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Salt stress induced accumulation of biomolecules in groundnut genotypes

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Abstract ;

Salinity is one of the environmental limiting factors in agricultural production. The aim of this study was to find out one of more salt tolerant groundnut genotypes through monitoring the growth and changes in biomolecules under salt stress condition. Purposively four groundnut genotypes, including a Traditional variety, Zhingabadam, Binachinabadam-1 and Dacca-1 were grown under three salinity levels viz. 0, 3 and 5 dSm^{-1}. The experiment was laid out in two factorial completely randomized design with three replications. This experiment was done in soil based pot culture up to 40 days. Increasing salt concentration drastically reduced all the growth parameters, and increase proline and sugar content of leaf. Among the varieties Traditional variety, Zhingabadam and Dacca-1 had statistically similar shoot and root dry weight. The leaves of the Traditional variety contain the highest amount of proline of 14.52 and 36.24 mg/100g fresh leaves in 3 and 5 dS/m salinity, respectively which was 236 and 737 % higher than that of respective control. At EC of 3 and 5 dS/m, the variety Binachinabadam-1 was appeared to be susceptible, having an increase of 6 and 113% proline content over the respective control. Based on the shoot dry weight, root dry weight, proline content, total sugar, reducing sugar and relative water content, the Traditional variety was strongly recommended to be grown in the coastal salt affected soils. The Zhingabadam and Dacca-1 variety also could be recommended as they had comparable performance of the Traditional variety.

Keywords: Salinity stress, Proline, Groundnut.

Introduction

Salinity is one of the most serious environmental factors limiting the productivity of crop plants. Agricultural productivity in arid and semiarid regions of the world is very low due to accumulation of salt in soils (Ashraf *et al*., 2002; Munns *et al*., 2002). About 100million ha of arable land has already been adversely affected by high salt concentration which reduces crop growth and yield (Ghassemi *et al*., 1995). Saline soil causes many adversely effects on plant growth, which is due to low osmotic potential of soil solution, specific ion effects, nutritional imbalance or a combination of these factors. All these factors adversely effects on plant growth and development at physiology and biochemical activities (Ashraf *et al*., 2002; Munns *et al*., 2003).

Tolerance to environmental stresses as salinity of plants can be determined by using different parameters. Plants need to have special mechanisms for adjusting internal osmotic conditions and changing of osmotic pressure in the root environment. It was thought that accumulated proline under salt stress do not inhibit biochemical reactions and plays a role as an osmoprotectant during osmotic stress (Yoshiba *et al*., 1997). The response of free amino acids content to salt stress differed depending on cultivars and stage of development. Proline is a compatible solute known to accumulate in plants subjected to unfavorable environmental conditions.

Salinity stress was found to induce the accumulation of carbohydrates in various plants (Dubey and Singh, 1999; Azad *et al*., 2013)). These organic compounds are thought to mediate osmotic adjusment, protecting sub cellular structure and oxidative damage by their free radical scavenging capacity.

Groundnut (*Arachis hypogaea* L.) is an annual legume and the 13th most important food crop and 4th most important oilseed crop of the world. Groundnut stands first in terms of yield per hectare and fourth in respect of area of production among the oil crops in Bangladesh. Groundnut karnel contains 45-50% high quality oil, more than 25% high assimable protein and vitamin B and E. Many oil seed crops are being grown in Bangladesh

from time immemorial. But the acute shortage of edible oil in the country is increasing every year with increasing population growth.

However, different growth stages of this crop is often subjected to various types of abiotic stress like drought, salinity, high temperature etc which may cause yield loss. Soil salinity, specially coastal and saline regions of Bangladesh, is one of the most important abiotic factors that significantly affect seedling, vegetative and reproductive growth, seed quality and productivity. Groundnut yields have been reported to be severely affected with an increase in soil and water salinity. Therefore, the key biochemical and physiological mechanism responsible for salt resistant in groundnut plants of Bangladesh is necessary for well investigated. The objective of the present work was to screen the groundnut genotypes for salt stress by assessing proline, total sugar, reducing sugar accumulation along with biomass production.

Materials and Methods

The pot experiment was conducted at the net house of Patuakhali Science and Technology University and at the laboratory of the Department of Biochemistry and Food Analysis. Four groundnut genotypes viz. a Traditional variety, Zhingabadam, Binachinabadam-1 and Dacca-1 were used in the screening program.

Soils were collected from the farmers field of the Patuakhali Science and Technology University nearby area. Collected soils were air dried and broken into small pieces. An amount of 3 kg soil was placed into each pots, accordingly 36 pots were prepared. The design of the experiment was two factor completely randomized design with three replications. First factor was groundnut genotypes and second factor was salt concentrations. According to treatment and layout pot soils were salinized with NaCl @ 0, 3 and 5dS/m NaCl. For basal fertilizers 100mg N/kg soil as urea and 80mg P/kg soil as triple super phosphate was applied to the pots. Six groundnut seeds were sown into each pot which were thinned to four after emergence.

