.17	0.10	0.13	14.31	8.53	17.19	10.63	0.17	0.12	0.16	0.10	0.87	0.71	0.86	0.63
UP 49	0.09	0.12	0.09	0.12	15.34	10.68	13.80	6.51	0.20	0.17	0.20	0.17	0.74	0.62	0.74	0.65
CoS 8432	0.12	0.17	0.10	0.13	11.21	4.56	12.34	8.64	0.18	0.10	0.18	0.10	0.60	0.42	0.58	0.44
CoSe 8231	0.10	0.17	0.09	0.15	14.65	6.11	14.21	6.72	0.18	0.13	0.17	0.11	0.74	0.58	0.73	0.60
Co 0237	0.10	0.10	0.12	0.19	11.79	5.90	9.58	4.27	0.17	0.09	0.17	0.10	0.70	0.52	0.69	0.55
Co 0240	0.13	0.16	0.15	0.22	14.28	7.44	9.64	4.78	0.18	0.10	0.18	0.11	0.40	0.26	0.57	0.42
Co 0241	0.12	0.18	0.11	0.14	13.84	6.26	13.63	8.67	0.19	0.10	0.18	0.10	0.61	0.53	0.79	0.64
CoS 6287	0.14	0.19	0.18	0.24	12.02	7.51	8.40	5.73	0.18	0.10	0.18	0.10	0.76	0.55	0.74	0.59
CoS 8276	0.13	0.20	0.17	0.26	10.81	3.87	7.21	4.00	0.18	0.10	0.17	0.10	0.68	0.49	0.68	0.52
BO 91	0.08	0.08	0.07	0.08	19.71	18.86	18.71	16.56	0.18	0.17	0.18	0.18	0.63	0.62	0.66	0.62
Co 1158	0.16	0.20	0.11	0.14	8.07	6.55	12.29	8.35	0.20	0.17	0.19	0.17	0.84	0.73	0.84	0.76
CoSe 1424	0.08	0.12	0.09	0.13	16.12	9.46	13.53	8.10	0.18	0.15	0.17	0.13	0.81	0.70	0.81	0.74
ISH 135	0.10	0.16	0.13	0.15	18.06	10.24	12.59	9.67	0.21	0.18	0.19	0.16	0.69	0.58	0.68	0.62
ISH 148	0.13	0.17	0.12	0.21	13.63	9.40	14.71	7.29	0.17	0.13	0.16	0.11	0.79	0.64	0.78	0.68
UP 05,125	0.11	0.19	0.13	0.24	14.61	5.31	12.30	5.05	0.15	0.09	0.15	0.09	0.66	0.47	0.65	0.49
CoS 88,230	0.10	0.21	0.17	0.22	16.23	4.95	8.89	5.21	0.18	0.11	0.18	0.10	0.87	0.66	0.85	0.66
CoS 08,279	0.13	0.21	0.15	0.22	13.50	5.90	11.80	5.73	0.21	0.12	0.20	0.11	0.75	0.55	0.74	0.56
Co 86,032	0.13	0.16	0.11	0.15	13.69	10.27	16.19	11.34	0.19	0.18	0.18	0.17	0.80	0.73	0.80	0.75
CoS 767	0.10	0.14	0.10	0.12	14.00	8.99	13.97	9.80	0.17	0.15	0.16	0.14	0.65	0.55	0.64	0.58
UP 9530	0.12	0.16	0.11	0.15	14.45	10.11	14.70	8.90	0.17	0.14	0.17	0.13	0.81	0.68	0.81	0.72
CoS 7250	0.14	0.17	0.10	0.14	12.41	7.50	15.20	7.32	0.18	0.15	0.18	0.15	0.79	0.65	0.78	0.68
G. Mean	0.12	0.16	0.13	0.18	13.98	8.57	12.41	7.65	0.18	0.13	0.17	0.12	0.72	0.59	0.72	0.57
SE(m)/CD for T	0.09/0.026		0.010/ 0.029		0.1874/ 0.5624		0.1971/ 0.5520		0.0019/ N.S		0.0016/ 0.0049		0.0103/ 0.03120		0.0036/ 0.0100	
SE(m)/CD for V	0.036/ 0.101		0.40/0.11		0.7257/ 2.0321		0.7634/ 2.1377		0.0073/ 0.0205		0.0061/ 0.0171		0.0399/ 0.1118		0.0138/ 0.0386	

Table 4 continued

Genotypes	Na^+ (%)				K^+/Na^+ ratio				Phosphorus (%)				Nitrate reductase activity (µ moles NO_2 h^{-1} g^{-1})			
	I		II		I		II		I		II		I		II	
	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S
SE(m)/CD for T x V	0.051/0.14		0.056/0.16		1.0262/2.874		1.0795/3.023		0.0104/ 0.029		0.0086/ 0.024		0.0565/0.158		0.0195/ 0.055	

C—Normal soil (control); S—alinity level (ECe = 8.0 dSm^{-1}); C. D.—Critical difference is significant at the 5% level

Potassium (K^+ %)

The RSTI showed a wide range of K^+ % ranged from 49.4 (Co 0237) to 99.1 (Co 7717) with a mean of 76.1 in salinity at stage S-1 and 55.6 (CoJ 64) to 93.2 (Co 7717) with a mean of 78.4 at S-2 in 2012–13 (Table S2c), whereas in 2013–14 it ranged from 50.4 (Co 0237) to 98.8 (BO91) with a mean of 76.6 at S-1 and 53.4 (CoJ 64) to 97.7 (BO 91) with a mean of 75.9 at S-2 (Table S2c).

Sodium (Na^+ %)

The RSTI exhibited a extensive range of sodium percent ranged from 99.0 (BO 91) to 207.9 (CoS 88,230) with a mean of 136.8 at S-1 and 106.3 (CoC671) to 185.4 (UP 05,125) with a mean of 138.1 at S-2 in 2012–13 (Table S2d), whilst in 2013–14 ranged from 101.7 (BO91) to 162.2 (CoS 8436) with a mean of 131.0 at S-1 and 97.6 (BO 91) to 167.1 (UP 05,125) with a mean of 135.5 at S-2 (Table S2d).

Potassium/Sodium (Na^+/K^+) ratio

The RSTI revealed a large range of potassium/sodium ratio ranged from 30.5 (CoS 88,230) to 95.7 (BO 91) with a mean of 59.9 at S-1 and 44.8 (CoS 9675) to 88.5 (BO 91) with a mean of 60.9 at S-2 in 2012–13 (Table S2d), whereas in 2013–14 ranged from 44.4 (Co 0239) to 98.1 (BO 91) with a mean of 69.at S-1 and 51.1 (CoS 96,268)—94.1 (BO 91) with a mean of 67.4 at S-2 (Table S2d).

Phosphorus (%)

The RSTI revealed a ample range of phosphorus % ranged from 46.7(CoJ 64) to 97.7 (CoC671) with a mean of 73.2 at S-1 and 46.6 (CoJ 64) to 96.8 (CoC671) with a mean of 73.1 at S-2 in 2012–13 (Table S2d), while in 2013–14 ranged from 51.0 (CoS 8276) to 96.9 (BO91) with a mean of 74.9 at S-1 and 50.4 (CoS 8276) to 96.0 (BO 91) with a mean of 73.2 in salinity S-2 (Table S2d).

Nitrate reductase activity

The RSTI revealed a wide range of nitrate reductase activity (µmolNO_2 g^{-1} h^{-1}) ranged from 62.0 (CoJ 64) to 98.6 (CoC671) with a mean of 81.0 under salt stress at S-1 and 49.2 (CoJ 64) to 94.4 (BO 91) with a mean of 78.8 in salinity at S-2 in 2012–13 (Fig. 1 and Table S2d), while in 2013–14 ranged from 56.4 (CoS 88,230) to 98.0 (UP 49) with a mean of 73.6 in salinity at S-1 and 42.4 (CoJ 64) to 93.0 (CoC671) with a mean of 75.3 in salinity at S-2 (Table S2d).

Relative salt tolerance index (RSTI)

The RSTI based on 4 morphological characters ranged from 71.6 (CoS 08,272) to 94.6 (CoC671) with a mean of 82.6 in salinity at S-1 and 65.7 (CoSe 98,231) to 94.2 (BO 91) with a mean of 77.8 at S-2 in 2012–13 (Table S2a), while in 2013–14 it varied from 71.4 (CoS 08,272) to 94.6 (BO 91) with a mean of 82.9 in salinity at S-1 and 65.4 (CoSe 98,231) to 93.2 (BO 91) with a mean of 77.1 in salinity at S-2 (Table S2a). The STI based on 5 physiological characters was varied from 65.8 (UP 05,125) to 96.6 (BO 91) with a mean of 77.9 in salinity at S-1 and 65.8 (CoS 6287) to 95.5 (BO 91) with a mean of 79.0 in salinity at S-2 (Table S2a & Table S2b) in 2012–13, while in 2013–14 ranged from 65.2 (Co 0240) to 96.2 (BO 91) with a mean of 78.5 in salinity at S-1 and 58.8 (UP 05,125) to 95.0 (BO 91) with a mean of 74.4 at S-2) (Table S2b). The RSTI based on 10 biochemical traits was ranged from 76.7 (CoS 8267) to 120.2 (BO 91) with a mean of 90.7 at S-1 and 71.4 (CoJ 64) to 116.1 (BO 91) with a mean value of 85.6 at S-2 (Table S2c & Table S2d) in 2012–13, while in 2013–14 it ranged from 77.4 (Co 0118) to 117.0 (BO 91) with a mean of 91.3 at S-1 and 71.1 (CoJ 64) to 114.2 (BO 91) with a mean of 85.7 at S-2 (Table S2c & Table S2d).

