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Research Article

Salinity (sodium and potassium chloride) influence on germination and growth factors of wheat (*Triticum aestivum*)

Zubia Rahim[1*], Gulnaz Parveen[1], Naila Mukhtar[2] and Kiran Natasha[3]
1. Department of Botany, Women University, Swabi, Swabi-Pakistan
2. Department of Botany, Government College University Faisalabad, Layyah Campus-Pakistan
3. Qurtaba University of Information and Technology Peshawar Campus-Pakistan
**Corresponding author's email:* zubia.rahim@wus.edu.pk

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Abstract

The effects of salt stress on wheat (*Triticum aestivum*) was assessed by application of various concentrations (100, 150, 200 and 250mM) of two types of salts (NaCl, KCl and Mixture of NaCl and KCl). This study revealed the extent to which the Wheat plant can tolerate the salt stress. The germination and growth parameters were analyzed in laboratory and in pots by application of the said concentrations of salts. Increasing levels of the salts reduced the growth of Wheat (*Triticum aestivum*) plant. Radical length reduced to 0.5, 0.3 and 0.2 cm at 200mM concentrations of NaCl, KCl and mixture of NaCl and KCl respectively which is less than control (2.8 cm). The stem length, leaves length, stem breadth, number of tillers, number of leaves per plant, number of seeds per spike, spike length, weight of whole plant and weight of 50 grains of wheat showed reduction as the salinity levels increased to 200 mM and 250mM compared to control. Wheat plant is found to be salt sensitive plant, not suggested to grow in saline or waterlogged areas.

Keywords: Cereal; Crop; Concentration; Mixture; Salt; Stress

Introduction

In this era of rising urbanization and development our diets are in transition states of being replaced by the food with refined fats, refined sugars and many other artificial ingredients **[1]**, but cereal grains are major part of human diet for decades **[2]** because it provides more energy worldwide **[3]**. Universally cereals are significant food crops **[3-5]**. Billions of people depend majorly upon wheat, rice and maize and slightly on millet and sorghum **[2, 6]**, among them wheat stand second after maize **[4]**, while millet is sixth most exclusive of them **[7]**. Cereal grains provide 50% of world's caloric need **[2]**. Crude cereals are rich in carbohydrates majorly starch (65 to 75%), vitamins, proteins (6 to 12%), minerals, oils and fats (1 to 5%). These cereals are suggested for chief part of food because of their high fiber content which checks weight gain and cardiac diseases **[3, 8]**.

For agricultural production, Irrigation of the land with salinity is one of the major environmental issue [9] and it's a major menace to modern agriculture resulting in impairment and imbalance in development of crop growth **[10]**. Due to salinization, different anthropogenic activities also in turn affects the processes of irrigation **[11]**. Salinity is the major issue of semi-arid and arid regions and now it has been debated as a worldwide environmental issue **[12,13]** Attempts have been made to discover the phenomenon of promoting salinity tolerance among different crops either by approaches related to molecular biology or with the help of salt tolerant genes transfer **[14,15]**. Sodium chloride has numerous functions in cereals, but its decrease is a topic that should be concentrated on due to nutritious recommendations **[16]**.

The yield of cereal crops especially rice has been noticed to be decreased due to certain factors along with salinity **[17]**. Rising levels of sodium chloride has negative impacts on wheat (*Triticum aestivum*) varieties [18]. Because salt stress is a type of ionic stress in which high chloride contents are accumulated in plants significantly which ultimately inhibits the uptake of potassium and other mineral ions [19] and among the ionic stress sodium is most hazardous ion which impairs the growth of plants by restricting their metabolic processes **[20]**. In many cases leaf area or shoot area of wheat (*Triticum aestivum*) does not show potentials to analyze the grain yield. whereas the gas exchange parameters can be correlated with biomass accumulation. The data reveals that stomatal closure is the main cause behind decrease in biomass production which may be due to inhibition of uptake of Potassium ion **[21]**.

In the present scenario this experiment was conducted to check the salinity level and the vigor of Wheat (*Triticum aestivum*) plant to tolerate salt stress of various concentrations.

Materials and methods

In-vitro test

Wheat (*T. astivum*) Var. Atta Habib seeds were collected from department of botany Islamia College Peshawar, surface sterilized for 30seconds by Mercuric Chloride ($HgCl_2$) (0.1%) and then washed by tap water, followed by distilled water. To find out the germination, plumule and radical length, seeds were placed in petri plates, already comprising a thin layer of cotton, and blotting paper. Petri dishes were sterilized and finally the seeds were soaked in salt solution (10 ml) of various concentrations (100,150, 200 and 250mm) of NaCl, KCl and combined (NaCl+KCl). Each of the three replicates contained 5 seeds. Plates moistened with distilled water were considered as control. Petri dishes were incubated at 27 ^oC for 3 to 5days.

