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Studies on Radish salinity tolerance and their growth response analysis

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Abstract

Increasing water demand in arid regions needs a substitute, especially the utilization of saline. However, the higher level of saline which leads to the plantlets death due to their toxic content. In currently, antioxidant enzymes are playing a role in minimizing the effects of salts in plants, among them there are the enzymes likes (HOD-Hydrogen Peroxide; SOD-Superoxide; LOD-Lipid Peroxidation; CAT-Catalase) has been used to monitor the oxidative stress. Therefore, this study was aimed to estimate the effects of irrigation combined with saline and oxidative enzymes on their growth, enzymatic and photosynthetic action of radish *Raphanus sativus var. longipinnatus* - Daikon (radish) plantlets. The experiment was conducted at controlled ground farmland, various concentrations of saline were used for evaluation. The evaluated parameters are germination profiles, shoot length, root length, auxiliary root, fresh weight, dry weight, chlorophyll a, b, and carotenoid. The experimental variables are highly influenced by saline in radish plantlets and their enzymatic roles regarding oxidative damage were also analyzed. It was observed that the concentration of 60mM of saline shown deleterious effects and increased activity of enzymes with photosynthetic pigments was found under abiotic stress.

Keywords: Abiotic stress, NaCl, Oxidative damage, Enzyme activity, Chlorophyll content

1. Introduction

Salinization is one of the major soil pollutions in the current environment, which affect plant growth and soil fertility in all over the world. Due to the water irrigation and higher population rate, there is a need to evaluate the soil fertility and to enrich the soil or to identify the stress-tolerant plants. Salinity also suppresses the plant growth and which leads to a susceptibility of plants by various biotic and abiotic factors. Conservation of plants by salts is a difficult process which contributing major criteria of physiological parameters, oxidative damage, oxidative enzymatic activities, and metabolic changes (Munns, 2002; Neumann,1997; Swapna et al., 2020; Hasegewa et al.,2000). Salinity induces the nutritional imbalances, reduction of signal transduction, and ion homeostasis regulation in plants (Zhu, 2002). Ionic homeostasis leads to the inefficiency of minerals uptake (Na^{2+}, Cl^{-}, K^{+}) with a reduction of water consumable rate and leads to the emergence of drought. The concentration of salt which directly affects the plant growth (Abdul., 2011, Beltagi et al., 2006; Mustard and Renault, 2006; Gama et al., 2007; Jamil et al., 2007; Houimli et al., 2008; Rui et al., 2009; Memon et al., 2010).

The physiological studies have shown a reduction of plant growth employing plant height, weight (Bayuelo Jimenez et al., 2002; Jamil et al., 2005; Niaz et al., 2005; Saqib et al., 2006; Rui et al., 2009; Taffouo et al., 2009,2010; Memon et al., 2010), auxiliary root development (Bacso et al,2004; Yu et al.,2008), chlorophyll content (Jamil et al,2007; Netondo,2004) and leaf morphology (Raul et al. (2003), Jamil et al. (2005), Gama et al. (2007), Ha et al. (2008). However, the halophytic plants can overcome the salt effects due to their salinity tolerance genes (Türkan and Demiral, 2009). Furthermore, the salt tolerance has been studied in some of the plants (Cabot et al., 2014; Gupta and Huang, 2014; Roy et al., 2014; Flowers et al., 2015; Shabala et al., 2013; Shabala et al., 2015) and associated with osmoregulatory enzymes and antioxidants such as superoxide dismutase (SOD), peroxidase (POD) and catalase (CAT) (Chen 2000; Shabala et al., 2015; You and Chan, 2015). Because of the above, the study aims to identify the salinity stressed plants by inducing the different levels of salt stress which results in variance effects in radish. Furthermore, to analyses these hypothetical statements, we have studied the phenotypes, physiology of radish, and enzymatic activity was characterized under abiotic stresses.

2. Materials and Methods

2.1. Sample collection

The experiments were carried out in the field, at Mahendra Arts and Science College, Biotechnology Department, Namakkal from August to January 2018 in a controlled environment. The seed was obtained from the local market. The total number of fifty seeds were taken for this study. Before the experimental startup, the soil was analyzed and well treated with organic fertilizer.

2.1.1. Salinity treatment

Salinity treatment was established in the concentration of 0 to 480mM NaCl and was diluted in 500ml of distilled water followed by poured upon the field in concentration wise every day. Control seed irrigation only normal water was poured. The experimental setup was randomly arranged and followed the 5× 5 factorial scheme as per the central box experiment matrix (Bortoluzzi and Alarez, 1997). Followed by the salinity treatments the electrical conductivities values, were commenced. The EC of the prepared solutions were analyzed by a conductivity meter. The EC values of the solutions was 1.60 dS m^{-1} (60mM) and 60.23 dS m^{-1} for 480 mM NaCl. The experiment was maintained under natural light conditions (35/25ºC) and 57% of relative humidity was observed. There are three replicates per treatment were maintained.