After 40 days the plants were harvested and the roots, leaves was sampled separately for chemical analysis as well as recording the growth parameters. The third leaf of each selected plant was detached for Relative Water Content (RWC) determination. The detached leaf was weighed immediately and the measurement recorded as fresh weight (F_W) basis. The cut end of the leaf was placed in distilled water in a test tube; the tube was stopped with cotton wool and kept under light condition in the laboratory following the method outline by Mata and Lamattina (2001). After 5 h, the leaves were removed, blotted dry and reweighed to obtain turgid weight (T_W). The leaves were dried over night at 80°C and re-weighed to obtain the dry weight (D_W). The relative water content (RWC) was calculated using the following formula:

$$\%RWC = \frac{F_w - D_w}{T_w - D_w} \times 100$$

Total sugar content was determined by the anthrone method (Dubois *et al.,* 1956). Two hundred milligrams of fresh leaves were ground in a mortar and pestle along with 5mL 80% ethanol. The content was then filtered through Whatman no. 1 filter paper. The residue remained in the filter paper was washed with 5mL 80% ethanol. The two portions of the filtrate were taken together and warmed for 10-15 minutes in water bath to evaporate the alcohol. It was then volume to 20mL with distilled water. One milliliter of the extract was poured into a test tube and 4mL of anthrone reagent (2g of anthrone dissolved in one liter of concentrate H_2SO_4) was added and mixed well. Glass marbles were placed on top of each test tube to prevent loss of water by evaporation. The test tubes were placed in a boiling water bath for 10 minutes, then removed and cooled. A reagent blank was prepared by taking 1mL of water and 4mL of anthrone reagent in a test tube. Absorbance was measured at 620nm wavelengths in a spectrophotometer.

Reducing sugar content was determined according to the method developed by Miller (1972). Three mL of extract (same as used for total sugar) was pipetted into a test tube and 3mL of Dinitrosalicylic acid (DNS) reagent (prepared through mixing 1 g of DNS, 200 mg of crystalline phenol and 50 mg of Sodium sulphide with 100 ml of 1% NaOH by stirring) added and mixed well. The test tubes with the content were heated for 5 minutes in a boiling water bath. One milliliter of 40% Rochelle salt (40 mg sodium potassium tartrate dissolve in 100 ml of distilled water) was added when the contents of the test tubes were still warm. The test tubes were cooled under

running tap water. A reagent blank was prepared by taking 3mL of distilled water and 3mL of DNS reagent in a tube and then treated similarly. Absorbance of the solution was measured at 540 nm wavelength in spectrophotometer.

Proline content was determined from the leaf sample using the method of Bates *et al.* (1973). Two hundred milligram of fresh leaf sample was homogenized in a mortar with pestle using 10mL of 3% sulfosalicylic acid. The homogenate was centrifuged and then filtered through Whatman no. 1 filter paper. Extraction was repeated and the two portions of the filtrate were taken together. Two milliliter of the filtrate was pipetted into the test tube and 2mL acid ninhydrin and 2mL glacial acetic acid were added to it and the mixture was shaken well. The test tubes were incubated for one hour at 100°C in a hot water bath and were then transferred to an ice bath to terminate the reaction. Four milliliter of toluene was added to each of the test tubes, which was stirred vigorously for 15 - 20 seconds. The toluene layer was separated from the aqueous phase and the absorbance was recorded at 520 nm wavelength against the reagent blank. A standard curve was prepared with analytical grade proline and proline content of the in sample was calculated by using the standard curve.

All the shoot-root parameters were recorded from all the 3 plants grown in a pot. Dry weight of shoot (g/plant) and dry weight of root (g/plant) were recorded on the basis of individual treatment.

Data recorded on plant characters were subjected to statistical analysis through computer based statistical program STAR (Statistical Tool for Agricultural Research) developed by International Rice Research Institute following the basic principles, as outlined by Gomez and Gomez (1984). Significant effects of treatments were determined by analysis of variance (ANOVA) and treatment means were compared at 5% level of significance by Duncan's Multiple Range Test (DMRT).

Results and Discussion

Effects on shoot dry weight/plant

The shoot dry weight/plant of groundnut genotypes significantly ($P<0.001$) influenced due to the single effect of different levels of salinity and variety and the interaction between salinity and variety (Table.1). Increasing salt concentration drastically reduced the shoot dry weight of groundnut. In control treatment ($0dSm^{-1}$) the shoot dry weight was as 3.40g/plant. In 3 and $5dSm^{-1}$ salt concentration plant dry weight was found as 2.58 and 2.15 g/plant, respectively.