Table 5 Data recorded for morphological traits viz, plant height, leaf area, number of tillers, length of internode and specific leaf area at stage I (120–150 day) & II (220–250 day) during 2013–14 under salt stress

Genotypes	Plant height (cm)				Leaf area (cm^2)				No. of tillers plant $^{-1}$				Length of Internode (cm)				Specific leaf area ($dm^2\ g^{-1}$)			
	I		II		I		II		I		II		I		II		I		II	
	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S
CoC671	85.03	82.03	175.57	167.13	222.77	188.23	368.13	312.13	5.4	5.3	6.3	6.0	4.40	4.27	10.48	9.61	0.177	0.169	0.173	0.164
Co 7717	71.43	67.07	181.00	168.03	211.40	174.57	299.33	228.33	4.4	4.3	4.3	3.7	3.73	3.67	10.28	9.86	0.166	0.159	0.203	0.182
CoS08272	83.27	63.17	176.47	131.17	180.17	102.07	270.63	153.70	5.4	4.2	6.3	4.4	4.20	3.11	8.78	6.90	0.155	0.101	0.150	0.081
CoS03234	58.50	41.20	149.10	118.90	138.93	95.70	217.43	112.89	4.4	3.2	5.2	4.2	3.86	3.77	9.48	8.36	0.160	0.121	0.158	0.112
Co 0238	73.00	57.53	195.50	124.73	219.30	119.43	376.23	249.76	6.4	5.8	6.2	5.1	4.26	4.17	10.28	9.40	0.164	0.123	0.160	0.105
CoJ 64	53.47	32.10	146.20	88.93	175.10	101.20	264.97	149.10	5.4	5.2	5.3	3.2	3.96	3.87	9.78	8.36	0.148	0.079	0.143	0.071
CoS95255	62.17	55.50	155.27	126.93	160.23	141.40	268.40	187.37	4.4	4.3	4.3	3.6	4.16	4.01	10.38	9.46	0.170	0.151	0.165	0.139
Co 0118	68.07	46.07	171.47	120.57	154.97	97.60	290.13	156.67	6.4	5.9	6.7	5.1	4.40	4.17	8.88	7.66	0.163	0.113	0.156	0.095
CoSe98239	55.23	38.90	145.97	93.30	166.43	91.43	317.90	167.57	4.4	4.1	5.3	5.1	3.30	3.21	8.38	7.56	0.154	0.108	0.150	0.092
CoS 8436	64.33	46.20	163.27	138.84	165.27	101.82	299.63	181.83	4.4	4.2	5.3	3.9	3.96	3.87	8.48	7.66	0.135	0.087	0.132	0.068
Co 98,014	56.20	35.67	171.13	119.60	147.73	94.07	214.37	105.50	5.4	4.8	6.3	5.1	4.06	3.87	8.68	8.16	0.165	0.113	0.163	0.108
Co 1148	51.17	44.93	151.50	124.00	147.10	109.38	221.90	163.50	4.4	4.3	5.3	3.9	3.66	3.57	10.68	9.76	0.155	0.144	0.149	0.132
Co 0239	65.37	46.47	146.40	95.90	152.77	97.83	256.50	164.90	5.3	4.9	5.3	3.7	4.26	4.17	10.28	8.96	0.158	0.096	0.156	0.087
CoS 96,268	67.63	45.73	156.53	103.90	176.90	112.50	249.30	150.00	4.3	4.0	4.3	3.4	3.46	3.41	9.18	7.86	0.154	0.103	0.148	0.089
Co 05,011	58.43	37.30	150.00	91.70	156.27	95.72	219.73	139.71	4.3	4.0	4.6	3.5	3.56	3.21	8.58	7.16	0.161	0.101	0.157	0.091
CoSe92423	51.50	46.33	180.83	159.90	110.33	89.93	269.17	206.40	5.3	5.2	6.1	5.7	4.56	4.47	8.68	8.16	0.156	0.148	0.152	0.137
CoS 96,275	64.27	39.37	144.77	97.13	168.10	102.87	288.27	158.63	3.3	3.0	4.3	3.1	4.20	4.11	10.38	8.76	0.139	0.096	0.136	0.094
CoS 01,434	52.03	39.80	158.33	98.20	168.23	113.50	258.07	184.30	5.4	4.4	6.3	4.4	3.20	3.87	9.48	8.56	0.154	0.108	0.151	0.088
UP 49	71.93	62.33	176.47	146.57	188.57	140.08	316.57	218.70	4.3	4.0	5.3	4.4	4.26	4.14	10.68	9.46	0.148	0.128	0.142	0.116
CoS 8432	65.00	47.10	155.50	96.97	192.13	111.30	298.07	156.41	5.3	4.8	5.3	5.0	3.83	3.81	8.48	7.56	0.151	0.118	0.147	0.100
CoSe 8231	47.43	35.83	168.23	80.30	108.53	56.73	215.87	111.53	4.3	4.0	6.3	4.6	3.56	3.37	8.28	7.36	0.154	0.106	0.144	0.088
Co 0237	71.97	54.00	159.10	108.30	150.30	84.73	287.43	175.41	3.3	3.0	6.3	5.1	4.60	4.31	9.18	8.26	0.150	0.089	0.145	0.072
Co 0240	69.87	46.97	165.47	104.60	157.97	87.09	290.10	149.70	4.4	3.9	5.3	4.8	3.56	3.37	9.38	8.26	0.152	0.078	0.146	0.072
Co 0241	68.20	53.73	158.00	101.57	186.37	116.13	329.03	187.17	5.3	4.9	6.2	5.0	4.46	4.27	8.28	7.16	0.154	0.093	0.150	0.072
CoS 6287	52.77	40.47	149.37	89.63	154.67	97.74	246.30	155.25	4.4	4.0	4.3	3.8	3.50	3.21	10.48	8.86	0.157	0.088	0.152	0.082
CoS 8276	65.40	41.90	154.20	92.53	167.70	101.37	308.93	195.97	3.4	3.2	4.3	5.4	3.60	3.51	9.48	8.16	0.152	0.081	0.149	0.078
BO 91	72.70	70.30	169.90	164.57	176.97	151.30	268.10	215.90	4.3	4.2	5.4	5.2	4.60	4.47	9.78	9.56	0.159	0.158	0.153	0.149
Co 1158	71.27	63.13	159.57	135.33	225.80	171.33	368.60	268.17	5.3	5.3	5.3	4.6	3.80	3.67	8.48	7.96	0.146	0.124	0.142	0.115
CoSe 1424	56.23	49.80	152.23	115.57	194.00	138.73	358.93	259.87	5.3	5.1	6.3	5.3	4.73	4.57	9.38	8.56	0.152	0.133	0.148	0.120
ISH 135	61.00	53.27	154.50	114.13	181.17	130.10	275.17	197.32	3.4	3.1	5.3	4.2	3.56	3.41	8.68	7.86	0.158	0.141	0.151	0.132
ISH 148	63.20	52.50	158.30	121.50	247.67	183.33	162.57	94.90	4.3	3.9	5.6	5.2	4.16	3.61	8.48	7.86	0.146	0.106	0.143	0.098
UP 05,125	64.97	46.43	159.17	108.20	158.77	86.60	268.03	145.97	3.3	3.2	4.3	3.4	4.26	3.71	10.18	8.96	0.155	0.083	0.149	0.057

Table 5 continued

Genotypes	Plant height (cm)				Leaf area (cm^2)				No. of tillers plant $^{-1}$				Length of Internode (cm)				Specific leaf area (dm^2 g^{-1})			
	I		II		I		II		I		II		I		II		I		II	
	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S
CoS 88,230	75.13	54.27	169.23	117.37	165.43	53.90	269.90	106.18	5.3	5.0	6.3	5.1	4.90	4.67	8.38	7.16	0.155	0.095	0.153	0.089
CoS 08,279	58.00	40.27	152.00	92.27	146.47	67.10	259.07	173.21	4.4	4.1	5.3	4.5	3.86	3.27	9.48	8.56	0.130	0.084	0.138	0.073
Co 86,032	70.50	64.83	175.50	150.80	199.33	167.18	402.13	332.48	6.3	5.9	6.3	5.2	3.50	3.37	10.28	9.86	0.147	0.136	0.141	0.123
CoS 767	69.37	61.70	172.37	142.80	160.33	115.13	255.23	178.19	4.3	4.2	5.3	4.7	4.60	4.21	11.18	10.26	0.164	0.154	0.170	0.156
UP 9530	55.87	47.37	158.97	120.87	123.63	83.30	246.13	139.41	3.4	3.0	6.2	5.1	3.96	3.77	8.68	7.56	0.173	0.143	0.167	0.129
CoS 7250	76.80	63.91	167.00	133.47	179.57	133.71	313.30	221.20	4.4	4.1	6.1	5.0	4.10	4.07	9.48	8.86	0.161	0.126	0.155	0.118
G. Mean	64.44	50.41	161.96	118.58	170.52	113.32	281.30	180.40	4.7	4.3	5.5	4.5	4.02	3.83	9.42	8.43	0.155	0.115	0.152	0.105
SE(m)/ CD for T	0.5266/ 1.5342		0.5657/1.5843		1.0220/3.1254		0.7420/2.0778		0.1111/ 0.3111		0.0975/ N.S		0.0658/ N.S		0.0658/ N.S		0.0036/N.S		0.0027/ 0.0076	
SE(m)/ CD for V	2.0397/ 5.7119		2.1911/6.1360		3.9583/11.0848		2.8736/8.0474		0.4302/ 1.2048		0.3775/ 1.0571		0.2548/ N.S		0.2548/ N.S		0.0139/ 0.0388		0.0106/ 0.0296	
SE(m)/ CD for T x V	2.8845/8.078		3.0987/8.678		5.5978/15.676		4.0639/11.381		0.6084/ 1.8641		0.5338/1.495		0.3603/ 1.009		0.3603/1.009		0.0196/ N.S		0.0149/0.042	