2.2. Seed sterilization and sowing

There are ten seeds were sown for each concentration and the emergence period was noted for control and salinity treated plants. In control plats, the emergence period occurred within 5 days whereas the salinity treated plants germinated after one week of seedlings. The plants were separated into one plant per bag in a second week.

2.3. Growth measurements

There are 5 radish plants were randomly selected for each concentration and were used to calculate the mean of each treated plants. The parameters of germination rate, leaf length (height and width), plant height, plant weight (fresh & dry), length of the shoot and root, auxiliary root system, and Chlorophyll content.

2.4. Determination of tissue water status

The tissue water status was determined by measuring the fresh weight (FW) and dry weight (DW) of the shoots and roots. The FW of the shoots and roots were determined immediately after removal from experimental spots and cleaning the bases of explants with tissue paper. The dry weight (DW) was recorded after drying the tissue at 700ºC in the air oven for 72 h until it was of constant weight. The FW and DW of the shoots and roots obtained from each treatment were used to determine the water status, which is expressed in the form of the percentage tissue water constant (TWC %), calculated using the following equation:

$$TWC\ \% = (FW\text{-}DW)/FW \times 100$$

2.5. Enzyme activity measurement

The levels of oxidative damage were measured by antioxidant enzymes viz., Hydrogen peroxide (H_2O_2), superoxide (O^{2-}), and lipid peroxidation assay methods by UV-Visible spectrophotometer.

2.5.1. Hydrogen peroxidase test

2g of the sample were taken and added 4ml of 0.1% TCA then incubated for 5 minutes in an ice bath. Centrifugation was done at 1200rpm for 20 minutes and collected their supernatant and added 1 ml of 10mm potassium phosphate buffer followed by 1ml of potassium iodide. Finally, the reaction was read at 390nm by spectrophotometer.

2.5.2. Super oxidase test

500mg of grind plant sample was taken and added 6mM potassium phosphate buffer, then the mixture was centrifuged at 5000rpm for 10 minutes at 4^{o}C. The supernatant was collected and added a potassium phosphate buffer with 10M of Hydroxylamide (Hcl). The reaction mixture was incubated at 25^{o}C for 20 minutes. Then, 17mM of Sulfanilamide, 7mM of α – Nathylanine were added and incubated for 20 minutes 20^{o}C. Furthermore, the same volume of N-Butanol and centrifuged at 5000rpm for 5minutes. The reaction mixture was read at 530nm by spectrophotometer.

2.5.3. Lipid peroxidation test

The frozen stem tissue and root samples of 0.5 g were taken followed by added 0.25%TBA in 10% Trichloroacetic acid (TCA) and then heated at 95^{o}C for 30 minutes. Simultaneously, the samples are cooled in an ice bath and centrifuged at 5000xg for 10 minutes. Then OD value was taken through UV-spectrophotometer at 600nm.

2.5.4. Peroxidase activity

50mM Potassium phosphate buffer (P^{H}-7), 1% Guaiacol, 0.4% of Hydrogen peroxidase, and 1:10 diluted enzyme extract were mixed and incubated for 5 min at 25 ^{o}C. Then the reaction was stopped by adding 0.5% (v/v) H_2SO_4. The amount of purpurogallin was determined by taking the absorbency at 470nm.

2.5.5. Photosynthetic pigments content

1g of leaf were taken and extracted by grinding in a mortar using acetone. Then the sample was centrifuged at 2500rpm for 5 min. The supernatant was collected and the procedure was repeated until the pellet is colorless. Photosynthetic pigments are Chlorophyll “a”, “b” and carotenoid concentration was determined by spectrophotometer by reading the absorbance at 663, 645, 440.5nm, respectively.

2.5.6. Protein Content analysis

Protein was determined by following Lowry et al.,1951; (1) 5 ml of copper solution was added to tubes containing 0.1 ml of the protein extract. The Copper solution composed of (a) 100 ml of sodium chloride (0.1 N) in which were dissolved, 2 g of anhydrous sodium carbonates, and 1 ml of sodium tartrate (2.7%). (b) 1 ml of copper sulphate (1%). (a and b) were mixed immediately before use and the tubes were left for 15 min, then the optical density (O.D.) was measured at 570 nanometers. (2) The same steps were repeated with the standard solution (of known concentration) of BSA. (3) Steps (1 and 2) were repeated thrice, and the mean value of the 3 readings was compared with the standard curve of BSA.

