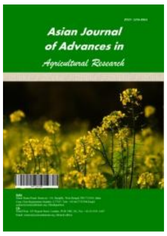

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Impact of Pre-anthesis Salt Stress on Biochemical and Yield Related Traits in Salt Sensitive and Salt Tolerant Genotypes of *Triticum aestivum L*.

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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Original Research Article

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ABSTRACT

Salinity stress negatively affects the growth and development of wheat leading to diminished grain yield and quality. Salt stress during the reproductive stage is one of the significant factors leading to the drastic reduction in grain yield. The objective of this study was to investigate the biochemical responses of pre-anthesis stage salt stress and yield-related traits in the KRL1-4 salt tolerant and UP2338 salt-sensitive cultivar of wheat. Three different levels of salinity stress (100, 200 and 300 mM NaCl) were induced. Untreated plants were kept in control. Samples were analyzed at pre-anthesis stage (50 DAS and 60 DAS) for various biochemical parameters viz., proline content, total reducing sugar content, total nitrogen content and total protein content. Yield-related traits harvest index, tiller numbers per plant, spike height and spike weight were recorded at the maturity stage. The amount of proline and reducing sugar increased with increasing salinity, the increase being more tolerant than in sensitive cultivar. Total nitrogen and total protein content, however, decreased with increasing salt concentration and reduction being more sensitive than in tolerant cultivar. Yield attributes were affected negatively. The effect was more pronounced in sensitive cultivars compared to tolerant ones.

Keywords: Salinity; pre-anthesis; osmolytes; harvest index.

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1. INTRODUCTION

Soil salinity is a major threat to crop yields, especially in arid and semi-arid countries where irrigation is an essential aid to agriculture [1]. 20% of global cultivable land is affected by salt stress. Changes in climate and anthropogenic activities are increasingly affecting arable lands [2]. The stress created by high salt concentration in the soil is attributed to early osmotic stress and sodium and chloride ion stress that appears late significantly reducing plant growth and development [3]. Osmotic stress immediately affects growth because of the salt [4]. Plant response towards salinity stress depends upon many factors like concentration of salts, variety of plant, growth stage and environmental conditions Reproductive age of any crop is the most sensitive stage to salinity stress [5], and causes a massive reduction in yield in wheat [6].

Wheat, rice, and maize are the most important staple crops globally and contribute a significant part of daily calorie and protein intake [7]. Among the cereals, *Triticum aestivum* is ranked in the first position due to its domestication and contribution as the primary staple food crop globally [8]. Wheat has been reported to provide 73% of the calorie and protein requirements of the daily diet [9]. It plays an important role in food security and poverty alleviation as a strategic crop and has an important role in the economy [10].

The unavailability of sufficient photoassimilates during the pre-anthesis stage is the leading cause of loss in production in wheat. Plants develop a large number of physiological and biochemical strategies to cope with stresses [11]. The response to osmotic stress primarily involves osmotic adjustments. Osmotic adjustment is crucial for cell turgor maintenance, which maintains plant metabolic activity and in turn plant growth and productivity [12]. Proline, soluble sugars, glycine, betaine, and other osmolytes synthesized by plants to promote osmotic balance can serve as sensitive markers for the selection of tolerant genotypes under salt stress [13].

The present study was performed to determine the salt tolerance for two wheat cultivars during pre- anthesis stage and to examine the changes in biochemical and yield parameters. The biochemical markers can be incorporated into high-yielding salt-tolerant wheat varieties.

2. MATERIALS AND METHODS

The field experiment was conducted at the Department of Botany, D.D.U. Gorakhpur University during the wheat growing period (Nov.-Feb 2009).

Healthy grains of wheat (salt tolerant KRL 1-4 and salt-sensitive UP 2338 cultivars) were surface sterilized with ethanol for 5 min followed by a thorough wash with distilled water. Seeds were obtained from Narendra Dev Agriculture University, Faizabad Grains were then inoculated with 96 h grown culture of *Azotobacter* (culture of *Azotobacter chrococcum* was obtained from the Department of Agriculture and Co-operation, National Biofertilizer Development Centre Ghaziabad, U.P.).