Among the varieties Dacca-1, Zhingabadam and Traditional variety had statistically similar plant dry weight of 2.83, 2.81 and 2.70 g/plant respectively. Binachinabadam-1 consistently had the lowest shoot dry weight of 2.32 g/plant.

The interaction effect of variety and salinity on shoot dry weight was significant ($P<0.001$). The highest shoot dry weight of 2.46g/plant was observed in the treatment combination of variety Traditional with $5dSm^{-1}$(high saline condition) and the lowest of 1.53g/plant was recorded in treatment combination of variety Binachinabadam-1 with same salinity level.

Percent decrease over control on shoot dry weight of Traditional variety, Zhingabadam, Binachinabadam-1 and Dacca-1 under 3dS/m and 5dS/m salinity had 18.91, 19.65, 36.75, and 6.71%, and 21.15, 37.28, 53.92 and 22.36%, respectively Thus the percent decrease on shoot dry weight was the lowest (21.15%) in Traditional variety at 5dS/m salinity treatment and was the highest (53.92%) in Binachinabadam-1 at same salinity level (Fig.1). The tolerant genotypes had the minimum decrease under respective control and that of higher decrease in susceptible genotype.

Table 1. Single and interaction effect of salinity and variety on shoot dry weight of groundnut genotypes at vegetative stage

Salt concentration	Traditional	Zhingabadam	Binachina badam-1	Dacca-1	Salt conc. mean
0 dS m^{-1}	3.12A	3.46A	3.32A	3.131A	3.40A
3 dS m^{-1}	2.53B	2.78B	2.10B	2.921B	2.58B
5 dS m^{-1}	2.46B	2.17C	1.53C	2.427C	2.15C
Variety mean	2.70a	2.81a	2.32b	2.83a	

Significance level: Variety-***, Salinity-*** and interaction***
%CV- 4.13; LSD- 0.185

Similar small letters in a row or similar capital letters in a column are not significantly different at 5% level by DMRT; CV= Co-efficient of variation, ***=Significant at 0.1% level

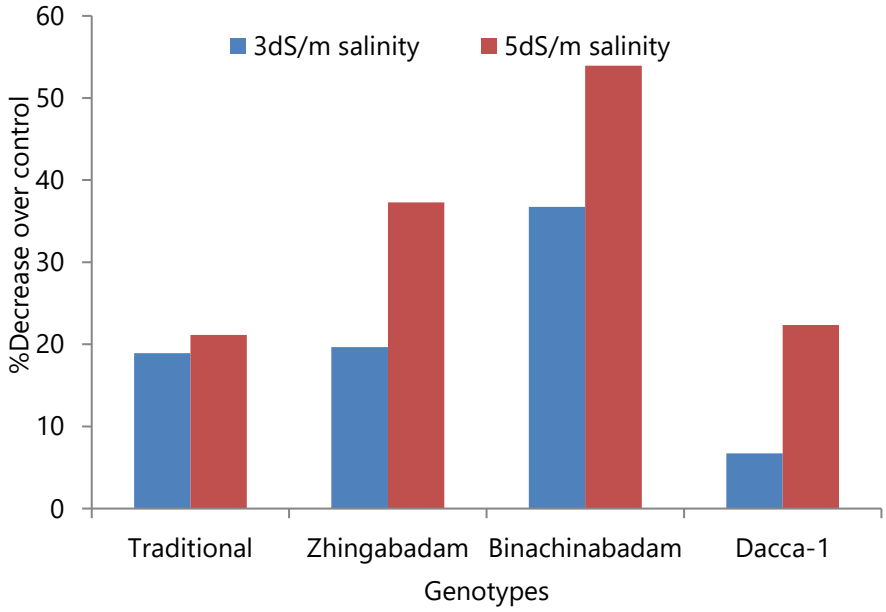

Fig.1 Percent decrease of shoot dry weight over control of groundnut genotypes under different levels of salinity

Effects on root dry weight/plant

The root dry weight/plant significantly (P<0.001) influenced due to the single effect of salinity and variety but their interaction was not significant (Table 2). Considering single effect of salinity, the root dry weight ranged from 0.216 g/plant in 5 dSm^{-1} to 0.281 g/plant in 0dSm^{-1} which evidenced that with the increase of the salt concentration root growth decreased gradually. Considering single effect of variety, Zhingabadam variety had the highest performance (0.279 g/plant), although it was statistically similar with Traditional variety (0.265 g/plant). Like other parameters Binachinabadam-1 had the lowest root dry weight (0.199 g/plant).

