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RESEARCH ARTICLE

Assessment of Deleterious Effects of Salinity Stress on Wheat (*Triticum aestivum* var. HD-3086) Plants

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ABSTRACT

Salinity is a severe abiotic environmental problem in soil which restricts the growth, alters physiological processes and ultimately causing death of salt sensitive plants. The high concentration of salts in soil alters plant water relationship due to osmotic and ionic stress in plants. The osmotic stress affects even the germination of seeds due to restriction of entry of water inside seeds while the intrusion of high sodium and chloride ions inside the cell causes ionic stress leading to production of reaction oxygen species causing oxidative damage to cellular components, mainly to the membrane lipids and other biomolecules like protein and DNA etc. Under salt stress conditions plants also respond to salinity stress by different adaptive mechanisms like exclusion of salt entry in root cells, accumulation of excess cellular salt in vacuoles, excretion of salts by salt glands, synthesis of osmolytes like glycine-betaine, proline and increased activity of components of antioxidative defense system etc. These mechanisms help the plants to survive under such environmental conditions but the responses to salinity are more pronounced in salt tolerant plants.

KEY WORDS: *Salinity stress, sodium ions, chloride ions, proline, cellular damage, antioxidant enzymes*

INTRODUCTION

Global climate change is a major environmental factor which greatly affects the different biotic and abiotic components of ecosystems. Soil salinity significantly reduces the growth and yield of the plants (mainly salt sensitive plants). The main problems that arise in plants due to salinity are osmotic stress and ion toxicity (Haq *et al.*, 2010). Salinity stress is one of the environmental stress responsible for poor plant growth, crop yield and biomass production, due to the changes taking place at structural, biochemical and molecular levelsin plants (Zhang, 2015). Wheat is a staple crop and the global area used for cultivation of wheat is about 221 million hectares, producing about 770 million metric tonnes of wheat grains (FAOSTAT, 2023). Soil salinity significantly reduces photosynthetic capacity, protein synthesis, cell elongation and many other metabolic functions (ElSayed *et al.*, 2023). Excess production of reactive oxygen species (ROS) leading to oxidative stress is one of the obligatory outcomes of the salinity stress in plants. Detoxification of relatively higher levels of ROS is achieved by scavenging these radicals through antioxidative enzymes like superoxide dismutase (SOD), catalase (CAT) and peroxidase (POD) etc. To maintain osmotic balance of cell, plants synthesize many osmolytes including proline, glycine betaine and sugar alcohols etc. The degree of activity of these biochemical pathways is relatively higher in plants which are relatively more tolerant to salt stress. Due to sharp rise in soil salinity, there is urgent need for research in physiological, genetic and molecular level, to alleviate salinity stress in plants.

MATERIALS AND METHODS

Plant material and seed surface sterilization

In study, healthy and uniform sized seeds of wheat (*Triticum aestivum* var. HD-3086) were used. The seeds were surface sterilized with 0.1% $HgCl_2$ solution and then rinsed thrice with distilled water. After rinsing, seeds were soaked in distilled water for 12 hours.

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Experimental design

The study was carried out in plastic pots (10 kg sand capacity each) in sand culture under controlled conditions in glass house. All the treatments were in triplicates. The sterilized silica was filled in all pots and supplied with adequate distilled water. After irrigation with distilled water, healthy, surface sterilized overnight water-soaked seeds (10 seeds per pot) were sown at the depth of about 2cm with the help of glass rod and each pot was supplied with nutrient solution and observed at regular intervals for germination, growth and biochemical parameters. The control plants (T1) were supplied only with Hoagland' nutrient solution, while T2, T3, T4 and T5 were supplied with Hoagland solution along with 20, 40, 60 and 80 mM of NaCl, respectively. The biochemical parameters were analyzed following standard method of analysis viz., pigments content determined by the method of Lichtenthalar (1967), activity of catalaseby method given by Euler & Josephson (1927), peroxidase by the method of Luck, (1963) and proline content estimated by the method of Bates *et al*. (1973). All the data were in triplicates and the tested statistically for their significance.

RESULTS

The experimental plants were observed on the regular basis for different growth and biochemical parameters. All the data presented is the mean of average of three values.

Effects of salinity on seed germination, shoot length and dry weight

Salinity of growth medium greatly reduces the water absorption by seeds and causes lower seed germination percentage (SGP), shoot length and dry weight per plant as compare to control plants (T1). The reduction in SGP, shoot length and dry weight per plant (Table 1) were increased progressively with increasing level of salinity from T2 to T5.