The inoculated seeds were sown in earthenware pots containing sterilized sand. These pots were treated with saline water containing 100mM, 200mM, and 300mM NaCl respectively and corresponding E.C. was maintained as 9.83, 21.9 and 32.5 dS/m respectively. Plants were supplied with Hoagland's nutrient solution weekly. Water was applied to each pot daily to keep the sand moist and hence to maintain the salt level [14,15]. Untreated plants were kept in control. All the biochemical parameters were recorded at the pre-anthesis stage (50 and 60 DAS) for various treatments and yield parameters were recorded post harvesting.

2.1 Biochemical Parameters

Proline content was estimated by the method of Bates et al. [16]. Estimation of total reduction sugar was done by the method of Somogyi's [17]. Determination of insoluble and total nitrogen was done by the method of Doneen [18]. For measurement of protein content, the amount of insoluble nitrogen fraction as obtained by the micro-Kjeldahl digestion method was multiplied by a factor of 6.25. Relative water content was measured by Barr and Weatherly [19].

2.2 Yield Parameters

Plants of different saline treatments were harvested at 110 DAS. Data on wheat harvest index, tiller numbers per plant, spike height and spike weight were recorded. Spikes were oven-dried at 70 1 °C for 72 h and their dry weights were determined. Tiller numbers per plant were recorded from 5 randomly chosen plants. Spike weight per plant was recorded from 5 randomly chosen plants.

The data have been statistically analyzed. The least significant difference (LSD) has been calculated for the data where F-test was found significant.

3. RESULTS AND DISCUSSION

For better yield and growth at the pre-anthesis stage leaf osmotic potential is of paramount importance. During salinity stress plants accumulate organic osmolytes for osmotic adjustments. In the current study, proline increased gradually with increasing salt concentration. The increment was more intolerant cultivar KRL1-4 than sensitive cultivar UP2338. However, proline content decreased at 60DAS in both the cultivars at all salt concentrations (Fig. 1a and 1b).

Our findings are in consideration with previous work of Sairam et al. [20] in wheat genotypes. Hasan et al. [21] also reported an increase in flag leaf proline content in salt tolerant wheat genotypes under salt stress. while a decrement was observed in sensitive genotypes as compared to control plants.

In the current study reducing sugar followed the same trend as that of proline (Fig. 2a and 2b). Confirmed with our data, other reports are indicating that the soluble carbohydrate content increased in response to salt stress, especially in tolerant varieties [22]. The decrease in reducing sugar at the advanced stage is due to the unavailability of sufficient photo-assimilates caused by salt stress during the pre-anthesis and grain filling stage [23,24]. Alteration of sucrose 1-fructosyltransferase, sucrose: fructan6-fructosyltransferase, and fructan exohydrolase hampers the fructan accumulation, and remobilization of carbohydrates to grains [25].

Salt in soil water affects available soil water, tissue water, cell turgidity, water potential and osmolytes [26,27]. In our study relative water content declined significantly with induction and duration of salt stress. The decline in relative water content was lower in salt tolerant cultivar KRL1-4 as compared to sensitive cultivar UP2338 (Fig. 3a and 3b). Our results are in agreement with those of Sairam et al. [20] and Zheng et al. [28] who reported a greater reduction in RWC of salt-sensitive wheat cultivar as compared with tolerant one under salt stress. It was proposed that retention of higher RWC was associated with higher proline accumulation in the tolerant cultivar. In the reproductive phase, reduction in water potential reduces cell elongation, leaf area and hence productivity [29].

The Nitrogen and Protein content decreased with increasing levels of salinity, both at 50 and 60 DAS. Yousfi et al. [30] reported that nitrogen metabolism and stomatal limitation at the anthesis stage are major causes of reduction in biomass under different salinity regimes. In the current study, the decrement was more sensitive than in tolerant cultivars (Fig. 4a, 4b, 5a, and 5b). Kaya et al. [31] reported salinity stress can decrease N concentration.