Percent decrease over control on root dry weight of the variety Traditional, Zhingabadam, Binachinabadam-1 and Dacca-1 under different levels of salinity was 10.34, 3.33, 25.00 and 10.71% at 3dS/m salinity, and 17.24, 20.00, 25.00 and 21.43% at 5dS/m salinity, respectively (Fig.2). Thus the percent decrease on root dry weight was the lowest (17.24%) in Traditional variety at 5dS/m salinity and was the highest (25.00%) in Binachinabadam-1 at same salinity level. The traditional variety had the minimum and Binachinabadam-1 had highest decrease over respective control, therefore the Traditional variety was identified as tolerant and Binachinabadam-1 was identified as susceptible genotype to salinity.

Shoot and root dry weights decreased with an increasing level of salt stress. The results are in agreement with those of Ghoulam *et al.* (2002), who reported that salinity caused a significant reduction in growth parameters of shoot and roots of sugar beet. Comparable results were obtained in sorghum (Netondo, 1999) and spider plants (Mwai, 2001), and in white seed coat Bambara at high-salt treatment (200 mM NaCl) (Tafouo *et al.*, 2008; 2010). Ghoulam *et al.* (2002) found that a high NaCl concentration caused reduction in growth parameters such as, root and shoot length, fresh weight and dry weight of sugar beet.

Table 2. Single and interaction effect of salinity and variety on root dry weight of groundnut genotypes at vegetative stage

Salt concentration	Traditional	Zhingabadam	Binachina badam-1	Dacca-1	Salt conc. mean

0 dS m^{-1}	0.29	0.301	0.235	0.281	0.281A
3 dS m^{-1}	0.26	0.298	0.184	0.248	0.248B
5 dS m^{-1}	0.24	0.238	0.180	0.216	0.216C
Variety mean	0.265ab	0.279a	0.199c	0.248b	
Significance level: Variety-***, Salinity-*** and interaction=Non significant %CV- 10.0; LSD- 0.024					

Similar small letters in a row or similar capital letters in a column are not significantly different at 5% level by DMRT CV= Co-efficient of variation, ***=Significant at 0.1% level

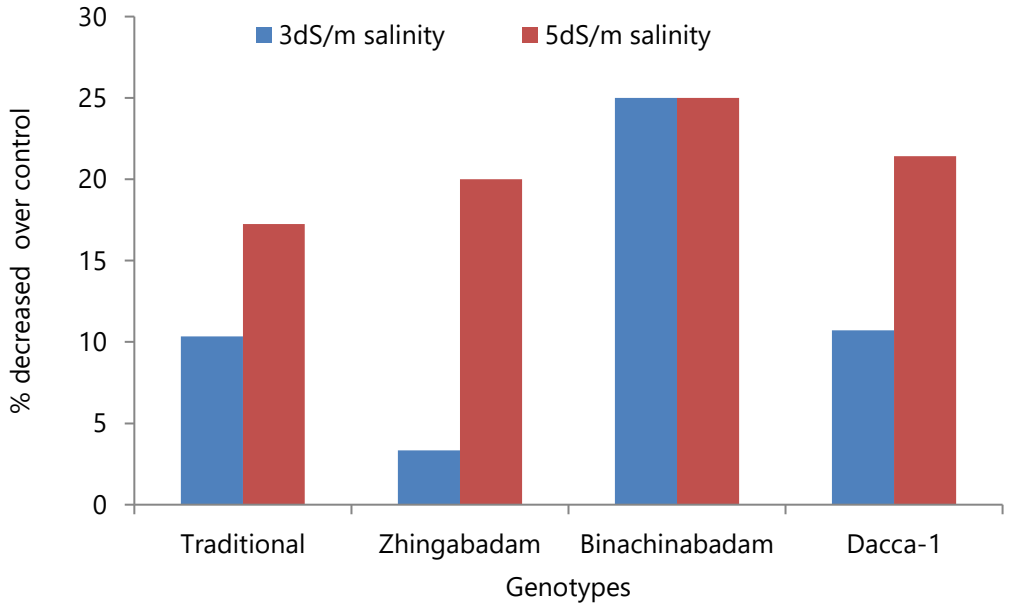

Fig. 2 Percent decrease of root dry weight over control of groundnut genotypes under different levels of salinity

Effects on proline content

For the determination of proline content, leaves were collected from the 30 days old plants. Salinity resulted in an elevated level of proline content in all groundnut genotypes and the increment was significant (P<0.001). Considering single effect of salinity the proline content varied from 3.21 to 17.85 mg $(100g)^{-1}$ fresh leaf (Table.3). The lowest proline content was found in 0dSm^{-1} salinity, which is progressively increased with the increase of the concentration of salt in the growth medium. Therefore, highest proline content was found in 5 dSm^{-1} salinity treatment.

There was found a highly significant variation among the groundnut genotypes to accumulate proline content in leaves. Among the genotypes Traditional variety had the highest proline content (18.37 mg $100g^{-1}$ fresh leaf). The second, third and fourth rank was recorded by the variety Zhingabadam, Dacca-1 and Binachinabadam-1, respectively.