3. Results

3.1. Morphological study

The Daikon plant morphology was affected due to salt stress; the chlorophyll content, the thickness of the stem, length of the plant, leaf size, etc., (Fig.1). By comparing the morphological evidence the length and width of the shoot and leaf size differ between controls to treated plants. The germination profile of treated plants has a lower germination rate compared to the control, Although 240mM concentration treated plants are germination level was reduced into one half and the plants were lost their viability within two weeks of germination. However, in the higher concentration profiles of 480mM doesn’t allow any germination. The rate of germination and their percentage were shown in Table 1 & Fig 2(a). The oxidative damage was observed during the salinity stress, which results in loss of respiration and metabolism changes. At finally which leads to the accumulation of toxic components due to the irregular photosynthesis process. These are the variables ultimately affect the growth.

In table 1 reflects the germination number of radish seeds shown the gradually decreased profile under salinity stress. In control, the lowest concentration of 60mM and, 120mM saline-treated plants were germinated compared to salinity treated plants. However, at 240mM concentration affects the germination profile gradually, it has shown only three

number of plants were germinated. In the highest concentration of 480mM not alloying the germination rate. Furthermore, the duration hours varied from control to salinity treated plants.

Final germination percentage, germination rate, and reduction of germination percentage were calculated (Azizi et al. 2011)(Sarker et al 2014):

Final germination percent = S/T×100 ----------(i)

Germination rate = N1/D1+N2/D2+ ... +Ni/Di ----------(ii)

Where S is the number of germinated seeds, T is the total number of seeds and Ni number of germinated seeds, per day (Di).

Reduction of germination percentage = (1-The number of germinated seeds conditions salinity / The number of germinated seeds conditions control) ×100 ----------(iii)

The germination percentage was calculated from the equation (i), (ii), (iii). The reduction of germination was depleted in 480mM salinity treatment, 0.4 % shown in per day and 90% were observed in final germination rate and germination reduction percentage, respectively. Furthermore, 240mM concentration exploited 3.40 and, 50 % respectively were observed for calculation of germination. Similarly, the remaining concentrations of 120mM and 60mM determined the 100% germination; the germination rate per day was 5.78 and 5.95 % were reduced compared to control (8.45%).

Fig. 1. Phenotypes of radish plantlets under salt stress (a) Control plants (0mM); (b) 60mM; (c) 120mM; (d) 240mM.

Table 1. The rate of germination under salinity affects for seed germination

Days	Control	60mM	120mM	240mM	480mM
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	-	-	-	-	-
5	10*	-	-	3*	2*
6	10	7*	6*	3+2*	Nil
7	10	7+3*	6+4*	5	Nil
8	10	10	10	5	Nil
9	10	10	10	5-2=3*	Nil
10	10	10	10	3	Nil

Tissue water content

The percentage of tissue water constant (TWC), calculated using the following equation:

TWC% = (FW-DW) / FW x 100 ---------- -------(iv)

Herewith the plant fresh weight, dry weight was calculated with the percentage of tissue water content were represented in Fig.2 (b) & (c).

In Fig. 2(c), the total water content (TWC) were measured in control and treated plants; the highest TWC was observed in 60mM (94.01%) compared to control. The lowest TWC was shown in 240mM concentration and their fresh and dry weight is 0.368g and 0.024g, respectively.

The morphological parameters of the full length of the plants, leaf length, and width, axillary root and shoot were analyzed and it was tabulated in Fig. 2(d). The length of the plants was affected under salinity treatment at higher concentrations (240mM above). However, the width of the plants was not affected fully, there was a gradual decline of leaf length and width were observed. In addition, shoot profiles of control, 0.89, 1.42, 0.71 in 60mM, 120mM and 240mM, and in root profiles 0.36, 1.09, 0.36 and 0.26 in control and other concentrations, respectively. The highest axillary root length was affected in 240mM (1.9) compared to control (7.7) and other concentrations of 60mM and 120mM shown moderate effects.

The parameters of full length were statically analyzed by ANOVA; the F-Ratio of between and within groups is F = 6.447646 with p-value = 0.00455. The critical value is 3.238 at 0.05 level for (3, 16) degrees of freedom. Hence the null hypothesis is rejected at a 5% significance level since $p < 0.05$. Hence can be concluded that there is a significant difference among the groups. Amongst the four groups, these different provides the full length.