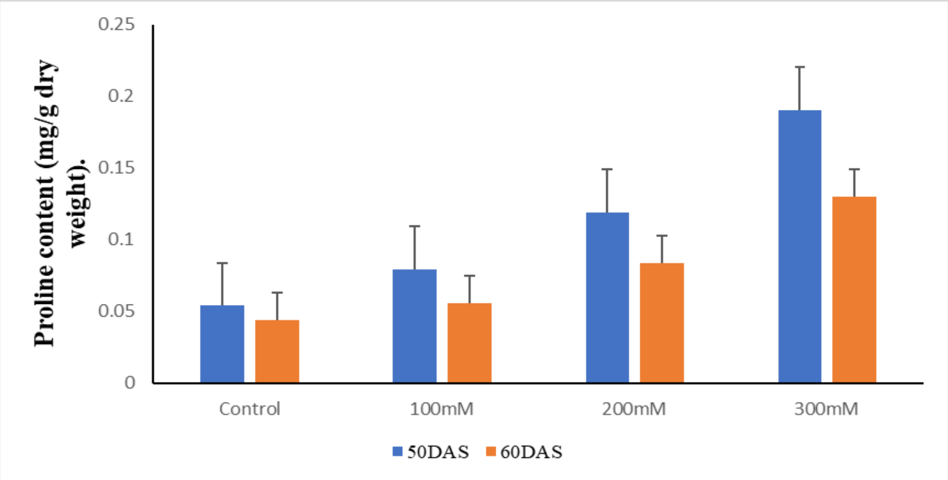

Fig. 1a. Effect of salt on Proline content in 50 and 60 DAS KRL1-4 cultivar of wheat under different NaCl concentrations

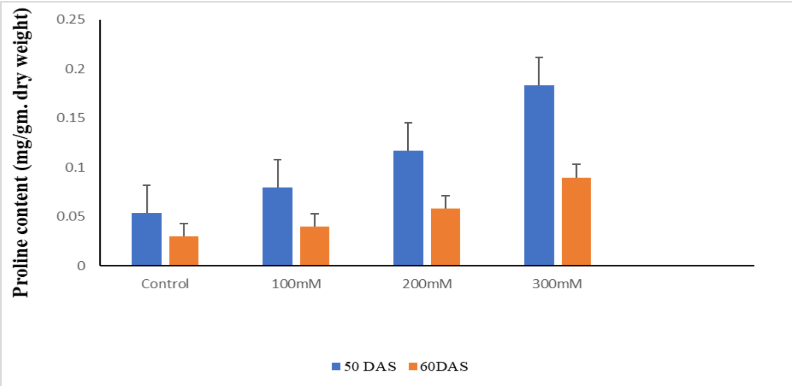

Fig. 1b. Effect of salt on Proline content in 50 and 60 DAS UP2338 cultivar of wheat under different NaCl concentrations

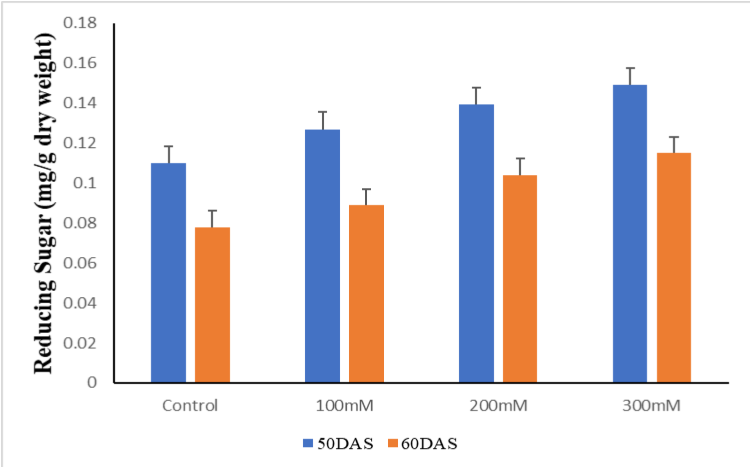

Fig. 2a. Effect of salt on Reducing Sugar in 50 and 60 DAS KRL1-4 cultivar of wheat under different NaCl concentrations