The effect of variety and salinity on proline content was also highly significant (P<0.001). The highest proline content of 36.24 mg $100g^{-1}$ fresh leaf was observed in the treatment combination of traditional variety with 5dS m^{-1} saline condition and lowest of 1.32 0mg$(100g)^{-1}$ fresh leaf was observed in the treatment combination of Dacca-1 x 0dS/m saline condition.

A general increase in proline accumulation was observed in both (EC of 3 and 5dS/m) salt stressed plants in relation to those under control, but the scale of variation in increments was very wide. In EC of 3dS/m proline accumulation was slightly increased, whereas in EC of 5dS/m proline accumulation in plants was highly increased over respective control. The leaves of the Traditional variety contain the highest proline of 14.52 and 36.24

mg/100g fresh leaves in EC of 3 and 5 dS/m salinity, respectively and these values were 236 and 737 % higher than that of respective control (Fig.3).

At EC of 3 and 5dS/m, the varieties Binachinabadam-1, was appeared to be susceptible, having an increase of 6 and 113% proline content over the respective control (Fig.3). These values are lower than other varieties. One of the important mechanisms exerted by higher plants under abiotic stress is the accumulation of compatible solutes, such as proline. In the experiment, free proline content in the stressed-plants of groundnut varieties was increased as increasing the levels of salinity. Considering accumulation of proline Traditional variety was identified as tolerant variety, Zhinga and Dacca-1 was seems to be moderately tolerant whereas Binachinabadam-1 was found as susceptible variety (Table.3). This present finding is supported by the report of several researchers.

Pal and Pal (2017) reported the increase in leaf proline content over control from tolerant and susceptible groundnut genotypes. Nithila *et al.* (2013) found that the salinity stress induced proline accumulation at various levels. At the time of pegging, salinity at lower levels caused an increase in proline accumulation by 15 and 16 per cent respectively over control. It was revealed that proline synthesis mighty have accelerated at the sub lethal level of stress rather than severe stress. These results are strongly supported by Muthukumarasamy and Panneerselvam (1997) who reported that NaCl salinity induced the accumulation of proline in all parts of peanut seedlings with increased accumulation at lower NaCl level. Girija *et al.* (2002) also observed similar results in various groundnut genotypes.

The dramatic increase in proline content in the leaves under salinity stress was consistent with the role of proline as a compatible solute for osmotic adjustment during osmotic shock. However, in addition to its function as osmoregulator, proline might also play the role of osmoprotectant in stabilizing protein and scavenging. Aazami *et al.* (2010) found that an increase in proline content under salinity stress was probably due to the capacity of some plants to accumulate organic (sucrose, fructose and glucose) and inorganic (Na, K and Cl) metabolites in the cytoplasm to reduce the water potential and change the osmotic gradient, assuring the water flow to the plant and thereby might increase tolerance.

Table 3. Single and interaction effect of salinity and variety on proline content of groundnut genotypes at vegetative stage

Salt concentration	Traditional	Zhingabadam	Binachina badam-1	Dacca-1	Salt conc. mean
0 dS m^{-1}	4.333Ca	3.80Cb	3.40Bc	1.32Cd	3.21C
3 dS m^{-1}	14.529Ba	4.95Bb	3.60Bd	3.95Bc	6.76B
5 dS m^{-1}	36.237Aa	17.43Ab	7.23Ad	10.49Ac	17.85A
Variety mean	18.37a	8.73b	4.74d	5.25c	
Significance level: Variety-***, Salinity-*** and interaction=***					
%CV- 2.14; LSD- 0.335					

Similar small letters in a row or similar capital letters in a column are not significantly different at 5% level by DMRT, CV= Co-efficient of variation, ***=Significant at 0.1% level