The evaluated parameters were statically analyzed by the two tests—Levene's test for equality of variances and t-test for equality of means. In two sets of analyses, the first one assuming equal variances in the two groups and the second one assuming unequal variances. Levene's test tells us which statistic to consider to analyze the equality of the means. It tests the null hypothesis that the two groups have equal variances. A small value of significance associated with Levene's test indicates that the two groups have unequal variances and the null hypothesis is false. A very small value of this test statistic indicates that the two groups, Control, and 60mM, 120mM, and 240mM, do not have equal variance. Therefore, the statistic associated with equal variances not assumed should be used for the t-test for equality of means.

The t-test result leaf length (with equal variances not assumed) shows t statistic of 1.208 with 7.575 degrees of freedom (df) (60mM), (120mM), and (240mM) in 0.179 and df is 8. The corresponding two-tailed p-value is 0.263(60mM), 0.354 (120mM) and 0.172 (240mM), which is greater than 0.05. Therefore, which accept the null hypothesis at 5% significance level, which means that the average outputs of the two groups are not significantly different from each other.

The t-test result of leaf width (with equal variances not assumed) shows t statistic of 0.900 with 6.672 degrees of freedom (df) (60mM), (120mM) in 1.341, and df is 6.874 and (240mM) 2.902 and their df is 7.950. The corresponding two-tailed p-value is 0.399 (60mM), 0.222 (120mM) and 0.020(240mM); which is greater than 0.05. Therefore, we can accept the null hypothesis at the 5% significance level, which means that the average outputs of the two groups are not significantly different from each other. The table also gives the mean difference, i.e., the difference between the average daily output by the plant of control & 60,120 and 240mM, standard error of difference, and 95% confidence interval of the difference.

In ANOVA, the F-Ratio of between and within groups is F = 58.38431 with p-value = 0.0000. The Critical value is 3.238 at 0.05 level for (3, 16) degrees of freedom. Hence the null hypothesis is rejected at a 5% significance level since $p < 0.05$. Hence can be concluded that there is a significant difference among the groups. Amongst the four groups, these differences provide the axillary root.