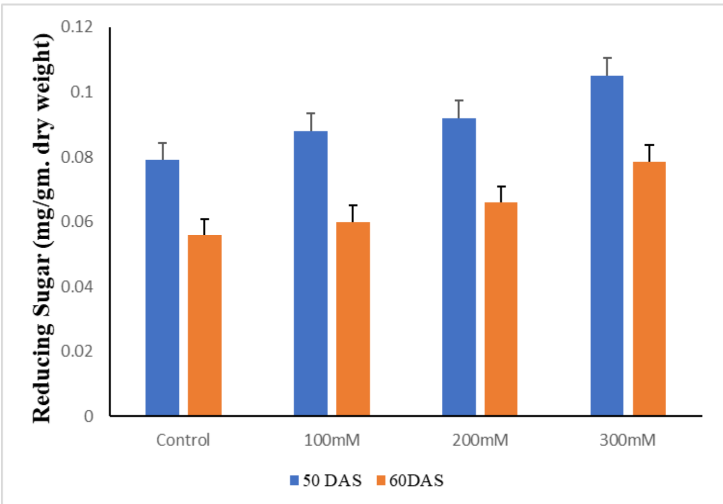

Fig. 2b. Effect of salt on Reducing Sugar in 50 and 60 DAS UP2338 cultivar of wheat under different NaCl concentrations

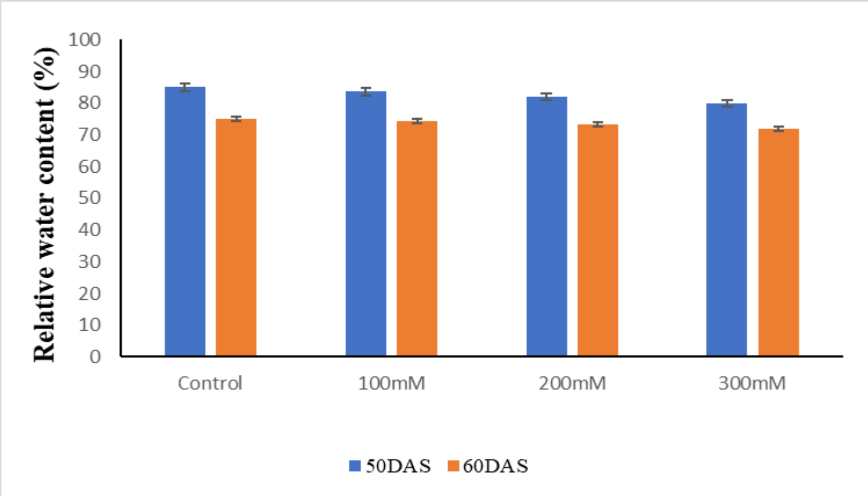

Fig. 3a. Effect of salt on Relative Water Content in 50 and 60 DAS KRL1-4 cultivar of wheat under different NaCl concentrations

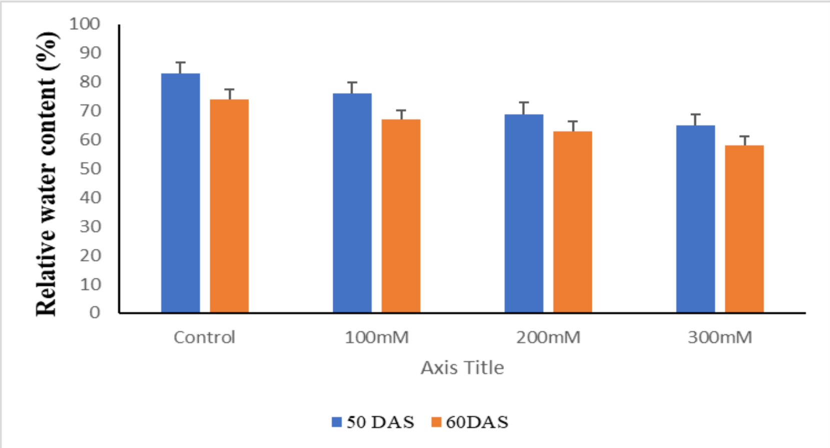

Fig. 3b. Effect of salt on Relative Water Content in 50 and 60 DAS UP2338 cultivar of wheat under different NaCl concentrations