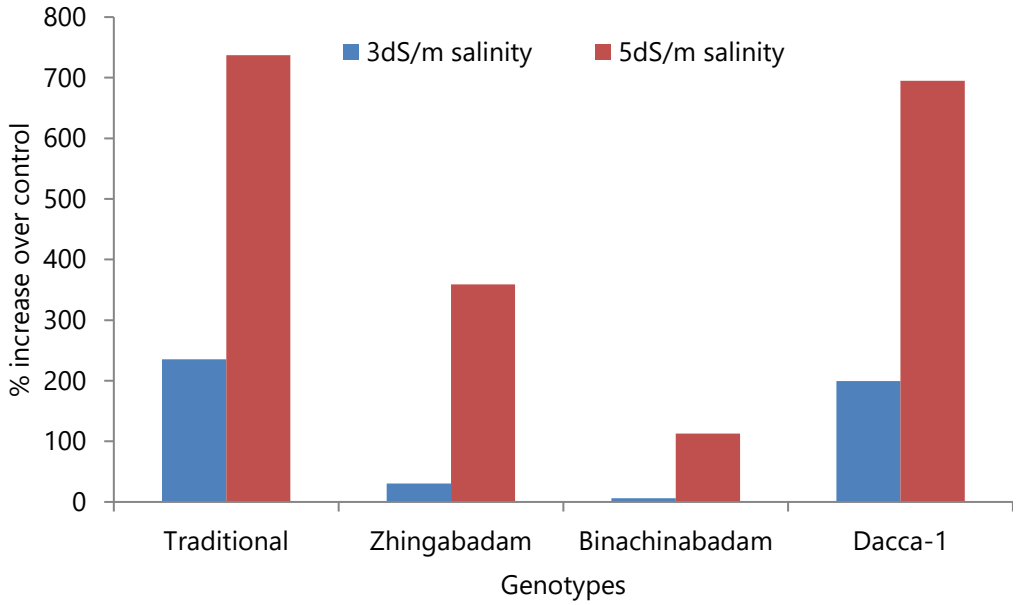

Fig.3 Percent increase of proline content over control of groundnut genotypes under different levels of salinity

Effects on total sugar content

Total sugar content significantly ($P<0.001$) increased due to salinity. Increasing concentration of salt in the growth medium resulted in a progressive increase in total sugar content of leaf. Under non saline condition ($0dSm^{-1}$) total sugar content was found as 1.99 g $100g^{-1}$ fresh leaf; which increased to 2.60 g $100g^{-1}$ fresh leaf in 3 dSm^{-1} salinity level and 4.55 g $100g^{-1}$ fresh leaf in $5dSm^{-1}$ salinity.

The varietal effect was also significant having highest of 3.48 g $100g^{-1}$ fresh leaf in Dacca-1 variety. The Traditional variety and Zhingabadam variety had statistically similar total sugar content. The Binachinabadam-1 variety had the least total sugar content (2.32 g $100g^{-1}$ fresh leaf) (Table.4). The interaction effect of variety and salinity on total sugar content was significant ($P<0.001$). The highest total sugar content of 6.02gm $100g^{-1}$ leaf was observed in the treatment combination of traditional variety with 5dS m^{-1} saline condition and lowest of 1.58 g $100g^{-1}$ fresh leaf was observed in the treatment combination of Traditional variety with $0dSm^{-1}$ saline condition.

Like proline, total sugar content was increased in both (EC of 3 and 5 dS/m) salt stressed plants in relation to those under control, but the magnitude of variation was very wide. In EC of 3dS/m total sugar content was slightly increased, whereas in EC of 5dS/m total sugar content in leaf was highly increased over respective control. The leaves of the Traditional variety contain the highest amount of total sugar content of 2.29 and 6.02g/100g fresh leaves in 3 and 5dS/m salinity, respectively and the value was 45 and 281 % higher than that of respective control (Fig. 4).

At EC of 3 and 5dS/m, the varieties Binachinabadam-1, was appeared to be susceptible, having an increase of 32 and 34% total sugar content over the respective control (Fig .4). These values are lower than other varieties. One of the important mechanisms exerted by higher plants under abiotic stress is the accumulation of compatable solutes, such as total sugar content. In the experiment, total sugar content in the stressed-plants of groundnut varieties was increased as increasing the levels of salinity. Considering accumulation of total sugar content Traditional was identified as tolerant variety; Zhinga and Dacca-1 were seems to be moderately tolerant whereas Binachinabadam-1 was found as susceptible variety (Table 4). Venkateswarlu and Ramesh (1993) observed that total sugar increased in groundnut with water stress increased. The findings of the present study appear to come in line with those of Karsten and MacAdam (2001). Gounipalli Veeranagamallaiah (2013) observed that the accumulation level of osmolytes such as proline, soluble sugars and free amino acids were increased significantly in groundnut cultivars with increasing salt stress compared with their controls. Lydia *et al.* (2015) investigate the effect of salt stress on several physiological and biochemical parameters of three sweet

corns and similar result were found. Azad *et al.* (2013) observed that the tolerant mutant/variety accumulated increased total sugar contents to that of unstressed control treatment.

Table 4. Single and interaction effect of salinity and variety on total sugar content of groundnut genotypes at vegetative stage

Salt concentration	Traditional	Zhingabadam	Binachina badam-1	Dacca-1	Salt conc. mean
0 dS m^{-1}	1.583Cc	2.33Ca	1.90Bb	2.15Bab	1.99C
3 dS m^{-1}	2.291Bb	3.22Ba	2.51Ab	2.39Bb	2.60B
5 dS m^{-1}	6.018Aa	3.73Ab	2.55Ac	5.91Aa	4.55A
Variety mean	3.30b	3.10b	2.32c	3.48a	
Significance level: Variety-***, Salinity-*** and interaction=***					
%CV- 5.43; LSD- 0.279					