In-vivo test

Soil used for experiment

Sandy loam soil with pH 8.0 taken from a trial field of the botanical garden, department of botany, Islamia College Peshawar, Pakistan was sterilized and used for cultivation of wheat.

Pot experiment

A pot experiment was performed in the screen house of the Islamia College Peshawar in completely randomized block design. Seeds of wheat (*T. aestivum*) were sown in 32 cm diameter Pots. Each containing 4kg soil. 10 seeds of wheat (*T.aestivum*) were sown in pots. The pots were arranged randomized on a screen house bench. After germination of seeds, five seedlings were removed from each pot while 5 were left. When seedlings were at two leaf stage, saline solution (100,150, 200 and 250mm) of NaCl, KCl and combined (NaCl+KCl) were added to each pot after interval of 15 days. Various growth parameters included weight of whole plant, number of tillers, stem breadth, stem length, leaves length, number of leaves, number of seeds per spike, spike length, weight of 50 seeds of spike in each concentration and control were recorded after 90 days.

Statistical analysis

The experiment was performed and data was recorded by analysis of variance (ANOVA). For Germination and growth parameters of Wheat plant, data was subjected to one-way ANOVA followed by the least significant difference LSD test at P=0.05. All analysis was performed using IBM-SPSS STATISTICS program **[22]**.

Results

In-vitro test

Length of radicle and Plumule of wheat was significant ($p<0.05$) effected or decreased by increase of the salt stress compared to control. Maximum stress was observed in the length of radical and Plumule at maximum concentration (200mM) of salt solution i.e. mix salt (NaCl+KCl). Where it showed the minimum length like 1.1 and 0.2 cm respectively. Highly significant ($p<0.05$) effect of stress was observed at 100mM of salts solution when combine salts (NaCl+KCl) were used for germination percent (Table 1).

In-vivo test

Vegetative growth is highly stunted due to salt stress. Stem Length, Stem breadth, Number of tillers and number of leaves reduced at the most concentrated level (250mM) of NaCl, KCl and mixture salt compared to control. The combine effect (NaCl+KCl) was observed to be more stress inducer. Length of leaves showed reduction at 200mM of mixture salt (i.e. 3.8 cm) as compared to control (Figure 1).

NaCl is observed to reduce Spike length (1.9 cm) and weight of whole plant (0.12 cm) at 250mM as compared to other concentrations and control i.e, 6.3cm and 0.86 respectively. KCl imposed more stress on Number of seeds per spike (4.3 cm) at 250mM as compared to other salts and their concentrations and control (20.7cm).

The yield of stressed crop also showed similar response like vegetative phase. Weight of 50 grains reduced at highly concentrated salt solution (250mM) of mix salt i.e. 1.5 cm as compared to other salt concentrations and control (2.5cm) (Figure 2).

Discussion

Salinity highly affects growth and germination of Wheat as the concentrations of the salts (NaCl, KCl and NaCl+KCl) increased. A significant reduction in length of root and shoot is reported at high concentration of NaCl by **[23]**. This reduction in root and shoot length may be caused by either toxic effects of NaCl higher concentrations or due to improper uptake of nutrients by seedlings. Higher levels of salinity may check the growth because of slow uptake of water for maintaining osmotic potential of plant under saline stress **[23]**. Germination percentage is reduced to 0.4cm at 100mM concentration of mix salt solution which is also reported by **[24]**.

According to **[25]** the concentrations at 125mM and 150 mM of NaCl completely inhibited the Wheat (*Triticum aestivum*) varieties growth. The processes of growth are highly susceptible to the salt stress, which can be predicted by the biomass and production of the standing wheat (*Triticum aestivum*) crop. The yield reflects the capacity of the plant to tolerate the salt stress. The result indicated reduction in the weight of whole plant by application of salt stress as compared to control. Same result is indicated by **[23]**. According to them the weight of whole plant reduced by increase of NaCl concentrations.

Number of spikes per plant (NSP), Spike length (SL), Number of leaves per plant (NLP) decreased by increase of salt concentrations. The values of LSD show significance level for weight of 50 grains. The weight of grains reduced to 1.4 cm at 100mM NaCl solution as compared to control. LSD show high significance level for number of tillers per plant as the concentration of salt solutions enhanced as compared to control. **[26]** worked on the same parameters i.e, NSP, SL, NLP, WTG (Weight of thousand grains) and NT of wheat (*Triticum aestivum*) reduced by increase of levels of salt solution.