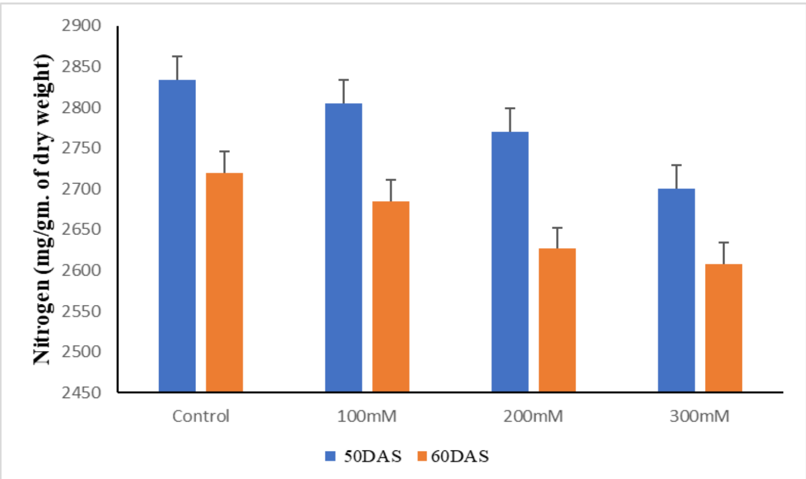

Fig. 4a. Effect of salt on Nitrogen Content in 50 and 60 DAS KRL1-4 cultivar of wheat under different NaCl concentrations

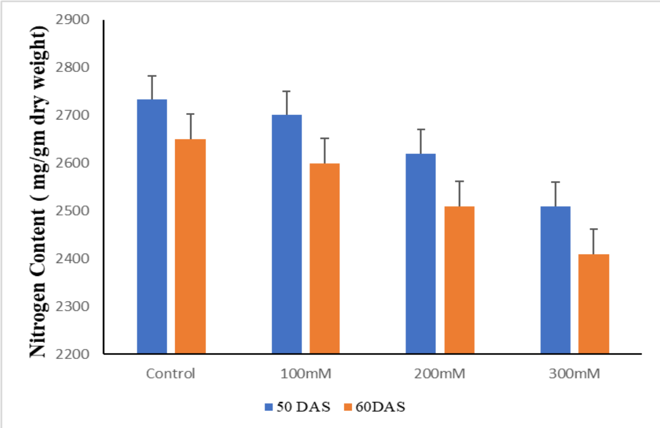

Fig. 4b. Effect of salt on Nitrogen Content in 50 and 60 DAS UP2238 cultivar of wheat under different NaCl concentrations

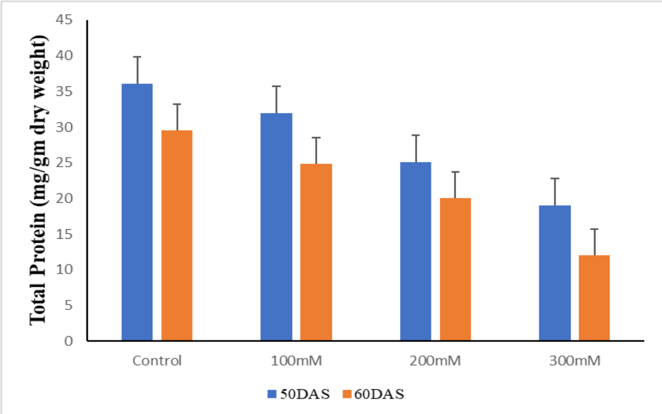

Fig. 5a. Effect of salt on Total Protein Content in 50 and 60 DAS KRL1-4 cultivar of wheat under different NaCl concentrations