C—Normal soil (Control); S—Salinity level (EC_e = 8.0 dSm^{-1}); C. D—Critical difference is significant at the 5% level

Table 6 Data recorded for physio-biochemical traits viz, relative water content, leaf sheath moisture, membrane stability index, photosynthetic rate and chlorophyll at stage I (120–150) and stage II (220–250) during 2013–2014 under stress

Genotypes	Relative water content (%)				Leaf sheath moisture (%)				Membrane stability index				Photosynthetic rate (μmol CO_2 m^{-2} s^{-1})				Chlorophyll a (mg g^{-1})			
	I		II		I		II		I		II		I		II		I		II	
	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S
CoC671	85.12	83.90	82.10	78.66	67.37	63.58	64.19	60.35	39.00	33.85	42.38	36.12	22.03	21.38	23.07	22.22	1.65	1.52	2.11	1.90
Co 7717	81.98	78.18	78.17	74.43	54.77	51.26	54.23	49.07	28.09	23.09	32.92	26.82	17.11	16.78	18.04	16.75	1.04	0.95	1.53	1.37
CoS08272	79.62	69.59	78.48	65.25	61.91	49.52	57.93	45.00	29.49	19.99	34.77	21.92	22.25	17.78	18.93	13.63	1.43	0.95	1.93	1.26
CoS03234	60.76	52.61	55.08	42.07	61.63	52.16	59.37	47.71	32.75	23.02	39.36	26.32	19.83	16.30	17.67	12.86	1.30	0.83	1.82	1.08
Co 0238	70.31	62.09	69.25	61.06	65.40	56.39	64.08	52.16	38.57	27.32	43.38	27.80	23.07	18.66	20.00	16.09	1.55	1.02	1.96	1.26
CoJ 64	88.19	71.02	85.80	72.20	67.07	50.87	63.26	45.32	25.96	18.74	37.20	22.52	15.30	11.12	14.23	10.58	1.74	1.09	2.18	1.27
CoS95255	70.56	64.39	67.48	59.65	55.93	48.75	55.04	48.65	29.90	21.57	37.13	25.50	21.70	19.34	22.77	19.81	1.45	1.13	1.97	1.51
Co 0118	69.18	59.58	67.49	51.94	63.10	47.33	61.17	45.37	27.63	16.51	40.02	23.04	20.40	15.50	18.02	11.31	1.56	0.95	2.09	1.29
CoSe98239	74.72	61.38	73.94	45.35	54.56	42.83	52.70	34.25	37.72	23.54	33.01	18.02	15.81	12.03	15.31	10.17	1.67	1.05	2.18	1.34
CoS 8436	76.34	63.18	73.80	58.56	51.33	36.13	49.64	33.73	35.50	21.03	41.09	23.88	19.23	13.88	17.04	10.99	1.18	0.75	1.66	1.05
Co 98,014	81.93	65.93	79.99	56.04	57.24	47.04	55.20	43.74	35.68	19.30	43.60	22.18	18.30	13.71	16.27	11.51	1.37	0.95	1.82	1.25
Co 1148	77.75	75.29	75.25	69.42	58.77	51.86	57.50	50.29	38.95	30.78	43.40	35.54	17.24	16.21	15.83	14.15	1.18	1.02	1.70	1.41
Co 0239	82.54	69.12	79.97	63.90	62.03	47.47	61.33	43.16	30.12	16.28	37.59	20.95	21.89	16.24	20.27	13.87	1.86	1.31	2.28	1.57
CoS 96,268	77.26	66.76	75.03	62.17	61.27	50.47	59.36	45.57	28.29	14.70	33.29	16.32	19.03	15.30	18.47	13.25	1.39	0.89	1.75	1.15
Co 05,011	80.15	61.63	76.18	61.81	57.22	46.29	56.28	41.35	30.19	17.70	39.19	22.55	23.01	19.16	20.22	15.50	1.46	1.06	1.88	1.31
CoSe92423	69.55	67.62	66.15	61.28	56.80	52.03	53.84	47.59	36.66	33.80	40.69	34.46	16.17	15.63	17.58	16.13	1.32	1.21	1.85	1.62
CoS 96,275	78.97	59.71	77.03	58.33	62.13	48.97	59.33	42.81	35.50	21.03	42.30	25.84	20.34	15.86	18.84	13.60	1.28	0.89	1.78	1.24
CoS 01,434	77.09	60.78	75.04	62.38	63.27	54.73	60.07	47.07	26.09	18.89	47.01	32.52	21.73	17.33	20.37	15.24	2.06	1.36	2.38	1.56
UP 49	85.20	76.84	82.21	70.53	61.50	54.80	52.88	46.11	35.05	25.89	41.14	27.81	20.38	19.19	19.17	17.56	1.51	1.31	2.03	1.72
CoS 8432	79.10	59.52	78.19	64.10	61.35	49.69	57.30	40.20	25.93	18.30	34.42	23.40	22.18	16.78	20.97	14.28	1.33	0.83	1.87	1.20
CoSe 8231	69.27	53.97	66.36	53.85	56.84	46.57	54.36	41.88	30.99	18.34	38.49	22.05	19.07	14.30	17.80	12.48	1.47	0.88	1.97	1.17
Co 0237	67.98	49.39	64.92	47.42	59.93	47.47	59.64	43.21	33.06	20.21	42.83	24.76	15.13	10.25	16.77	11.05	1.16	0.86	1.65	1.21
Co 0240	65.06	47.44	63.73	48.31	50.10	35.83	49.14	33.56	29.32	18.07	38.33	22.46	17.20	11.76	15.72	11.21	1.61	1.15	2.13	1.46
Co 0241	80.12	64.39	77.59	61.56	56.51	43.74	51.07	34.13	33.19	23.23	47.13	32.71	18.97	12.85	18.40	13.10	1.41	0.89	1.91	1.19
CoS 6287	68.01	49.17	65.96	49.27	51.30	37.37	47.08	30.12	36.15	26.13	43.04	32.45	20.50	15.25	19.14	12.43	1.39	0.95	1.81	1.23
CoS 8276	79.42	60.57	75.86	58.88	64.87	50.81	62.09	46.98	28.93	15.29	35.96	18.82	15.81	13.19	15.35	10.90	1.35	0.92	1.83	1.24
BO 91	70.02	66.42	65.83	61.59	65.53	63.57	63.47	57.83	33.34	30.33	40.56	38.65	19.63	19.45	20.97	20.45	1.06	1.03	1.63	1.57
Co 1158	78.97	72.24	75.77	68.48	57.64	52.91	56.66	48.03	30.52	20.91	39.76	26.14	20.61	18.34	18.40	15.32	1.73	1.46	2.12	1.77
CoSe 1424	72.23	61.75	69.36	62.03	61.43	53.51	59.58	50.01	35.27	23.77	47.06	30.63	19.10	17.23	20.22	16.94	1.66	1.18	2.15	1.59
ISH 135	81.16	74.73	79.13	73.23	53.92	49.18	53.41	46.47	26.06	18.31	47.07	33.19	14.99	13.80	14.30	11.59	1.30	0.93	1.82	1.36
ISH 148	73.54	65.80	70.01	61.56	57.95	50.68	55.10	45.14	33.12	23.20	42.56	29.95	12.90	10.92	13.23	10.24	1.59	1.17	2.08	1.49
UP 05,125	69.93	51.92	64.99	46.57	62.23	47.97	56.06	39.97	28.08	15.10	37.21	19.35	18.15	12.17	16.29	9.85	1.38	0.87	1.85	1.15