Table 1: Effects of salinity on growth of wheat plants

Treatments	Germination percentage (30 DAS)	Shoot Length(cm)	Dry weight per plant (g)
T1	100.0 ± 0 (00.00)	13.8 ± 0.17 (00.00)	1.90 ± 0.11 (00.00)
T2	97.0 ± 0.20 (-3.0)	11.7 ± 0.40 (-17.94)	1.42 ± 0.03 (-25.26)
T3	96.33 ± 0.28 (-3.67)	11.1 ± 0.35 (-19.56)	1.25 ± 0.0.03 (-34.21)
T4	93.86 ± 0.57 (-6.14)	10.63 ± 0.25 (-22.97)	1.15 ± 0.28 (-39.47)
T5	93.66 ± 0.57 (-6.34)	10.3 ± 0.28 (-25.36)	1.03 ± 0.04 (-45.78)

The error bars indicate ± SEM.

Treatments: T1 = Control (0 mM NaCl); T2 = 20 mM NaCl; T3 = 40 mM NaCl; T4= 60 mM NaCl and T5= 80 mM NaCl.

Effects of salinity on pigments content

Application of grades of NaCl in growing medium progressively reduced the pigments content including chlorophyll a, b, total chlorophyll and carotenoids content in wheat plants. The maximum reduction in chlorophyll a, chlorophyll b, total chlorophyll and carotenoids was 94.61, 68.6, 87.3 and 98.4% over control at T5.

Effects of salinity on activity of CAT and POD

Salinity stress causes increase in production of ROS which are dismutated and detoxified by components of antioxidative defense system. In the experimental plants, the application of graded concentration of NaCl progressively increased ROS production and dismutation of these excess ROS in cells. In case of catalase and peroxidase, the least activity was recorded at control and progressively increased in plants growth at T1 to that

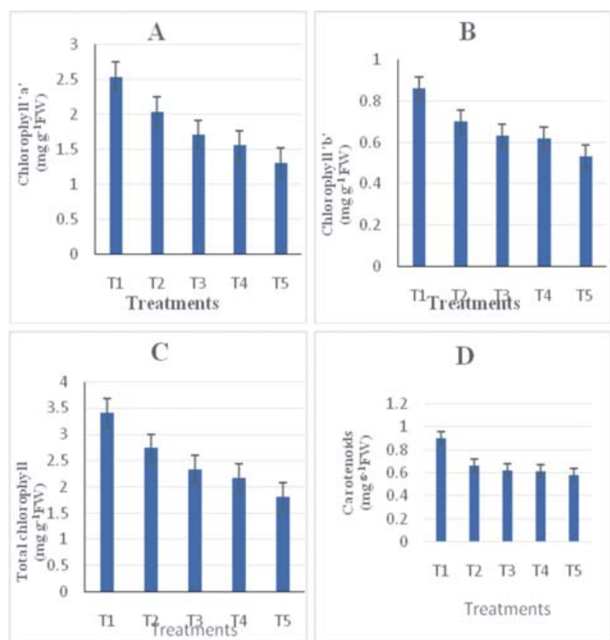

Figure 1: Effect of grades of NaCl on the Chlorophyll a content (A), Chlorophyll b content (B), total Chlorophyll content (C) and carotenoid content (D) in wheat plants

The error bars indicate ± SEM.

Treatments: T1 = Control (0 mM NaCl); T2 = 20 mM NaCl; T3 = 40 mM NaCl; T4= 60 mM NaCl and T5= 80 mM NaCl.

grown at T5. The least catalase and peroxidase activity was recorded at control while maximum activity was recorded at T5.

Effects of salinity on lipid peroxidation

Lipid peroxidation is the product of excess production of ROS which ultimately causes peroxidation of membrane lipids. The least lipid peroxidation was recorded at control and lipid peroxidation was increased progressively with increase in NaCl concentration. The degree of lipid peroxidation was increased with increase in concentration of NaCl in growth media.

Effects of salinity on proline

Proline is an imino acid and play a significant role in osmotic adjustment in plants mainly experiencing osmotic stress due to excess of salinity of growth media. In experimental plants growing at control, the least proline content was recorded while proline concentration was increased with increase in salinity concentration from T2 to T5. The maximum proline concentration was recorded in plants grown at T5 and least in plants grown at T1.