Similar small letters in a row or similar capital letters in a column are not significantly different at 5% level by DMRT

CV= Co-efficient of variation, ***=Significant at 0.1% level

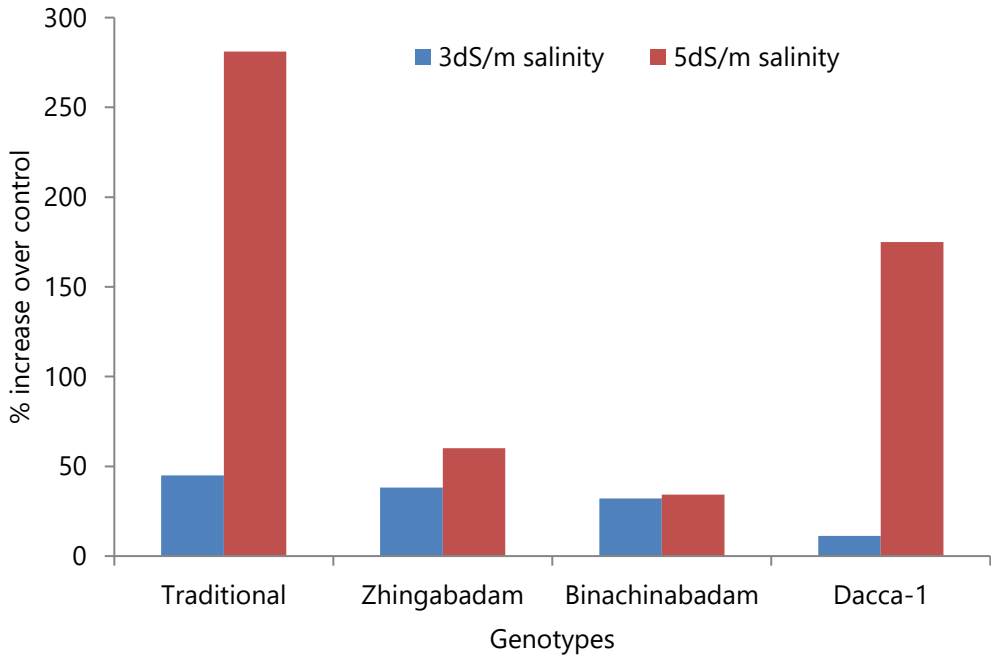

Fig 4. Percent increase of total sugar content over control of groundnut genotypes under different levels of salinity

Effects on reducing sugar content

Salinity resulted in an elevated level of reducing sugar content in all groundnut genotypes and the increment was significant (P<0.001)). Considering single effect of salinity the reducing sugar content progressively increased from 0.143 in 0 dSm^{-1} salinity to 0.225 g $100g^{-1}$ fresh leaf in 5 dSm^{-1} salinity (Table.5). Among the varieties Dacca-1, Traditional variety, Zhingabadam and Binachinabadam-1 had mean reducing sugar content of 0.197, 0.185, 0.184 and 0.169 g $100g^{-1}$ fresh leaf, respectively.

Regarding interaction effect the highest reducing sugar content of 0.26 g $100g^{-1}$ leaf was observed in the treatment combination of variety Zhingabadam with 5 dSm^{-1} saline condition and lowest of 0.17g $100g^{-1}$ fresh leaf was observed in the treatment combination of Binachinabadam-1 x 5 dSm^{-1} saline condition.

Comparing salt concentrations the reducing sugar content in EC of 3dS/m was slightly increased, whereas in EC of 5dS/m reducing sugar content in leaf was highly increased over respective control. The leaves of Traditional variety contain the highest amount of reducing sugar content by 0.23 and 0.26g/100g fresh leaves in EC of 3

and 5dS/m salinity, respectively, and it was 68 and 69% higher than respective control treatment. The Zhingabadam variety had 0.185 and 0.18 g/100g fresh leaves reducing sugar content in EC of 3 and 5dS/m, respectively; which was 54 and 34% higher than respective control (Fig. 5).

At EC of 3 and 5dS/m, the varieties Binachinabadam-1, was appeared to be susceptible, having an increase of 6% reducing sugar content in both cases over the respective control (Fig 5). These values are lower than other varieties. It is believed that under salinity stress accumulation of sugars along with other compatible solutes contribute to an osmotic adjustment (Dubey and Singh, 1999) allows the plants to maximize sufficient storage reserves to support basal metabolism under stressed environment. In the experiment, reducing sugar content in the stressed-plants of groundnut varieties was increased as increasing the levels of salinity. Considering accumulation of reducing sugar content Traditional and Zhingabadam variety was identified as tolerant variety whereas Binachinabadam-1 was found as susceptible variety (Table 5).