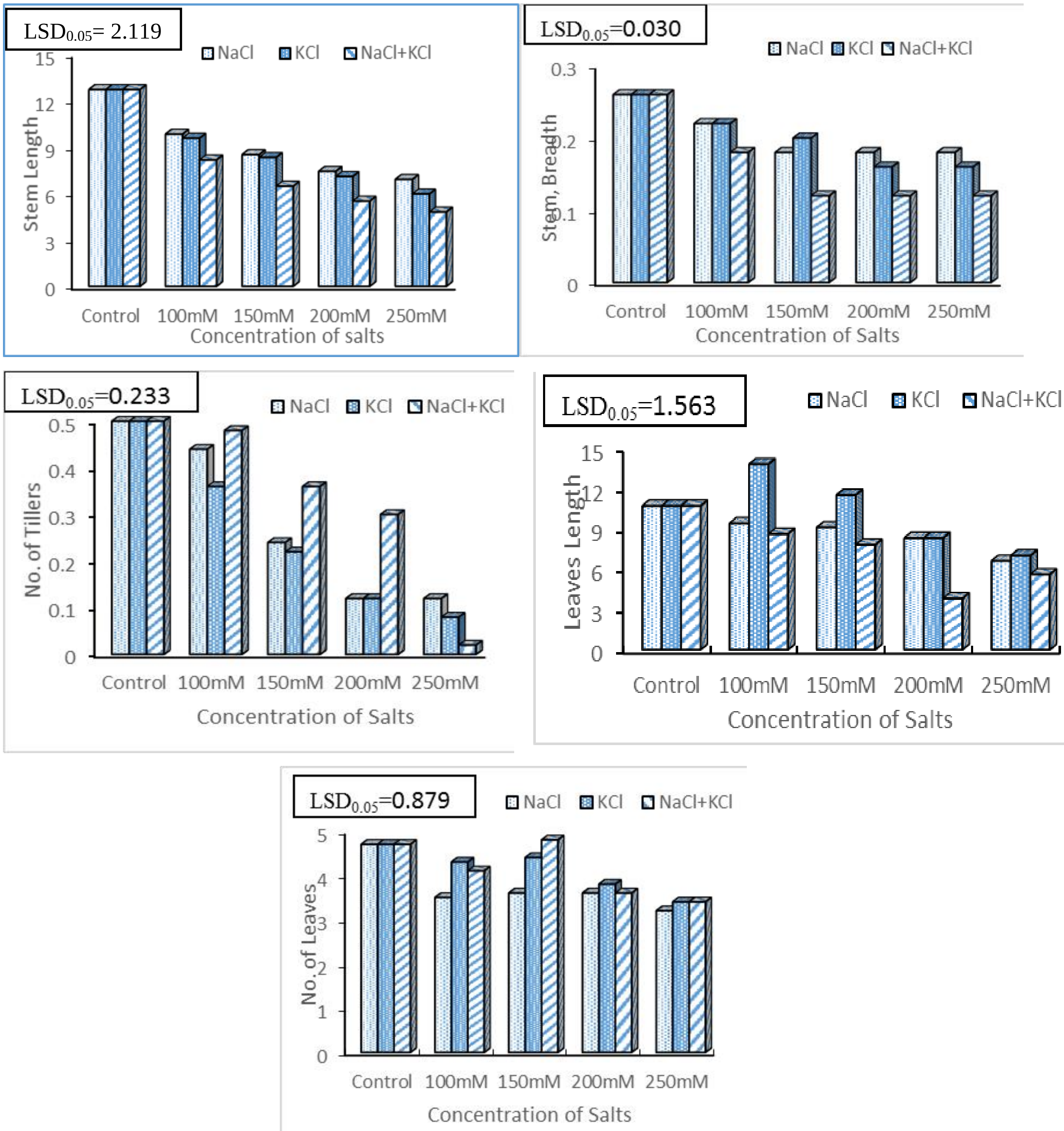

Figure 1. Effect of different salt concentrations (100 mM, 150 mM, 200 mM, 250mM) on vegetative gowth of Wheat (*Triticum aestivum*) (Stem Length, Stem breadth, No. of Tillers, Leaves length and No. of Leaves)