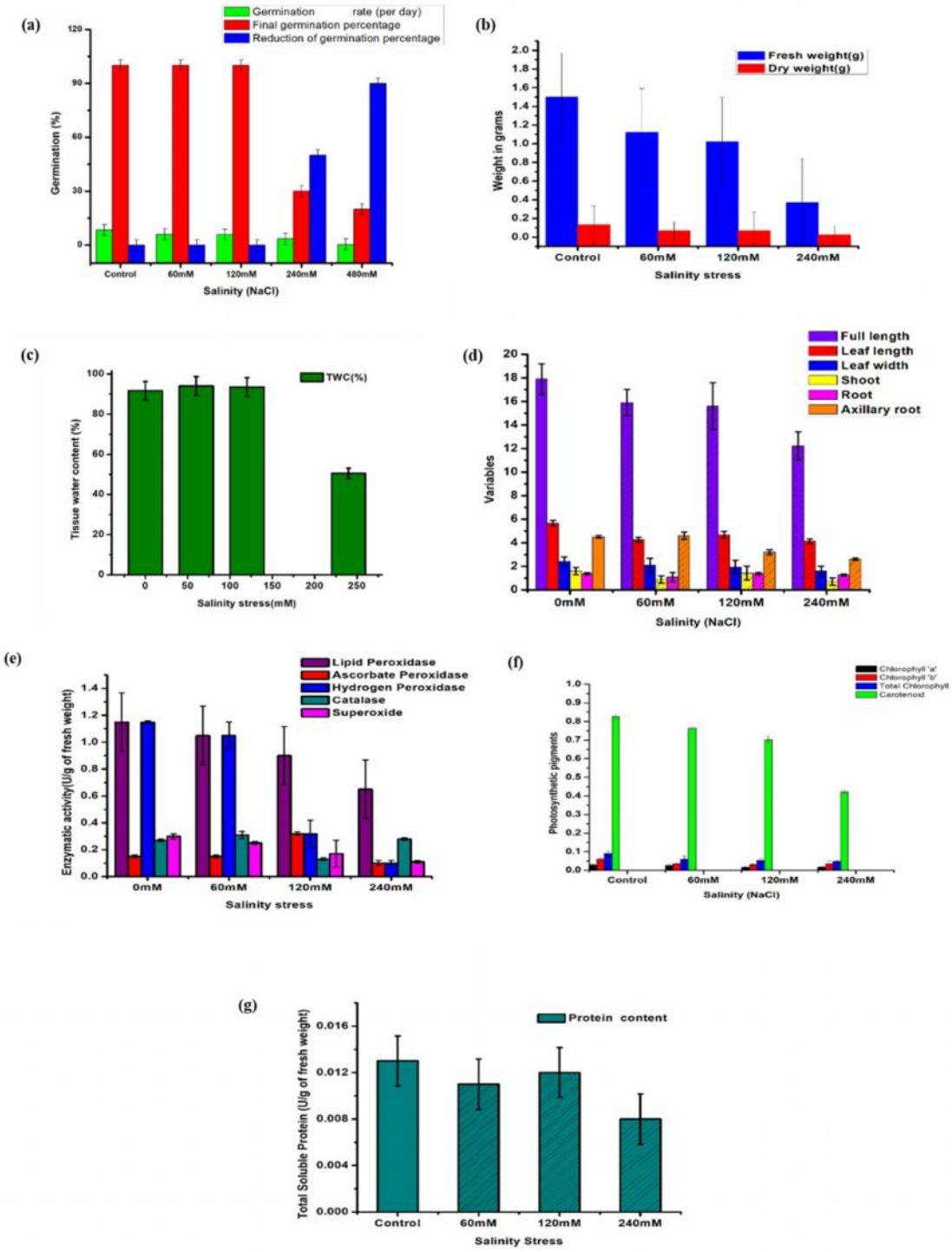

Fig. 2. Salinity expression analysis (a) Percentage of germination under different salinity treatment; (b) Fresh and dry water content; (c)Tissue water content percentage; (d) Morphological parameters profiles; (e) Enzymatic profiles; (f) Chlorophyll and carotenoid; (g) Soluble protein content under abiotic stresses. Values are expressed as Mean ± SEM for the three experiments.

The enzymatic profiles under salinity stress were shown in Fig.2 (e). The release of ascorbate peroxidase induces the enzymatic changes at 120 and 240mM concentrations, the release of the enzyme was found to be more in above 120mM. Also, the release of peroxidase activity was higher in control (1.15) and it was gradually reduced in a higher concentration (1.05, 0.32, and 0.10). During the stress period, H_2O_2 releases the signal which spatially and temporally reflects changes in the plant growth. These specific signaling molecules perceive the elevation of H_2O_2 in cells. Besides, finding the mechanism of H_2O_2 has interacted with cysteine residues within the protein. This modulation induces the conformational changes of protein, causes loss of protein activity initiating a subsequent cellular response. Also, the release of excess H_2O_2 induces higher oxidative stress leads to radish plant death.

Catalase (CAT) activity was found to be higher in 60mM like control. Similarly, the release of superoxide (SOD) in 60mM was maximum and it was reduced in remaining concentrations. Typically an increasing level of SOD confirms the oxidative damage. Fe SODs are most abundantly localized inside plant chloroplasts, where they are indigenous. Second, Mn SODs consists of a homodimer and homotetramer species each containing a single Mn (III) atom per subunit. They are found predominantly in mitochondrion and peroxisomes. Third, Cu-Zn SODs have electrical properties very different from those of the other two classes. These are concentrated in the chloroplast, cytosol, and some cases the extracellular space.

Lipid peroxidase activity was measured and represented in Fig. 2(e). The major lipid peroxidase activity was displayed in control. It may due to the stealing of electron transfer by the presence of free radicals. The expression of oxidative damage was measured by thiobarbituric acid reaction through malondialdehyde (MDA). Release of MDA increases due to the salt stress resulting in cell damage. Besides, the catalytic reaction was occurred due to the presence of a peroxidase enzyme induces the decomposition of hydrogen peroxide. The release of toxic hydrogen peroxide is split into water and oxygen without the presence of peroxidase.

The chlorophyll content estimated by following the formula and the results were represented in Fig.2 (f) by following the literature of Jamil et al., (2007).

The amount of pigment present in each sample was calculated,

mg chlorophyll “a”/g of tissue =12.7(O.D) 663 – 2.69(O.D) 645 x v/ w x 1000

mg chlorophyll “b”/g of tissue =22.9(O.D) 645 – 4.68(O.D) 663 x v/ w x 1000

mg total chlorophyll /g of tissue =20.2(O.D) 645 + 8.02(O.D) 663 x v/ w x 1000

mg carotenoids/g of tissue=46.95(O.D) 440.5 – 0.268 x chlorophyll “a”+“b”

V - Final size of the extract in 80% acetone.
W - Fresh weight by grams for extracted tissue.