Table 6 continued

Genotypes	Relative water content (%)				Leaf sheath moisture (%)				Membrane stability index				Photosynthetic rate (μmol CO_2 m^{-2} s^{-1})				Chlorophyll a (mg g^{-1})			
	I		II		I		II		I		II		I		II		I		II	
	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S
CoS 88,230	71.95	57.36	69.84	56.13	59.11	44.75	52.98	36.99	37.57	20.62	47.32	23.21	19.77	14.07	18.53	11.77	1.66	0.93	2.11	1.23
CoS 08,279	82.07	59.43	78.99	64.49	65.74	44.81	62.20	47.37	30.48	17.40	39.31	18.67	21.70	15.82	19.62	13.45	1.33	0.79	1.83	1.05
Co 86,032	72.72	64.49	70.41	63.54	58.29	54.19	50.82	43.53	39.19	33.96	47.01	39.02	17.04	15.53	18.53	16.32	2.32	1.99	1.83	1.58
CoS 767	68.32	64.01	67.41	61.99	58.33	52.78	55.39	49.54	43.17	35.03	46.01	34.16	19.00	17.77	17.58	15.17	1.39	1.25	1.88	1.68
UP 9530	70.19	65.58	65.16	58.25	58.95	52.55	58.17	49.09	33.12	24.43	47.08	32.03	20.33	17.76	16.49	12.70	1.57	1.05	2.07	1.49
CoS 7250	78.14	70.77	76.04	66.50	56.11	49.13	53.99	46.17	39.35	28.15	44.93	30.26	23.83	21.71	20.30	16.43	1.75	1.50	2.11	1.82
G. Mean	75.41	63.91	72.74	60.6	59.46	49.47	56.73	44.72	32.84	22.57	40.94	26.90	19.23	15.80	18.18	13.97	1.48	1.07	1.94	1.38
SE(m)/ CD for T	0.6503/ 1.8211		0.5586/ 1.5642		0.5552/ N.S		0.5091/ 1.4256		0.0048/ N.S		0.0057/ 0.0158		0.4597/1.267		0.3393/0.9868		0.0540/N.S		0.0445/ 0.1242	
SE(m)/ CD for V	2.5187/ 7.0533		2.1633/ 6.0580		2.1502/ 6.0216		1.9716/ 5.5214		0.0186/ 0.0522		0.0220/ 0.0616		1.7804/4.9858		1.3141/3.6799		0.2090/ 0.5853		0.1724/ 0.4827	
SE(m)/ CD for T x V	3.5619/9.975		3.0593/8.567		3.0409/8.516		2.7883/7.808		0.0264/0.074		0.0311/0.087		2.5178/6.128		1.8584/5.204		0.2956/ N.S		0.2438/ 0.6471	

C—Normal soil (Control); S—Salinity level (EC_e = 8.0 dSm^{-1}); C. D—Critical difference is significant at the 5% level

Table 7 Data recorded for morphological, physio-biochemical traits viz, chlorophyll b, total chlorophyll, proline content, protein content and potassium at stage I (120–150) and stage II (220–250) during 2013–2014 under salt stress

Genotypes	Chlorophyll b (mg g^{-1})				Total chlorophyll (mg g^{-1})				Proline content (μmoles/g)				Protein content (mg/g)				K^+ (%)			
	I		II		I		II		I		II		I		II		I		II	
	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S
CoC671	0.77	0.74	0.72	0.69	2.88	2.68	2.50	2.29	0.34	0.82	0.35	0.56	298.42	383.78	241.18	304.02	1.67	1.62	1.65	1.56
Co 7717	0.42	0.40	0.50	0.47	1.92	1.84	1.88	1.71	0.27	0.73	0.29	0.42	247.79	321.77	254.49	305.92	1.56	1.49	1.45	1.35
CoS08272	0.65	0.41	0.57	0.34	2.55	2.07	2.15	1.70	0.31	0.35	0.32	0.33	274.16	262.66	274.81	254.63	1.64	1.15	1.56	1.09
CoS03234	0.47	0.33	0.42	0.29	2.23	1.57	2.29	1.63	0.22	0.27	0.23	0.26	256.96	236.34	261.88	261.59	1.69	1.43	1.53	1.24
Co 0238	0.63	0.50	0.39	0.30	2.64	1.79	2.58	1.68	0.29	0.34	0.29	0.32	321.65	311.22	320.72	290.23	2.09	1.63	1.88	1.44
CoJ 64	0.85	0.44	0.69	0.33	3.05	1.98	2.91	1.82	0.13	0.17	0.14	0.13	241.93	213.97	241.63	230.19	1.45	0.79	1.35	0.72
CoS95255	0.65	0.53	0.61	0.48	2.56	2.08	2.61	2.08	0.33	0.42	0.34	0.38	315.40	357.38	318.31	332.25	1.50	1.43	1.38	1.28
Co 0118	0.67	0.35	0.62	0.30	2.70	1.63	2.76	1.77	0.20	0.22	0.21	0.21	300.49	265.85	298.17	256.50	1.69	1.01	1.49	0.90
CoSe98239	0.63	0.36	0.75	0.42	2.95	1.89	2.98	1.75	0.26	0.30	0.28	0.29	267.58	250.39	270.42	239.01	1.58	1.12	1.44	1.05
CoS 8436	0.72	0.42	0.64	0.35	2.37	1.63	2.34	1.55	0.19	0.22	0.26	0.27	244.74	216.24	245.01	203.59	1.97	1.24	1.81	1.13
Co 98,014	0.58	0.36	0.54	0.33	2.42	1.70	2.41	1.57	0.23	0.28	0.25	0.28	206.41	145.00	209.82	166.87	1.71	1.29	1.54	1.13
Co 1148	0.48	0.40	0.41	0.34	2.12	1.71	2.15	1.65	0.25	0.61	0.26	0.37	253.92	251.79	262.19	227.65	1.55	1.46	1.43	1.31
Co 0239	0.39	0.25	0.34	0.21	2.72	2.04	2.66	1.89	0.23	0.24	0.33	0.23	277.76	243.84	281.09	209.23	1.69	1.03	1.59	0.95
CoS 96,268	0.64	0.44	0.57	0.36	2.49	1.81	2.37	1.65	0.34	0.38	0.35	0.36	195.96	188.55	207.02	188.08	1.75	1.25	1.55	1.08
Co 05,011	0.47	0.27	0.41	0.23	2.40	1.87	2.34	1.68	0.22	0.26	0.24	0.26	273.94	267.34	278.08	252.44	1.44	0.93	1.34	0.84
CoSe92423	0.61	0.54	0.57	0.50	2.40	2.13	2.46	2.22	0.27	0.68	0.28	0.41	306.24	395.59	313.22	361.93	1.37	1.31	1.28	1.12
CoS 96,275	0.57	0.42	0.48	0.34	2.32	1.75	2.31	1.69	0.22	0.23	0.22	0.21	264.51	245.40	266.93	222.67	1.56	0.92	1.51	0.85
CoS 01,434	0.91	0.64	0.80	0.54	3.43	2.49	3.23	2.20	0.24	0.29	0.25	0.27	277.43	217.43	277.25	206.78	1.90	1.45	1.74	1.28
UP 49	0.68	0.51	0.61	0.49	2.66	2.34	2.69	2.31	0.38	0.69	0.31	0.48	362.91	338.35	365.50	361.54	1.40	1.33	1.82	1.70
CoS 8432	0.45	0.33	0.34	0.22	2.25	1.65	2.24	1.58	0.33	0.36	0.34	0.35	190.04	157.56	190.52	172.39	1.33	0.79	1.26	0.91
CoSe 8231	0.83	0.46	0.78	0.38	2.77	1.77	2.78	1.67	0.24	0.28	0.25	0.27	288.37	264.17	288.17	253.66	1.48	1.06	1.35	0.97
Co 0237	0.49	0.37	0.45	0.32	2.12	1.72	2.14	1.64	0.21	0.25	0.22	0.24	233.62	231.04	236.35	192.64	1.25	0.63	1.15	0.82
Co 0240	0.82	0.59	0.77	0.55	2.90	2.28	2.94	2.11	0.27	0.30	0.28	0.29	244.78	227.43	249.90	209.23	1.80	1.25	1.45	1.02
Co 0241	0.64	0.41	0.56	0.33	2.51	1.66	2.52	1.58	0.13	0.15	0.14	0.15	220.37	204.80	220.44	180.68	1.68	1.15	1.59	1.09
CoS 6287	0.54	0.28	0.45	0.23	2.39	1.63	2.31	1.45	0.32	0.37	0.33	0.33	269.49	257.87	276.41	224.73	1.66	1.07	1.56	0.99
CoS 8276	0.74	0.37	0.64	0.31	2.55	1.82	2.52	1.71	0.31	0.33	0.31	0.31	246.65	217.87	249.68	209.62	1.36	0.81	1.26	0.86
BO 91	0.50	0.48	0.44	0.42	3.00	2.93	2.12	2.04	0.23	0.63	0.25	0.63	239.05	332.97	302.93	383.64	1.55	1.53	1.49	1.46
Co 1158	0.78	0.65	0.71	0.58	2.97	2.63	2.88	2.37	0.20	0.28	0.21	0.28	308.28	360.67	316.47	333.39	1.44	1.31	1.35	1.18
CoSe 1424	0.75	0.57	0.64	0.48	2.87	2.57	2.83	2.44	0.20	0.29	0.21	0.18	227.31	252.87	230.47	240.42	1.38	1.19	1.26	1.08
ISH 135	0.39	0.35	0.41	0.36	2.16	1.97	2.28	2.03	0.13	0.38	0.16	0.24	216.53	277.70	218.88	250.17	1.78	1.70	1.65	1.48
ISH 148	0.73	0.57	0.66	0.46	2.79	2.30	2.78	1.98	0.16	0.22	0.17	0.20	187.83	223.03	189.20	193.65	1.82	1.57	1.78	1.51
UP 05,125	0.70	0.41	0.54	0.31	2.55	1.94	2.44	1.73	0.24	0.27	0.25	0.26	269.39	254.91	269.39	210.94	1.65	1.03	1.59	0.99