Table 5. Single and interaction effect of salinity and variety on reducing sugar content of groundnut genotypes at vegetative stage

Salt concentration	Traditional	Zhingabadam	Binachina badam-1	Dacca-1	Salt conc. mean
0 dS m^{-1}	0.138Cb	0.11Cc	0.16Aa	0.17Ca	0.143B
3 dS m^{-1}	0.185Bab	0.18Bab	0.17Ab	0.19Ba	0.183B
5 dS m^{-1}	0.233Ab	0.26Aa	0.17Ac	0.23Ab	0.225A
Variety mean	0.185a	0.184a	0.169b	0.197a	
Significance level: Variety-***, Salinity-*** and interaction=***					
%CV- 5.07; LSD- 0.0157					

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CV= Co-efficient of variation, **= Significant at 1% level, ***=Significant at 0.1% level

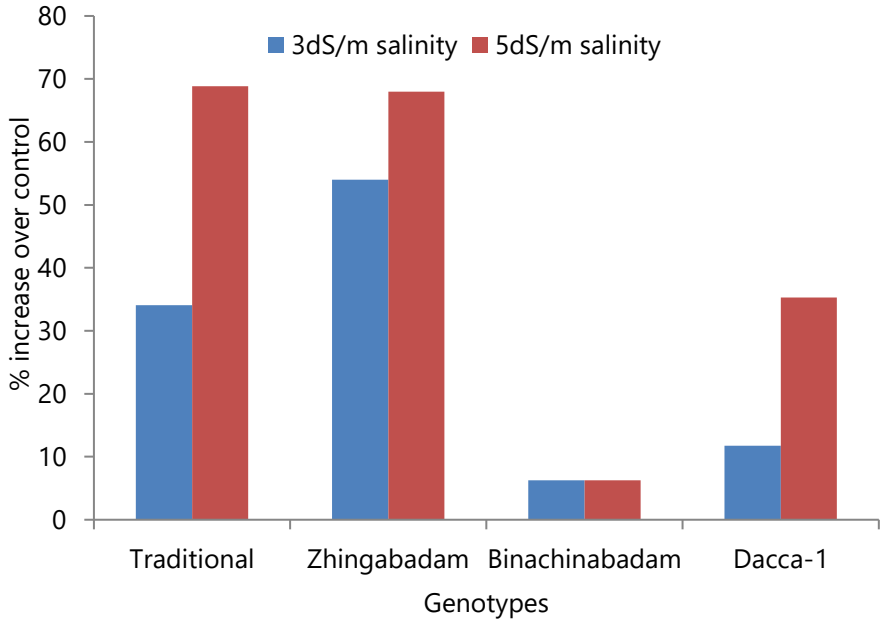

Fig. 5 Percent increase of reducing sugar content over control of groundnut genotypes under different levels of salinity

Effects on leaf relative water content (LRWC)

The relative water content of leaf was significantly ($P<0.001$) varied due to salinity and variety and their interactions (Table 6). Regarding single effect of salinity the RWC of leaf was found to vary from 68.14 to 84.10%. In control treatment RWC was the highest. The RWC found in 3dSm^{-1} salinity was closer to control treatments;

however, it is drastically reduced to 68.14% in 5 dSm^{-1} salinity. The results clearly indicate that 3dSm^{-1} salinity may be safe for groundnut cultivation whereas 5dSm^{-1} salinity severely restricts the growth of groundnut. Among the varieties traditional variety were able to keep highest RWC as it found as tolerant to salt stress. In the experiment Traditional variety, Zhingabadam and Dacca-1 variety had closer RWC.

Table 6. Single and interaction effect of salinity and variety on leaf %LRWC content of groundnut genotypes at vegetative stage

Salt concentration	Traditional	Zhingabadam	Binachina badam-1	Dacca-1	Salt conc. mean
0 dS m^{-1}	87.787Ac	90.14Aa	69.05Ad	89.41Ab	84.10A
3 dS m^{-1}	87.383Ab	88.59Ba	66.10Bd	83.89Bc	81.49B
5 dS m^{-1}	74.977Ba	67.69Cc	57.85Cd	72.04Cb	68.14C
Variety mean	83.38a	82.14b	64.33d	81.78c	
Significance level: Variety-***, Salinity-*** and interaction=*** %CV-1.435; LSD- 0.571					

Similar small letters in a row or similar capital letters in a column are not significantly different at 5% level by DMRT, CV= Co-efficient of variation, ***=Significant at 0.1% level

Conclusion

Salinity is the most devastating environmental stress seriously restricts agronomic crop production in the coastal regions. Use of salt tolerant crop variety is the most profitable approach to improve crop production in this unfavorable ecosystem. In the experiment four groundnut genotypes were test under varying salt concentrations. A traditional variety was found most tolerant to salt stress. However, Zhingabadam and Dacca-1 variety also could be recommended to be grown in the coastal salt affected soils.

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