The amount of chlorophyll content was greatly affected by salt stresses. The total amount of chlorophyll was estimated in 0.09 in control, the lowest chlorophyll was observed in 240mM (0.047). Furthermore, the moderate decline profiles were shown in 60mM and120mM. Similarly, the pigmentation of chlorophyll ‘a’ and ‘b’ was significantly affected. In addition, the carotenoid in control shown 0.828 whereas other salt-treated plants were shown 0.763 (60mM), 0.702 (120mM), 0.424 (240mM), respectively.

The amount of protein content was estimated by Lowry’s et al shown in Fig. 2(g). The protein content was higher in control (0.013mg/ml) whereas in 60mM and 120mM expressed as 0.012 and 0.11mg/ml of protein. The lowest protein content was measured at 240mM (0.008 mg/ml) was observed.

4. Discussion

The first sensitive stage in life cycles of plants is seed germination (Ahmed, 2009). Salinity causes a reduction of plant growth (Sarker et al 2014). Additionally, osmotic inhibition of water availability and lethal salt effects inhibits plant growth (Hakim et al., 2009) (Sarker et al 2014). The three-fold effects were found in salt stress which causes water potential and ionic imbalances with additional toxicity to the growing plants (de la Peña and Hughes 2007).The germination growth speed, root/shoot, dry weight, and Na+/K+ ratio in root and shoot (Parida and Das 2005). However, it has been reported that the tolerance seeds have the ability under salt stress at the grownup stage (Akinci et al. 2004). Additionally, salinity can also

alter the physiological processes such as enzyme activities (Croser et al. 2001; Essa and Al-Ani 2001). In cassava plants at 20mM NaCl, the H_2O_2 content was found to be significantly increased in shoots of stressed plantlets. Similarly, the release of H_2O_2 was significantly affected at lower concentrations (60mM). Catalase (CAT) activity was found to be higher in 60mM. Similarly, the release of superoxide (SOD) in 60mM was maximum and it was reduced in remaining concentrations. Recent studies were also reported similar results Cheng et al., 2018, Gleadow et al., 2016. The SOD activity was significantly increased in 2-fold at 20mM. Furthermore, under a controlled condition, the POD activity was found to be significantly lower in shoots than rootlets. CAT activity was found in significantly higher in shoots than in rootlets under NaCl stress (Cheng et al., 2018). However, cassava plants have a unique tolerance under the salt environment, reported that 50mM NaCl reported that withstanding ability El-Sharkawy (2004), Carretero et al., 2008; Gleadow et al., 2016. Our results showed that 120mM NaCl harshly affected the growth of radish plants originated from seeds and found that 240mM NaCl was lethal to seeds. The lethal doses of various plant species were reported in (Carretero et al., 2008; Gleadow et al., 2016. However, the enhanced growth replaced plant growth, surface area, viability, width, length, shoot, and root was higher in 60mM NaCl (Carretero et al., 2007; Gleadow et al., 2016; Yeo et al., 1997). It may be due to the increased accumulation of total soluble starch (Li et al., 2016).

Conclusion

The effects of salinity on plant growth and development as a method for the finding of salt and drought tolerance in the radish breeding program. The radish plantlets could possible to grown under abiotic stresses of salt stress (EC 3.76 dS/m). The salt stress plantlets exhibiting maximum growth at 240mM. However, the accumulation of NaCl in shoots and Gibberellic acid (GA) content in seed also acts as a major tool to find their salt stress level because GA enhances the germination speed. However, the above evaluation tools will be a path for finding suitable breeds under abiotic stress and water irrigation.

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Declaration of interest

There is no conflict of interest.