Table 7 continued

Genotypes	Chlorophyll b (mg g^{-1})				Total chlorophyll (mg g^{-1})				Proline content (µmoles/g)				Protein content (mg/g)				K^+ (%)			
	I		II		I		II		I		II		I		II		I		II	
	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S
CoS 88,230	0.82	0.52	0.77	0.53	2.95	2.08	2.93	1.93	0.20	0.22	0.20	0.20	263.37	251.57	265.50	229.63	1.65	1.03	1.55	0.93
CoS 08,279	0.71	0.43	0.64	0.35	2.50	1.71	2.52	1.66	0.28	0.30	0.29	0.29	197.73	183.23	197.21	163.58	1.83	1.35	1.75	1.25
Co 86,032	0.68	0.62	0.51	0.39	3.47	2.95	2.38	1.95	0.13	0.30	0.14	0.26	291.36	378.22	288.91	329.70	1.81	1.65	1.80	1.58
CoS 767	0.63	0.55	0.36	0.30	2.49	2.03	2.47	2.18	0.25	0.59	0.26	0.36	213.05	278.19	216.27	248.72	1.45	1.34	1.38	1.21
UP 9530	0.67	0.60	0.61	0.53	2.71	2.27	2.72	2.21	0.23	0.30	0.25	0.31	266.26	276.71	262.50	257.61	1.82	1.58	1.61	1.37
CoS 7250	0.82	0.61	0.77	0.59	3.04	2.48	2.93	2.22	0.19	0.27	0.23	0.26	272.05	306.24	274.48	293.70	1.71	1.36	1.57	1.24
G. Mean	0.64	0.46	0.57	0.39	2.63	2.04	2.53	1.87	0.24	0.36	0.25	0.3	258.78	264.47	261.35	248.77	1.62	1.24	1.52	1.155
SE(m)/ CD for T	0.0182/N.S		0.0178/ 0.0324		0.0566/N.S		0.0542/0.162		0.0048/ 0.0015		0.057/0.1536		1.0162/2.892		0.6710/1.8790		0.0044/ 0.0123		0.0104/ 0.0290	
SE(m)/ CD for V	0.0707/ 0.1979		0.0689/ 0.1928		0.2193/ 0.3142		0.2193/ 0.6142		0.0186/ 0.0522		0.2200/ 0.6161		2.6422/6.342		2.5987/7.2774		0.0171/ 0.0478		0.0401/ 0.1123	
SE(m)/ CD for T x V	0.0999/ N.S		0.0974/ 0.2410		0.3102/ 0.9821		0.2460/ 0.6281		0.0264/0.074		0.3110/ 0.8721		2.9672/8.9642		3.0751/9.292		0.0241/0.068		0.0567/0.159	

C—Normal soil (Control); S—Salinity level (EC_e = 8.0 dSm^{-1}); C. D—Critical difference is significant at the 5% level

Table 8 Data recorded for physio-biochemical traits viz, sodium, K^+/Na^+ratio, phosphorus and nitrogenase reductase activity at stage I (120–150) and stage II (220–250) during 2013–2014 under stress

Genotypes	Na^+ (%)				K^+/Na^+ ratio				Phosphorus (%)				Nitrate reductase activity (μ moles NO2- h^{-1} g^{-1})			
	I		II		I		II		I		II		I		II	
	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S
CoC671	0.11	0.11	0.11	0.12	21.88	20.80	19.87	18.60	0.44	0.43	0.46	0.43	0.93	0.90	0.77	0.72
Co 7717	0.09	0.10	0.11	0.12	23.12	21.21	18.31	16.28	0.45	0.42	0.41	0.38	0.82	0.80	0.66	0.59
CoS08272	0.13	0.19	0.15	0.22	15.09	11.12	12.55	9.05	0.35	0.27	0.34	0.26	0.76	0.59	0.60	0.34
CoS03234	0.12	0.17	0.15	0.21	17.37	12.80	12.83	9.21	0.40	0.31	0.40	0.32	0.78	0.59	0.62	0.43
Co 0238	0.13	0.20	0.14	0.22	18.49	10.78	16.04	8.96	0.37	0.29	0.36	0.31	0.95	0.84	0.79	0.62
CoJ 64	0.20	0.28	0.20	0.28	8.37	4.34	8.00	4.41	0.30	0.19	0.29	0.19	0.64	0.43	0.49	0.21
CoS95255	0.12	0.15	0.12	0.15	15.52	11.95	15.13	10.91	0.41	0.38	0.42	0.38	0.72	0.62	0.56	0.48
Co 0118	0.23	0.35	0.23	0.37	8.49	4.24	6.10	3.50	0.31	0.17	0.32	0.18	0.88	0.70	0.72	0.45
CoSe98239	0.13	0.18	0.14	0.20	14.49	9.45	12.14	7.87	0.35	0.26	0.34	0.23	0.76	0.56	0.60	0.43
CoS 8436	0.16	0.26	0.18	0.30	9.16	4.10	7.45	3.97	0.30	0.19	0.29	0.18	0.79	0.61	0.63	0.47
Co 98,014	0.20	0.27	0.16	0.21	10.75	7.84	12.12	7.52	0.37	0.27	0.36	0.26	0.52	0.31	0.51	0.29
Co 1148	0.12	0.13	0.11	0.13	15.77	13.34	16.61	13.63	0.38	0.35	0.38	0.34	0.77	0.67	0.61	0.50
Co 0239	0.14	0.21	0.17	0.26	13.35	5.93	11.01	5.97	0.28	0.19	0.28	0.18	0.96	0.71	0.79	0.54
CoS 96,268	0.11	0.15	0.18	0.25	18.88	9.60	10.20	5.22	0.33	0.24	0.32	0.21	0.82	0.48	0.66	0.42
Co 05,011	0.16	0.20	0.17	0.23	10.69	5.69	9.54	4.92	0.32	0.22	0.32	0.20	0.74	0.58	0.57	0.35
CoSe92423	0.12	0.14	0.09	0.11	14.09	12.43	17.49	14.77	0.33	0.30	0.32	0.29	0.83	0.77	0.67	0.60
CoS 96,275	0.11	0.13	0.19	0.23	17.00	10.61	9.44	5.67	0.30	0.19	0.29	0.18	0.71	0.43	0.55	0.29
CoS 01,434	0.16	0.19	0.13	0.16	15.07	9.37	17.96	10.90	0.42	0.26	0.41	0.24	0.94	0.67	0.78	0.54
UP 49	0.11	0.13	0.11	0.13	16.14	13.22	14.60	11.44	0.41	0.38	0.41	0.37	0.82	0.71	0.66	0.56
CoS 8432	0.13	0.18	0.12	0.14	12.07	7.28	13.21	7.49	0.34	0.21	0.34	0.20	0.67	0.51	0.51	0.35
CoSe 8231	0.11	0.18	0.11	0.17	15.75	9.18	15.31	8.83	0.30	0.22	0.30	0.20	0.82	0.54	0.65	0.51
Co 0237	0.13	0.17	0.14	0.20	12.53	7.74	10.31	5.95	0.38	0.24	0.38	0.21	0.77	0.51	0.61	0.46
Co 0240	0.14	0.17	0.16	0.22	15.08	8.21	10.44	5.54	0.34	0.21	0.34	0.17	0.48	0.30	0.50	0.33
Co 0241	0.13	0.19	0.12	0.19	14.67	8.42	14.47	8.21	0.28	0.15	0.27	0.14	0.68	0.47	0.72	0.55
CoS 6287	0.16	0.21	0.20	0.28	12.72	9.84	9.10	6.98	0.39	0.29	0.39	0.22	0.83	0.48	0.67	0.50
CoS 8276	0.15	0.21	0.19	0.29	11.47	6.23	7.87	4.73	0.40	0.20	0.40	0.20	0.76	0.58	0.60	0.43
BO 91	0.09	0.09	0.09	0.08	20.44	20.05	19.44	18.30	0.32	0.31	0.32	0.31	0.70	0.68	0.58	0.53
Co 1158	0.18	0.21	0.12	0.14	8.97	8.01	13.19	11.38	0.31	0.26	0.31	0.26	0.92	0.83	0.76	0.67
CoSe 1424	0.10	0.11	0.10	0.13	17.05	10.29	14.46	8.93	0.28	0.24	0.28	0.23	0.89	0.79	0.73	0.65
ISH 135	0.11	0.13	0.14	0.16	18.96	11.04	13.49	8.43	0.30	0.26	0.28	0.23	0.80	0.68	0.60	0.52
ISH 148	0.14	0.18	0.13	0.22	14.50	11.22	15.58	12.75	0.28	0.23	0.28	0.23	0.86	0.74	0.70	0.59
UP 05,125	0.14	0.21	0.15	0.25	15.41	11.50	13.10	6.79	0.40	0.22	0.40	0.28	0.73	0.40	0.57	0.40
CoS 88,230	0.11	0.18	0.18	0.27	17.03	13.14	9.69	6.61	0.29	0.16	0.29	0.18	0.94	0.72	0.77	0.57
CoS 08,279	0.14	0.22	0.16	0.26	14.20	10.13	12.50	8.55	0.31	0.19	0.30	0.18	0.82	0.65	0.66	0.47
Co 86,032	0.14	0.16	0.12	0.14	14.45	12.65	16.96	13.68	0.28	0.25	0.27	0.24	0.88	0.82	0.72	0.65
CoS 767	0.13	0.15	0.12	0.14	15.03	11.52	15.00	11.00	0.41	0.37	0.40	0.36	0.72	0.65	0.56	0.48
UP 9530	0.15	0.17	0.13	0.16	15.35	10.97	15.60	10.58	0.44	0.39	0.44	0.38	0.89	0.78	0.73	0.63
CoS 7250	0.15	0.18	0.11	0.14	13.27	9.96	16.07	12.10	0.30	0.25	0.29	0.24	0.87	0.75	0.71	0.59
G. Mean	0.14	0.18	0.14	0.20	14.81	10.43	13.24	9.20	0.35	0.26	0.34	0.25	0.79	0.63	0.65	0.49
SE(m)/ CD for T	0.0031/ 0.0087		0.0041/ 0.0116		0.1775/ 0.5264		0.2511/ 0.7514		0.0290/N.S		0.0287/ 0.0412		2.3983/N.S		0.0137/ 0.0397	
SE(m)/ CD for V	0.0120/ 0.0336		0.0160/ 0.0448		0.6876/ 1.9255		0.9725/ 2.7234		0.1123/ 0.3211		0.1113/ 0.3142		4.8452/N.S		0.0529/ 0.1483	