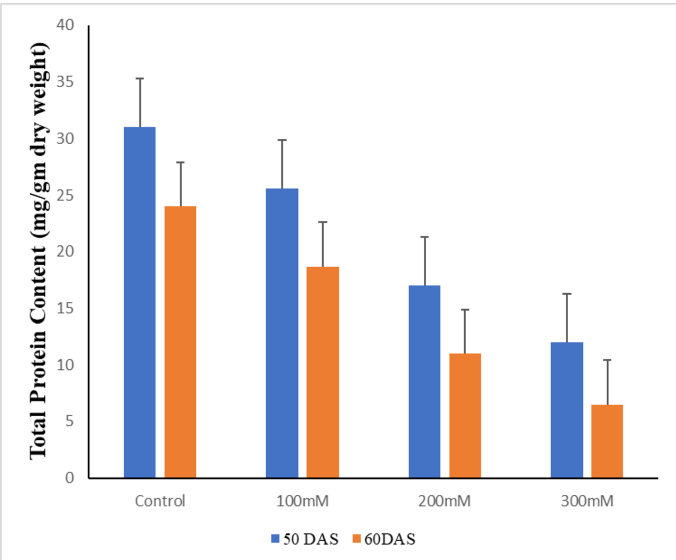

Fig. 5b. Effect of salt on Total Protein Content in 50 and 60 DAS UP2338 cultivar of wheat under different NaCl concentrations

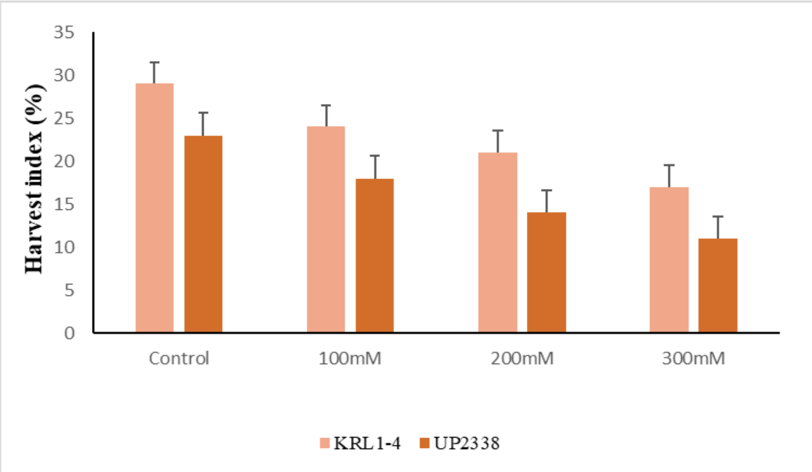

Fig. 6. Effect of salt on Harvest Index (%) in KRL1-4 and UP2338 wheat plants under different NaCl concentrations

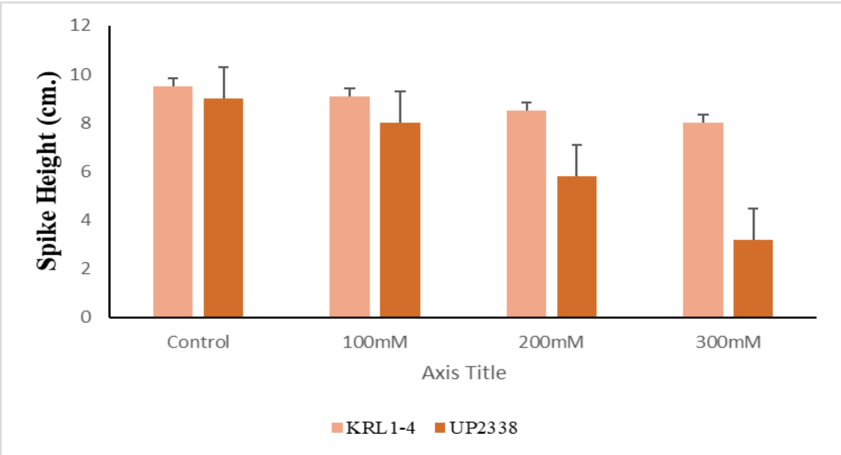

Fig. 7. Effect of salt on Spike height in KRL1-4 and UP2338 wheat plants under different NaCl concentrations