References

1. Munns R (2002). Comparative physiology of salt and water stress. Plant, Cell & Environment 25: 239-250.
2. Neumann P (1997). Salinity resistance and plant growth revisited. Plant, Cell & Environment 20: 1193–1198.
3. Swapna MNS, Sreejyothi S, Sankararaman S (2020). Investigation of factuality and variation of fractal dimension in germinating seed. European Physical Journal Plus 1: 135-138.
4. Hasegawa PM, Bressan RA, Zhu JK, Bohnert HJ (2000). Plant cellular and molecular responses to high salinity. Annual Review Plant Physiology and Plant Molecular Biology 51: 463–499.
5. Zhu JK (2002). Salt and droughts tress signal transduction in plants. Annual Review of Plant Biology 53: 247–273.
6. Abdul Qados AMS (2011). Effect of salt stress on plant growth and metabolism of Bean Plant *Vicia faba* (L.). Journal of the Saudi Society of Agricultural Sciences 10: 7–15.
7. Beltagi MS, Ismail MA, Mohamed FH (2006). Induced salt tolerance in common bean (*Phaseolus Vulgaris* L.) by gamma irradiation. Pakistan Journal of Biological Sciences 6: 1143–1148.
8. Mustard J, Renault S (2006). Response of red-osier dogwood (*Cornus sericea*) seedling to NaCl during the onset of bud break. Canadian Journal of Botany 84: 844–851.
9. Gama PBS, Inanaga S, Tanaka K, Nakazawa R (2007). Physiological response of common bean (*Phaseolus vulgaris* L.) seedlings to salinity stress. The African Journal of Biotechnology 6: 79–88.
10. Jamil M, Rehman S, Rha ES (2007a). Salinity effect on plant growth, Ps11 photochemistry and chlorophyll content in sugar beet (*Beta vulgaris* L.) and cabbage (*Brassica oleracea capitata* L.). The Pakistan Journal of Botany 39: 753–760.
11. Houimli SIM, Denden M, Elhadj SB (2008). Induction of salt tolerance in pepper (B0 or Hbt 10mmtt1) by 24-epibrassinolide. EurAsian Journal of BioSciences 2: 83–90.
12. Rui L, Wei S, Mu-xiang C, Cheng-jun J, Min W, Bo-ping Y (2009). Leaf anatomical changes of *Burguiera gymnorrhiza* seedlings under salt stress. Journal of Tropical and Subtropical Botany 17: 169–175.

13. Memon SA, Hou X, Wang LJ (2010). Morphological analysis of salt stress response of Pak Choi. Electronic Journal of Environmental, Agricultural and Food Chemistry 9: 248–254.
14. Bayuelo Jimenez JS, Debouk DG, Lynch JP (2002). Salinity tolerance in phaseolus species during early vegetative growth. Crop Science 42: 2184–2192.
15. Jamil M, Lee CC, Rehman SU, Lee DB, Ashraf M, Rha Ez (2005). Salinity (NaCl) tolerance of Brassica Species at germination and early seedling growth. Electronic Journal of Environmental, Agricultural and Food Chemistry 4: 970-976.
16. Niazi BH, Athar M, Saum M, Rozema J (2005). Growth and ionic relations of fodder beet and sea beet under saline environments. International Journal of Environmental Science and Technology 2: 113–120.
17. Saqib M, Zorb C, Schubert S (2006). Salt resistant and salt-sensitive wheat genotypes show similar biochemical reaction at protein level in the first phase of salt stress. The Journal of Soil Science and Plant Nutrition 169: 542–548.
18. Taffouo VD, Wamba OF, Yombi E, Nono GV, Akoe A (2010). Growth, yield, water status and ionic distribution response of three bambara groundnut (*Vigna subterranean* (L.) verdc.) landraces grown under saline conditions. International Journal of Botany 6: 53–58.
19. Bacsó R, Molnár A, Papp I et al. (2008). Photosynthetic behavior of Arabidopsis plants with a cap binding protein 20 mutation under water stress. Photosynthetica 46: 268.
20. Yu H, Chen X, Hong YY., Wang Y, Xu P, Ke SD et al. (2008). Activated expression of an arabidopsis HD-START protein confers drought tolerance with improved root system and reduced stomatal density. The Plant Cell Online 20: 1134–1151.
21. Netondo GW, Onyango JC, Beck E (2004). Crop physiology and metabolism sorghum and salinity II – gas exchange and chlorophyll fluorescence of sorghum under salt stress. Crop Science 44: 806–811.
22. Raul L, Andres O, Armado L, Bernardo M, Enrique T (2003). Response to salinity of three grain legumes for potential cultivation in arid areas (plant nutrition). The Journal of Soil Science and Plant Nutrition 49: 329–336.
23. Ha E, Ikhajiagba B, Bamidele JF, Ogic-odia E (2008). Salinity effects on young healthy seedling of *kyllingia peruviana* collected from Escravos, Delta state. Global Journal of Environmental Science and Management 2: 74–88.
24. Turkan, Ismail, Demiral, Tijen (2009). Recent developments in understanding salinity tolerance. Environ Exp Bot 1(Special issue):2-9. Environmental and Experimental Botany 67: 2-9.
25. Cabot C, Sibole JV, Barceló J, Poschenrieder C (2014). Lessons from crop plants struggling with salinity. Plant Science 226: 2–13.
26. Gupta B, Huang B (2014). Mechanism of salinity tolerance in plants: physiological, biochemical, and molecular characterization. International Journal of Genomics 701596.
27. Roy SJ, Negrão S, Tester M (2014). Salt resistant crop plants. Current Opinion in Biotechnology 26: 115–124.
28. Flowers TJ, Munns R, Colmer TD (2015). Sodium Chloride toxicity and the cellular basis of salt tolerance in halophytes. Annals of Botany 115: 419–431.
29. Shabala S (2013). Learning from Halophytes: physiological basis and strategies to improve abiotic stress tolerance in crops. Annals of Botany 112: 1209–1221.
30. Shabala S, Wu H, Bose J (2015). Salt stress sensing and early signaling events in plant roots: current knowledge and hypothesis. Plant Science 241: 109–119.
31. Chen CL, Li HS et al. (2000). Nitroblue tetrazolium (NBT) method for determining superoxide dismutase (SOD) activity. In: Li HS, Sun Q, Zhao SJ (Eds.), The experiment principle and technique on Plant Physiology and Biochemistry (in Chinese). Higher Education Press, Beijing.
32. You J, Chan Z (2015). ROS regulation during abiotic stress responses in crop plants. Frontiers in Plant Science 6: 1092.
33. Bortoluzzi AL, Alvarez VVH (1997). Pesquisa em casa de vegetação e em campo: matrizes experimentais. Departamento de Solo/CCA - UFV, Viçosa, Brazil.
34. Lowry OH, Rose brough NJ, Farr AL, Randall RJ (1951). Protein measurement with the Folin phenol reagent. The Journal of Biological Chemistry 193: 265–275.
35. Azizi M, Chehrazi M, Zahedi SM (2011). Effects of salinity stress on germination and early growth of sweet william (*Dianthus barbatus*), Asian Journal of Agricultural Research 3: 453-458.
36. Ashoka Sarker Md, Imam Hossain Md, Abul Kashem (2014). Salinity (NaCl) tolerance of four vegetable crops during germination and early