Table 8 continued

Genotypes	Na^+ (%)				K^+/Na^+ ratio				Phosphorus (%)				Nitrate reductase activity (μ moles NO2- h^{-1} g^{-1})			
	I		II		I		II		I		II		I		II	
	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S
SE(m)/ CD for T x V	0.0170/ 0.048		0.0226/ 0.063		0.9724/2.723		1.3753/3.852		0.1589/N.S		0.1574/ 0.3741		7.6354/ 9.6872		0.0749/0.210	

C—Normal soil (Control); S—Salinity level (EC_e = 8.0 dSm^{-1}); C. D—Critical difference is significant at the 5% level

Discussion

In nature, abiotic stress conditions like salinity rarely occurs in isolation and combination of different stresses is usually not predictable by single factor analyses because synergistic, antagonistic, or overlapping effects can occur simultaneously (Katerji et al., 2009; Plaut et al., 2000). There is a strong coordination between various physiological responses of crop plants to drought and salinity and their tolerance mechanisms such as relative water content and excised leaf water retention capacity (Patade et al., 2011). RWC has been reported as an important indicator of salinity stress in leaves than other water potential parameters under stress condition. It is closely related to cell volume, which is known to reflect the balance between water supply to the leaf and transpiration rate (Marcos et al., 2018). Several aspects (i.e. leaf expansion) of plant growth and development are affected by salt stress due to the sensitivity of plant cell towards the water stress. Salt stress reduces leaf production and promotes senescence and abscission resulting in decreased total leaf area per plant. Reduction in leaf area reduces crop growth and thus biomass production. Salt injury is due to Na^+ or Cl^- (or both) is accumulating in transpiring leaves to excessive levels, exceeding the ability of the cells to compartmentalize these ions in the cell vacuole (Cha-um et al., 2012). Ions then build up rapidly in the cytoplasm and inhibit enzyme activity, or they build up in the cell walls and dehydrate the cell.

Morphological evaluation

On the basis of findings of the phenotypic analysis the following sugarcane cultivars including, BO 91, CoC671, Co 7717, CoSe 92,423, CoS 767, CoS 95,255, Co 1148, UP 49, ISH 135, Co 86,032, ISH 148, CoS 07,250, UP 9530, and Co 1158 were found to be salt tolerant among all the 38 studied genotypes (Table 9). Our results were congruence with that of many earlier findings on study of salt stress tolerance in sugarcane (Akhtar et al., 2001; Nasir et al., 2000; Tiku et al., 2014; Vasantha et al., 2010). In present investigation, all the morphological parameters measured were substantially affected under the salt stress conditions such as plant growth was stunted for instance; plant (CoS 01,434) height of control plant was 51.2 cm observed and treated plant was 30.0 cm long (Table 1). Leaf area was reduced from 167.4 to 113.9 cm^2 in CoS 01,434 cultivar under salt stress. Our results were concurred with a previous study, wherein reduction frequency ranged from 8.8 to 56.6% in shoot height, 5.9 to 36.2% in leaf area, and 2.1 to 8.9% of biomass production in sugarcane. Study indicates that the sugarcane phenotypes are adversely affected under excesses of salt contents (Saxena et al., 2010). Salinity causes a significant reduction in sucrose accumulation (Subbarao & Shaw, 1985), tillering ability (Nasir et al., 2000; Wahid & Rasul, 1997), plant height, leaf area and length of internode in sugarcane (Saxena et al., 2010). Sugarcane production starts decline above EC_e 4.0 dSm^{-1} (Rozeff, 1998). Evaluation of large number of genotypes for salt tolerance is difficult in field due to soil heterogeneity. However, various statistical techniques are being utilized to tackle these dilemmas e.g. use of small blocks. These techniques reduced the error variations and increased the identification of varietal differences. Generally crop evaluation for stress tolerance is done under controlled conditions where conditions are different from field conditions (Munns & James, 2003). Therefore, crop salinity tolerance in field has to be evaluated as a function of yield (Yamaguchi & Blumwald, 2005). Four developmental stages i.e., formative phase (60–150 days), grand growth phase (150–240 days), maturation phase and harvesting phase can be distinguished with respect to salt tolerance are good screening criteria for morphological characters under field conditions (Akhtar et al., 2001). In sugarcane effect 8 EC_e of salt on biomass was that reduced by 41% under salt treatment, while tolerant clones showed only moderate reduction of 28 and 17% during formative and grand growth phases, respectively. However, in the sensitive clones, the biomass reduction was 60 and 71% at formative and grand growth phases. The higher reduction of biomass at formative phase supports the principle of feedback inhibition of

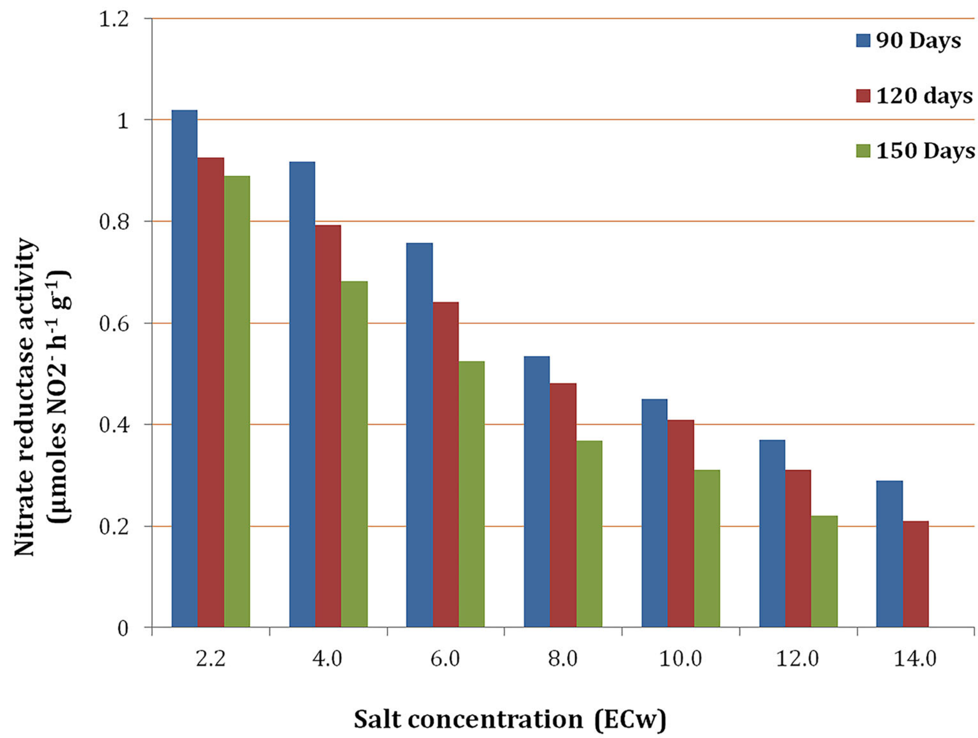

Fig. 1 Nitrate reductase activity in pot grown cultivar BO 91 under different (NaCl: Na_2SO_4: $CaCl_2.2H_2O$, 7:1: 2 ratio) concentration of salt levels in EC_w at 90, 120 and 150 days

photosynthesis by reduced sink activity (Vasantha et al., 2010). Salinity affects the plant growth at various developmental stages including germination and emergence of embryonic tissues (Shannon et al., 1994), vegetative and reproductive growth stages (Abrol et al,. 1988). Time course studies show that salinity influences relative growth, net assimilation capacity, leaf expansion rate in sunflower and leaf area index in wheat (Zheng et al., 2008). Studies show that sugarcane lines capable of producing stronger and ramified root systems showed relatively better salt tolerance than the sensitive one (Wahid & Rasul, 1997).