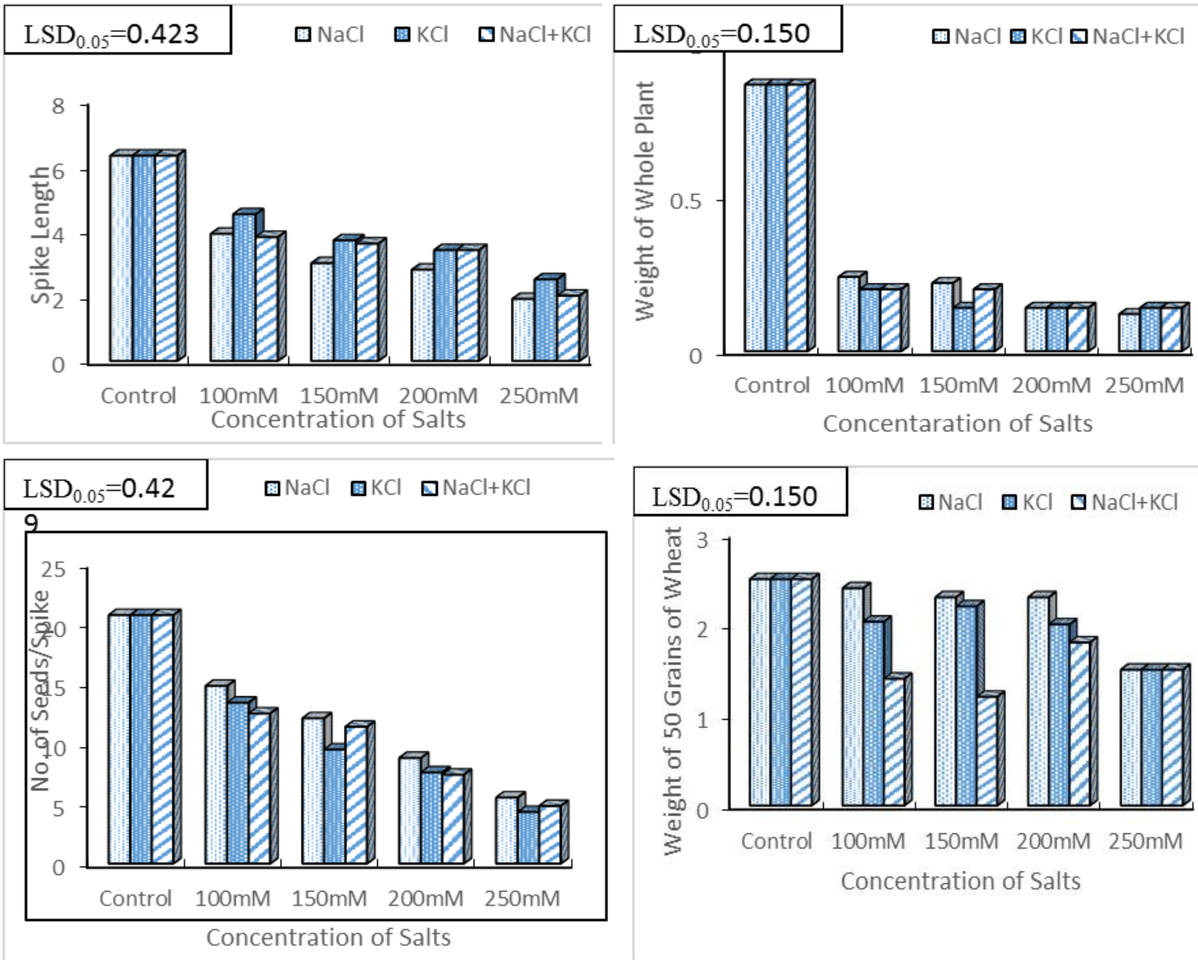

Figure 2. Effect of different salt concentrations (100 mM, 150 mM, 200 mM, 250mM) on yield of Wheat (Spike Length, Weight of whole plant, Number of seeds per spike, weight of grains)

Table 1. Effect of different salt concentrations (100 mM, 150 mM, 200 mM, 250mM) on germination of Wheat

Treatments	Concentration	Radical Length (cm)	Plumule Length (cm)	Germination% (cm)
Control	Distilled Water	2.8	3	1
NaCl	100mM	2.6	1.5	0.9
	150mM	2.3	0.5	0.6
	200mM	2.0	0.5	0.6
KCl	100mM	2.1	1.04	0.9
	150mM	2.2	0.4	0.6
	200mM	1.7	0.3	0.6
NaCl + KCl	100mM	2.1	0.9	0.4
	150mM	2.1	0.3	0.5
	200mM	1.1	0.2	0.5
LSD0.05		0.101	0.053	0.054

Conclusion

It is concluded that increase of salt concentrations highly affected the growth and germination of wheat (*Triticum aestivum*). Among all concentrations 200mM and 250mM levels caused more stress. The yield of wheat was reduced highly by increase of salt concentrations. Further research need to be done to developed the resistant or salinity tolerance of wheat (*Triticum aestivum*) variety to overcome the losses of wheat in saline area and ultimately enhance the economy of Pakistan.

Authors' contributions

Conceived and designed the experiments: Z Rahim, Performed the experiments: Z Rahim, Analyzed the data: G Parveen & Z Rahim, Contributed materials/ analysis/ tools: Z Rahim & K Natasha, Wrote the paper: G Parveen, Z Rahim & N Mukhtar.

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