seedling growth. International Journal of Latest Research in Science and Technology 3(1): 91-95.
37. Rodrigues RM, Cavalcante LF, Souto AGL, Ghey HR, Mesquita FO (2017). Growth and regrowth of neem after cutting in saline-sodic soil treated with organics inputs. Revista Caatinga 30: 116-124
38. Hakim MA, Juraimi AS, Begum M, Hanafi MM, Ismail MR, Selamat A (2009). Effect of salt stress on germination and early seedling growth of rice (*Oryza sativa* L.) The African Journal of Biotechnology 9: 1911-1918.
39. de la Peña R, Hughes J (2007). Improving vegetable productivity in a variable and changing climate. SAT eJournal (ejournalicrisatorg) 4:1–22.
40. Parida AK, Das AB (2005). Salt tolerance and salinity effects on plant: a review. Ecotoxical Environ Safety 60: 324–349.
41. Akinci IE, Akinci S, Dikici YHK (2004). Response of eggplant varieties (*Solanum melongena*) to salinity in germination and seedling stages. New Zealand Journal of Crop and Horticultural Science 32: 193–200.
42. Croser C, Renault S, Franklin J, Zwiazk J (2001). The effect of salinity on the emergence and seedling growth of *Picea Mariana*, *Picea Glanca* and *Pinus Barksiana*. Environmental Pollution 115: 6–16.
43. Essa AT, Al-Ani DH (2001). Effect of salt stress on the performance of six soybean genotypes. Pakistan Journal of Biological Sciences 4: 175–177.
44. Cheng YE, Dong MY, Fan XW, Nong LL, Li YZ (2018). A study on cassava tolerance to and growth responses under salt stress. Environmental and Experimental Botany 155: 429–440.
45. Gleadow R, Pegg A, Blomstedt CK (2016). Resilience of cassava (*Manihot esculenta Crantz*) to salinity: implications for food security in low-lying regions. Journal of Experimental Botany 67: 5403–5413.
46. El-Sharkawy MA (2004). Cassava biology and physiology. Plant Molecular Biology 56: 481–501.
47. Carretero CL, Cantos M, García JL, Azcón R, Troncoso A (2008). *Arbuscular-mycorrhizal* contributes to alleviation of salt damage in cassava clones. Journal of Plant Nutrition 31: 959–971.
48. Carretero CL, Cantos M, García JL, Troncoso A (2007). In vitro–ex vitro salt (NaCl) tolerance of cassava (*Manihot esculenta Crantz*) plants. In Vitro Cellular & Developmental Biology – Plant 43: 364–369.
49. Yeo AR, Kramer D, Lauchli A, Gullasch J (1977). Ion distribution in salt stressed mature zea mays root in relation to ultrastructure and retention of sodium. Journal of Experimental Botany 28: 27–29.
50. Li YZ, Zhao JY, Wu SM, Fan XW, Luo XL, Chen BS (2016). Characters related to higher starch accumulation in cassava storage roots. Scientific Reports 6: 19823.

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