Physio-biochemical characterization

RWC has been reported as an important indicator of salt stress in leaves than other water potential parameters under salinity stress (Carter and Petterson, 1985). RWC is closely related to cell volume, which is known to reflect the balance between water supply to the leaf and transpiration rate (Farquhar et al., 2007). High degree of RWC in leaf means that the plants can improve its inner aquatic relations under stress conditions (Chakherchaman et al., 2009). All the physio-biochemical traits studied here were affected significantly under salt stress (Tables 2 and 6) and our results were found to be analogous to the previous studies (Azevedo et al., 2011; Mahajan et al., 2013; Saxena et al., 2010). Salinity reduces net photosynthetic rate in plant species (Burman et al., 2003) and increases chlorophyll content at low salinity (Winicov & Button, 1991). Salt-induced reduction of photosynthesis can be caused by stomatal limitation with stomatal closure non-stomatal limitation at low tissue salt concentration (Drew et al., 1990) and a disturbance of photosynthetic activity at high tissue salt concentration (Yeo et al., 1991). Salinity increases Na^+, decreased K^+ and K^+/Na^+ ratio in flag leaves of rice genotypes under NaCl salt of EC_e control, 6.0 and 10.0 (Moradi & Ismail, 2007). Sugarcane genotypes grown for 28 days at two levels of salinity i.e. 1.0 and 10 dSm^{-1} differed significantly in their biomass and K +/Na + ratio. Addition of 100 mM NaCl (EC = 10 dSm^{-1}) to root medium significantly ($P < 0.05$) increased Na^+ concentration and decreased plant biomass accumulation. The total dry matter of ten sugarcane genotypes significantly correlated with K +/Na + ratio (r = 0.81). The genotypes HSF 240 and CP 77–400 produced maximum biomass and K +/Na + ratio and proved to be salt tolerant. Various salt sensitive genotypes of sugarcane were CPF 243 > SPF 213 > SPF 245 > SPF 242 ~ SPF 244 (Ashraf et al., 2007).

The genotypes, BO 91, CoC671, Co 7717, CoSe 92,423, CoS 767, CoS 95,255, Co 1148, UP 49, ISH 135, Co 86,032, ISH 148, CoS 07,250, UP 9530 and Co 1158 were found the most tolerant among studied genotypes respectively (Tables 10 and 11). Our result was supported by the finding of Vasantha et al., (2010), Saxena et al., (2010), Cha-um et al., (2012), and Mahajan et al., (2013). The wide range of relative salt tolerance indices for different traits indicates that genotypes had broad genetic base for these

Table 9 Ranking of genotypes based on ward's minimum variance for morphological and physiological traits during 2012–13 season

Sl. No	Genotype	Based on PH, LA, NT and LI				Based on SLA, RWC, LSM, MSI and PHR			
		S-1		S-2		S-1		S-2	
		GR	TR	GR	TR	GR	TR	GR	TR
1	CoC 671	1	Tolerant	1	Tolerant	1	Tolerant	1	Tolerant
2	Co 7717	1	Tolerant	1	Tolerant	1	Tolerant	1	Tolerant
3	Co 0238	1	Tolerant	2	Moderate	1	Tolerant	1	Tolerant
4	CoS 95,255	1	Tolerant	1	Tolerant	1	Tolerant	1	Tolerant
5	Co 1148	1	Tolerant	2	Moderate	1	Tolerant	1	Tolerant
6	CoSe 92,423	1	Tolerant	1	Tolerant	1	Tolerant	1	Tolerant
7	UP 49	1	Tolerant	1	Tolerant	1	Tolerant	1	Tolerant
8	BO 91	1	Tolerant	1	Tolerant	1	Tolerant	1	Tolerant
9	Co 1158	1	Tolerant	1	Tolerant	2	Moderate	1	Tolerant
10	CoSe 01,424	1	Tolerant	2	Moderate	2	Moderate	1	Tolerant
11	Co 86,032	1	Tolerant	1	Tolerant	1	Tolerant	1	Tolerant
12	CoS 767	1	Tolerant	1	Tolerant	1	Tolerant	1	Tolerant
13	CoS 7250	1	Tolerant	2	Moderate	1	Tolerant	1	Tolerant
14	CoS 08,272	3	Susceptible	3	Suscetible	2	Moderate	1	Tolerant
15	CoS 03,234	3	Susceptible	3	Suscetible	2	Moderate	1	Tolerant
16	CoJ 64	3	Susceptible	3	Suscetible	3	Susceptible	3	Susceptible
17	Co 05,011	3	Susceptible	3	Suscetible	3	Susceptible	3	Susceptible
18	CoS 01,434	3	Susceptible	3	Suscetible	2	Moderate	3	Susceptible
19	CoS 8432	3	Susceptible	2	Moderate	3	Susceptible	3	Susceptible
20	CoSe 98,231	3	Susceptible	3	Suscetible	3	Susceptible	3	Susceptible
21	CoS 6287	3	Susceptible	3	Suscetible	3	Susceptible	3	Susceptible
22	Co 0240	3	Susceptible	2	Moderate	3	Susceptible	3	Susceptible
23	UP 05,125	3	Susceptible	3	Suscetible	3	Susceptible	3	Susceptible
24	CoS 88,230	3	Susceptible	3	Suscetible	3	Susceptible	3	Susceptible
25	CoS 08,279	3	Susceptible	3	Suscetible	3	Susceptible	3	Susceptible
26	Co 0118	2	Moderate	3	Suscetible	3	Susceptible	3	Susceptible
27	CoSe 98,239	2	Moderate	2	Moderate	3	Susceptible	3	Susceptible
28	CoS 8436	2	Moderate	2	Moderate	3	Susceptible	3	Susceptible
29	Co 98,014	2	Moderate	3	Suscetible	3	Susceptible	3	Susceptible
30	Co 0239	2	Moderate	3	Suscetible	3	Susceptible	3	Susceptible
31	CoS 96,268	2	Moderate	3	Suscetible	3	Susceptible	3	Susceptible
32	CoS 96,275	2	Moderate	3	Suscetible	3	Susceptible	3	Susceptible
33	Co 0237	2	Moderate	2	Moderate	3	Susceptible	3	Susceptible
34	Co 0241	2	Moderate	3	Suscetible	3	Susceptible	3	Susceptible
35	CoS 8276	2	Moderate	2	Moderate	3	Susceptible	3	Susceptible
36	ISH 135	2	Moderate	2	Moderate	2	Moderate	3	Susceptible
37	ISH 148	2	Moderate	2	Moderate	2	Moderate	3	Susceptible
38	UP 9530	2	Moderate	2	Moderate	2	Moderate	3	Susceptible

GR Genotype rank; *TR* Tolerance rank

traits. In a breeding program where a large number of genotypes have to be evaluated, relative salt tolerance indices can be computed for different agronomic parameters, cluster analysis can be used to facilitate the ranking of the genotypes for salt tolerance.

Nitrate reductase activity (μ moles NO_2 h^{-1} g^{-1}) was significantly reduced (Fig. 1) under excesses salt

Table 10 Ranking of genotypes based on ward's minimum variance for biochemical traits during 2012–13 season

Sl. No	Genotype	Based on CHA, CHB, CH, PR, PTN, K, N, KN, P and NR			
		S-1		S-2	
		GR	TR	GR	TR
1	CoC671	1	Tolerant	1	Tolerant
2	Co 7717	1	Tolerant	1	Tolerant
3	Co 1148	1	Tolerant	1	Tolerant
4	CoSe 92,423	1	Tolerant	1	Tolerant
5	BO 91	1	Tolerant	1	Tolerant
6	ISH 135	1	Tolerant	1	Tolerant
7	Co 86,032	1	Tolerant	1	Tolerant
8	CoS 767	1	Tolerant	1	Tolerant
9	CoS 95,255	1	Tolerant	1	Tolerant
10	CoS 03,234	2	Moderate	2	Moderate
11	Co 0238	2	Moderate	2	Moderate
12	Co 98,014	2	Moderate	2	Moderate
13	CoS 96,268	2	Moderate	3	Susceptible
14	CoS 01,434	2	Moderate	3	Susceptible
15	UP 49	2	Moderate	1	Tolerant
16	Co 1158	2	Moderate	2	Moderate
17	CoSe 01,424	2	Moderate	2	Moderate
18	ISH 148	2	Moderate	2	Moderate
19	CoS 88,230	2	Moderate	3	Moderate
20	UP 9530	2	Moderate	2	Moderate
21	CoS 07,250	2	Moderate	2	Moderate
22	CoS 08,272	3	Susceptible	3	Susceptible
23	CoJ 64	3	Susceptible	3	Susceptible
24	Co 0118	3	Susceptible	3	Susceptible
25	CoSe 98,239	3	Susceptible	3	Susceptible
26	CoS 8436	3	Susceptible	3	Susceptible
27	Co 0239	3	Susceptible	3	Susceptible
28	Co 05,011	3	Susceptible	3	Susceptible
29	CoS 96,275	3	Susceptible	3	Susceptible
30	CoS 8432	3	Susceptible	3	Susceptible
31	CoSe 98,231	3	Susceptible	3	Susceptible
32	Co 0237	3	Susceptible	3	Susceptible
33	Co 0240	3	Susceptible	3	Susceptible
34	Co 0241	3	Susceptible	3	Susceptible
35	CoS 6287	3	Susceptible	3	Susceptible
36	CoS 8276	3	Susceptible	3	Susceptible
37	UP 05,125	3	Susceptible	3	Susceptible
38	CoS 08,279	3	Susceptible	3	Susceptible