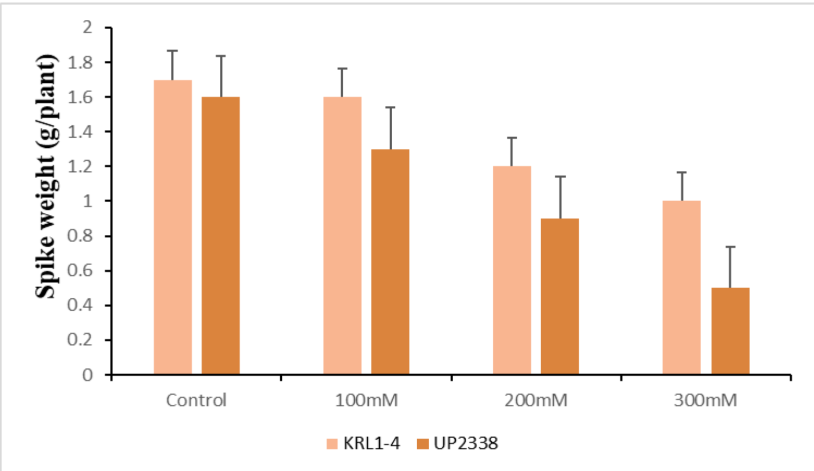

Fig. 8. Effect of salt on Spike weight in KRL1-4 and UP2338 wheat plants under different NaCl concentrations

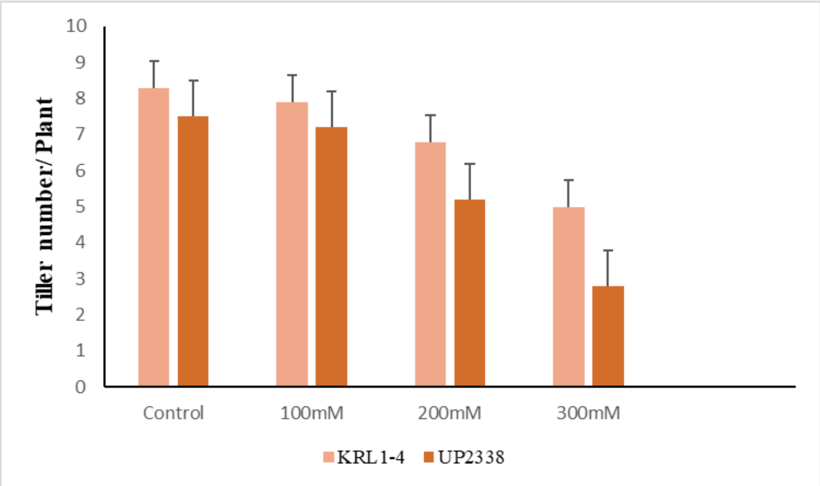

Fig. 9. Effect of salt on Tiller number in KRL1-4 and UP2338 wheat plants under different NaCl concentrations

Subjecting wheat plants to salt stress had a negative effect on agronomic traits like harvest index (Fig. 6), spike height (Fig. 7), spike weight (Fig. 8) and tiller number (Fig. 9). However, the impact was more pronounced on UP2338 as compared to KRL1-4. A significant decrease was observed on 60DAS at a higher concentration of salt stress. Mass and Grieve, 1990 suggested salinity causes a decrease in the number of spikelet primordia and early anthesis. Our results are in accordance with Tareq et al. [32] who suggested 8, 3, 37, 20 and 10% reduction in spike length, spike weight, filled spike let per plant, total spikelet per plant and weight respectively under stress conditions. Eroglu et al. [33] reported that salt stress at pre-anthesis and post-anthesis stages caused a reduction in ear weight and biomass.

4. CONCLUSION

Anthesis and grain filling period are crucial stages that determine productivity. Hence environmental stresses at these stages act as major constraints to wheat production worldwide Salinity tolerance is an outcome of various features that depend on different physiological interactions, which are difficult to determine. According to our study better growth and yield of KRL1-4 tolerant cultivar compared to UP2338 sensitive cultivar when exposed to stress may be due to increased osmolyte production, higher water content and total nitrogen and proteins in leaves.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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