DISCUSSION

Wheat is a major cereal crop and a staple food for a large portion of population of the world and have been reported to be moderately tolerant (electrical conductance up to 8 dS/m) to salinity stress (Mass & Grattan, 1999). Result of our study shows that salinity stress reduces biomass accumulation in wheat plants (Table 1). Similar results were reported by Munns & Tester (2008) showing salinity induced reduction in production of crop plants, because water absorption by germinating seeds and plant roots is disrupted, creates hindrance in nutrients absorption and uptake. Under salt stress conditions, excess uptake and accumulation of toxic ions and oxidative damage to plants leads to poor plant growth and may lead to death of plants under extreme levels of salinity (Munns & Tester, 2008). In our study, wheat plants being moderately tolerant to the moderate level of salt concentration, so with the exposure and increasing salt concentration in growth medium, the plants showed reduction in germination percentage of seeds, reduced shoot length and biomass of plants. Several researchers have reported the reduction in germination percentage, shoot length and biomass of plants grown under salt stress. These results are in accord to Robin *et al*. (2016) and Munns & Tester (2008).

It is an established fact that high salt concentrations in growing medium and within the plant tissues compromise the development of roots and leaves in many crop plants (Robin *et al*., 2016). Plants showed reduction in germination percentage, shoot length, dry weight and pigments content even at 20 mM NaCl as compared to control plants (T1). These results are in accord to Munns & Tester (2008). In our experimental data the maximum reduction in above parameters was observed at T5 having application of 80mM NaCl supply with about 8dS/m electrical conductance (Munns & Tester, 2008). In wheat plants being moderately tolerant to salinity, the activity of catalase, peroxidase, lipid peroxidation and tissue proline content were increased with increase in NaCl concentration in growth medium and maximum increase in these parameters was observed at T5 with 80mM NaCl concentration. Increase in activity of components of antioxidative defense system indicates the increased

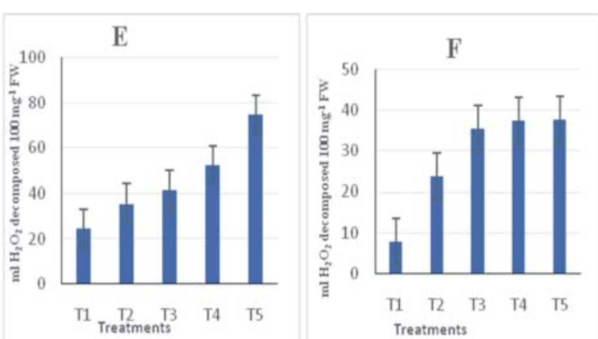

Figure 2: Effect of grades of NaCl on activity of catalase (E) and peroxidase (F) in wheat plants

The error bars indicate ± SEM

Treatments: T1 = Control (0 mM NaCl); T2 = 20 mM NaCl; T3 = 40 mM NaCl; T4= 60 mM NaCl and T5= 80 mM NaCl.

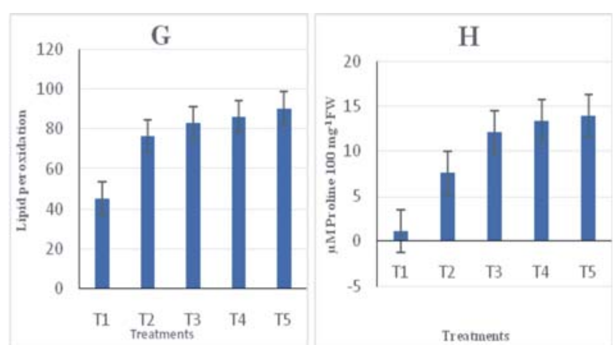

Figure 3: Effect of grades of NaCl on lipid peroxidation (E) and proline content (F) in wheat plants

The error bars indicate ± SEM

Treatments: T1 = Control (0 mM NaCl); T2 = 20 mM NaCl; T3 = 40 mM NaCl; T4= 60 mM NaCl and T5= 80 mM NaCl production of ROS under salt stress conditions followed by their dismutation and resulting in maintaining the optimum level of ROS in cells. Similar results were reported by Sachdev *et al*. (2023).

CONCLUSION

Our study has clearly shown that application of grades of NaCl has significantly affected the germination by decreasing germination percentage of seeds, delayed seed germination as well as reduced seedling and shoot length. Increase in NaCl supply in growth medium has severe deleterious effects which negatively affects germination percentage, shoot length and dry weight of experimental. The degree of reduction of these parameters is higher in relatively more salt sensitive plants. Therefore, from our study, it is suggested that for better growth of crop plants in such saline soils, more salt tolerant crops must be grown and in salt sensitive plants some exogenous substances must be added in growth medium or as foliar spray which has been reported to increase salt tolerance even in salt sensitive crop plants.

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