GR Genotype rank; *TR* Tolerance rank

concentrations (Tables 4 and 8). Nitrate uptake and reduction is also affected by salinity stress. Nitrate reductase is the first enzyme involved in nitrate assimilation, catalyses the reduction of nitrate to nitrite. Similar findings of the reduced nitrate reductase activities have also been reported in previous studies under saline soils (Mahajan et al., 2013) and reduced nitrate reductase activity leads to the hampered nitrogen metabolism and protein biosynthesis. There was a reduction in the phosphorus (P) and potassium (K^+ %), K^+/Na^+ ratio and an increase in the sodium (Na^+) concentrations in salt-stressed sugarcane

Table 11 Ranking of genotypes based on ward's minimum variance for morphological and physiological traits during 2013–14 season

Sl. No	Genotype	Based on PH, LA, NT and LI				Based on SLA, RWC, LSM, MSI and PHR			
		S-1		S-2		S-1		S-2	
		GR	TR	GR	TR	GR	TR	GR	TR
1	CoC671	1	Tolerant	1	Tolerant	1	Tolerant	1	Tolerant
2	Co 7717	1	Tolerant	1	Tolerant	1	Tolerant	1	Tolerant
3	CoS 95,255	1	Tolerant	1	Tolerant	1	Tolerant	1	Tolerant
4	Co 1148	1	Tolerant	1	Tolerant	1	Tolerant	1	Tolerant
5	CoSe 92,423	1	Tolerant	1	Tolerant	1	Tolerant	1	Tolerant
6	UP 49	1	Tolerant	1	Tolerant	1	Tolerant	1	Tolerant
7	Co 0241	1	Tolerant	1	Tolerant	3	Susceptible	1	Tolerant
8	CoS 6287	1	Tolerant	1	Tolerant	3	Susceptible	1	Tolerant
9	BO 91	1	Tolerant	1	Tolerant	1	Tolerant	1	Tolerant
10	Co 1158	1	Tolerant	1	Tolerant	2	Moderate	1	Tolerant
11	CoSe 01,424	1	Tolerant	1	Tolerant	2	Moderate	1	Tolerant
12	ISH 135	1	Tolerant	1	Tolerant	2	Moderate	1	Tolerant
13	ISH 148	1	Tolerant	1	Tolerant	2	Moderate	1	Tolerant
14	Co 86,032	1	Tolerant	1	Tolerant	1	Tolerant	1	Tolerant
15	CoS 767	1	Tolerant	1	Tolerant	1	Tolerant	1	Tolerant
16	UP 9530	1	Tolerant	1	Tolerant	2	Moderate	1	Tolerant
17	CoS 7250	1	Tolerant	1	Tolerant	2	Moderate	1	Tolerant
18	CoS 08,272	2	Susceptible	2	Susceptible	3	Susceptible	2	Susceptible
19	CoS 03,234	2	Susceptible	2	Susceptible	2	Moderate	2	Susceptible
20	Co 0238	2	Susceptible	2	Susceptible	2	Moderate	2	Susceptible
21	CoJ 64	2	Susceptible	2	Susceptible	3	Susceptible	2	Susceptible
22	Co 0118	2	Susceptible	2	Susceptible	3	Susceptible	2	Susceptible
23	CoSe 98,239	2	Susceptible	2	Susceptible	3	Susceptible	2	Susceptible
24	CoS 8436	2	Susceptible	2	Susceptible	3	Susceptible	2	Susceptible
25	Co 98,014	2	Susceptible	2	Susceptible	3	Susceptible	2	Susceptible
26	Co 0239	2	Susceptible	2	Susceptible	3	Susceptible	2	Susceptible
27	CoS 96,268	2	Susceptible	2	Susceptible	3	Susceptible	2	Susceptible
28	Co 05,011	2	Susceptible	2	Susceptible	3	Susceptible	2	Susceptible
29	CoS 96,275	2	Susceptible	2	Susceptible	3	Susceptible	2	Susceptible
30	CoS 01,434	2	Susceptible	2	Susceptible	2	Moderate	2	Susceptible
31	CoS 8432	2	Susceptible	2	Susceptible	2	Moderate	2	Susceptible
32	CoSe 98,231	2	Susceptible	2	Susceptible	3	Susceptible	2	Susceptible
33	Co 0237	2	Susceptible	2	Susceptible	3	Susceptible	2	Susceptible
34	Co 0240	2	Susceptible	2	Susceptible	3	Susceptible	2	Susceptible
35	CoS 8276	2	Susceptible	2	Susceptible	3	Susceptible	2	Susceptible
36	UP 05,125	2	Susceptible	2	Susceptible	3	Susceptible	2	Susceptible
37	CoS 88,230	2	Susceptible	2	Susceptible	3	Susceptible	2	Susceptible
38	CoS 08,279	2	Susceptible	2	Susceptible	3	Susceptible	2	Susceptible

GR Genotype rank; *TR* Tolerance rank

Table 12 Ranking of genotypes based on ward's minimum variance for biochemical traits during 2013–14 season

Sl. no	Genotype	Based on CHA, CHB, CH, PR, PTN, K, N, KN, P and NR			
		S-1		S-2	
		GR	TR	GR	TR
1	CoC671	1	Tolerant	1	Tolerant
2	Co 7717	1	Tolerant	1	Tolerant
3	Co 1148	1	Tolerant	1	Tolerant
4	CoSe 92,423	1	Tolerant	1	Tolerant
5	BO 91	1	Tolerant	1	Tolerant
6	ISH 135	1	Tolerant	1	Tolerant
7	Co 86,032	1	Tolerant	1	Tolerant
8	CoS 767	1	Tolerant	1	Tolerant
9	CoS 08,272	2	Susceptible	2	Moderate
10	CoS 03,234	2	Susceptible	2	Moderate
11	Co 0238	2	Susceptible	2	Moderate
12	CoJ 64	2	Susceptible	3	Susceptible
13	CoS 95,255	2	Susceptible	2	Moderate
14	Co 0118	2	Susceptible	2	Moderate
15	CoSe 98,239	2	Susceptible	3	Susceptible
16	CoS 8436	2	Susceptible	3	Susceptible
17	Co 98,014	2	Susceptible	3	Susceptible
18	Co 0239	2	Susceptible	3	Susceptible
19	CoS 96,268	2	Susceptible	3	Susceptible
20	Co 05,011	2	Susceptible	3	Susceptible
21	CoS 96,275	2	Susceptible	3	Susceptible
22	CoS 01,434	2	Susceptible	3	Susceptible
23	UP 49	2	Susceptible	1	Tolerant
24	CoS 8432	2	Susceptible	3	Susceptible
25	CoSe 98,231	2	Susceptible	3	Susceptible
26	Co 0237	2	Susceptible	3	Susceptible
27	Co 0240	2	Susceptible	3	Susceptible
28	Co 0241	2	Susceptible	3	Susceptible
29	CoS 6287	2	Susceptible	3	Susceptible
30	CoS 8276	2	Susceptible	3	Susceptible
31	Co 1158	2	Susceptible	1	Tolerant
32	CoSe 01,424	2	Susceptible	3	Susceptible
33	ISH 148	2	Susceptible	3	Susceptible
34	UP 05,125	2	Susceptible	3	Susceptible
35	CoS 88,230	2	Susceptible	3	Susceptible
36	CoS 08,279	2	Susceptible	3	Susceptible
37	UP 9530	2	Susceptible	3	Susceptible
38	CoS 07,250	2	Susceptible	3	Susceptible

GR Genotype rank; *TR* Tolerance rank

cultivars (Tables 3 and 8) under salt stress. These findings were corresponding to earlier study (Medeiros et al., 2014).

Conclusion

Substantial variability was observed in sugarcane genotypes for morpho-physiological and biochemical traits under salt stress conditions. In present study; BO 91, CoC 671, Co 7717, CoSe 92,423, CoS 95,255, ISH 135, ISH 148, CoS 07,250, UP 9530, CoS 767 and Co 86,032 genotypes of sugarcane were found to be salt tolerant and shown conformity with that of other researchers, but Co 1148, UP 49 and Co 1158 genotypes have been first time found salt tolerant under both stages (formative and grand-growth stage) of plant growth. The tested morpho-physiological and biochemical parameters were less differed significantly among genotypes at formative stage of crop growth (60–150 days of crop age) in comparison to grand growth stage (150–240 days of crop age). These tolerant genotypes therefore, could be used as a new source of salt tolerance in sugarcane breeding program. There is a strong coordination between various physiological responses of plants to drought and salinity and their tolerance mechanisms such as relative water content and leaf water retention capacity.

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Authors' contributions VPR and RSS conceived and designed the study. VPR: performed experiments and data analysis. RBS: wrote the manuscript. All authors have read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest directly or indirectly and informed consent to publish this research work.

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