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Effects of NaCl Salinity on Wheat (*Triticum aestivum* L.) Cultivars

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Abstract: The response of four cultivars of wheat (*Triticum aestivum* L.) to NaCl salinity at germination and early seedling growth was investigated. Salinity treatments measuring ψ_π 0.00, -2.457, -4.914, -9.828 and -14.742 bars were achieved by adding NaCl in deionized water. There was a decrease in water up take and germination of all cultivars. Increase salt concentration also affected the early seedling growth. Among the cultivars under investigation zarlasht cultivar appeared to be more sensitive at germination stage. However, it performed quite satisfactorily at seedling stage.

Key words: Cultivars . Wheat . Salinity . Germination . Seedling

INTRODUCTION

Salinization is the scourge of intensive agriculture [1]. High concentration of salts have detrimental effects on germination of seeds [2, 3] and plant growth [4]. Many investigators have reported retardation of germination and growth of seedlings at high salinity [5]. However plant species differ in their sensitivity or tolerance to salts [6].

Wheat is a major staple food crop for more than one third of the world population and is the main staple food of Asia [7]. It is originated in South Western Asia and has been a major agricultural commodity since pre historic times. The total production area in Pakistan is 8.2 mha and the average yield is 2170 kg/hectare [8]. The wheat crop is mainly cultivated under rain fed conditions where precipitation is less then 900 mm annually. Wheat is grown both as spring and winter crop. Winter crop is more extensively grown than spring. The possible cause of varietial difference most likely evolves ion transport properties and cellular compartementation [9]. Schachtmann and Munns [10] reported that sodium exclusion was a general characteristic of salt tolerance in wheat lines, where as, salt tolerant display much higher shoot sodium level than sensitive lines. Few studies have been carried out on the relative salt tolerance of various cultivars of agricultural crops of Pakistan [1,2]. The screening of salt tolerant lines/cultivars has been attempted by many researchers on various species at seedling growth stage [11]. The relation of various seedling growth parameters to seed yield and yield component under saline conditions are important for the development of salt tolerant cultivar for production under saline conditions. The study presented here deals with the response of four cultivars of wheat to NaCl stress at germination and early seedling growth stage.

MATERIALS AND METHODS

Seeds of four wheat (*Triticum aestivum* L.) cultivars Viz.: Zarghoon, Zarlasht, Zardana, Raskoh were obtained from Agriculture Research Institute, Sariab Road Quetta. The seeds were surface sterilized by dipping the seeds in 1% mercuric chloride solution for 2 minutes and rinsed thoroughly with sterilized distilled water. There were five salinity treatments having osmotic potential 0.00, -2.457, -4.914, -9.828 and-14.742 bars. Treatment having osmotic potential 0.00 bars served as control. These treatments were prepared by dissolving separately calculated amounts of NaCl in deionized water. All the experiments were conducted in 9 cm Petri plate on filter paper beds in growth chambers. 20 seeds were sown in 9 cm diameter Petri plate on filter paper beds, irrigated with 5 ml solution of respective treatment and incubated at 30°C. Each treatment was replicated thrice. The filter paper beds were irrigated daily with 5 ml solution of the respective treatment. The filter beds were changed after 48 hours in order to avoid salt accumulation.

Water uptake: Water uptake was recorded for 12 hours. Water uptake percent was calculated by the formula given below.

$$\text{Water uptake, \%} = \frac{W_2 - W_1}{W_1} \times 100$$

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W_1 = Initial weight of seed
W_2 = Weight of seed after absorbing water in a particular time.

Germination: The emergence of radical/plumule from seed was taken as an index of germination. The germination percent was recorded daily up to 10 days.

Recovery test: Recovery test was applied on those seeds which did not germinate in the scheduled time. Non-germinated seeds were washed with distilled water and sown in Petri plates on Whatmann's No.1 filter paper in an incubator at 25°C±1 for 6 days. 5 mL distilled water was added to each Petri plate daily.

Seedling growth: After 10 days the seedlings were harvested and the following observations were made:

Root/ Shoot Length
Root/ Shoot Biomass

Salt tolerance: Salt tolerance was calculated by the formula given below:

$$\text{Salt tolerance} = \frac{\text{Germination/Growth in particular treatment}}{\text{Germination/ Growth in control}} \times 100$$

RESULTS

Water uptake: Water uptake by the seeds showed direct relation with increase in salinity of the medium (Fig. 1). At higher osmotic potentials i.e., -9.828 and -14.742 bars the water uptake decreased as compared with control. The reduction in water uptake at -14.742 bars with respect to control was 51.09, 36.55, 42.82, 35.35 % in cv. raskoh, zardana, zarghoon and zarlasht, respectively. Minimum reduction in water uptake was recorded in cv. zarlasht and maximum in cv. raskoh. The cultivars can be arranged in the following order on the basis of water uptake.

Zarlasht>Zardana>Zarghoon>Raskoh

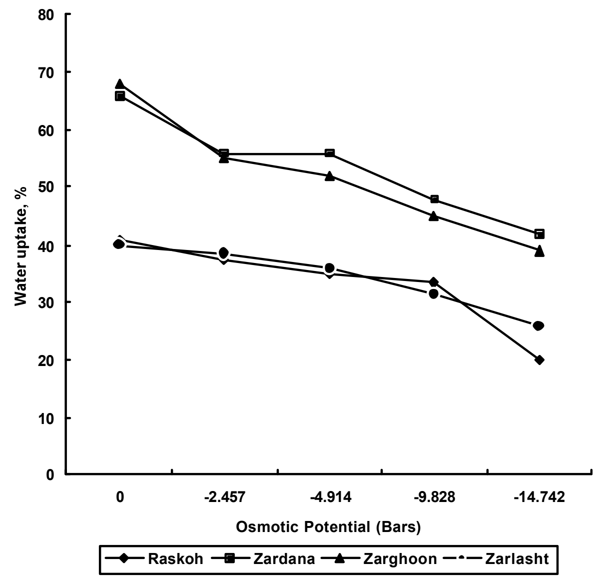

Fig. 1: Effects of NaCl salinity on water up take by seeds of wheat (*Triticum aestivum* L.) cultivars

Germination: Salt tolerance at germination stage is important factor, where soil salinity is mostly dominated at surface layer. The increase in salinity not only decreased the germination but also delayed the germination initiation (Fig. 2). The initiation of germination of cv. raskoh was delayed up to one day by all levels of salinity while of cv. zarlasht beyond-4.914 bars osmotic potential. The increase in salinity up to -14.742 bars osmotic potential had no effect on germination of cv. zardana seed. The maximum decrease in germination was observed in c.v. zarlasht i.e., 76.67 %. The cultivars had the following order on basis of germination at-14.742 osmotic potential.

Zardana>Raskoh>Zarghoon>Zarlasht

The results of recovery test applied to the non germinated seed (Table 1) show that the seeds of cultivar zarlasht showed up to 50 % recovery at and beyond-9.828 bars osmotic potential. The non germinated seeds in different salinity treatment of other

Table 1: Recovery of wheat (*Triticum aestivum* L.) cultivars at germination stage

Treatments	Cultivars (Germination, %)			
Osmotic potential (Bars)	Raskoh	Zardana	Zarghoon	Zarlasht
-2.457	(-)	(-)	(-)	(-)
-4.914	(-)	(-)	(-)	(2) 100.00
-9.828	(11) 00.00	(-)	(-)	(28) 50.00
-14.742	(15) 00.00	(-)	(40) 25.00	(37) 45.94

() No. of non germinated seeds sown in each treatment

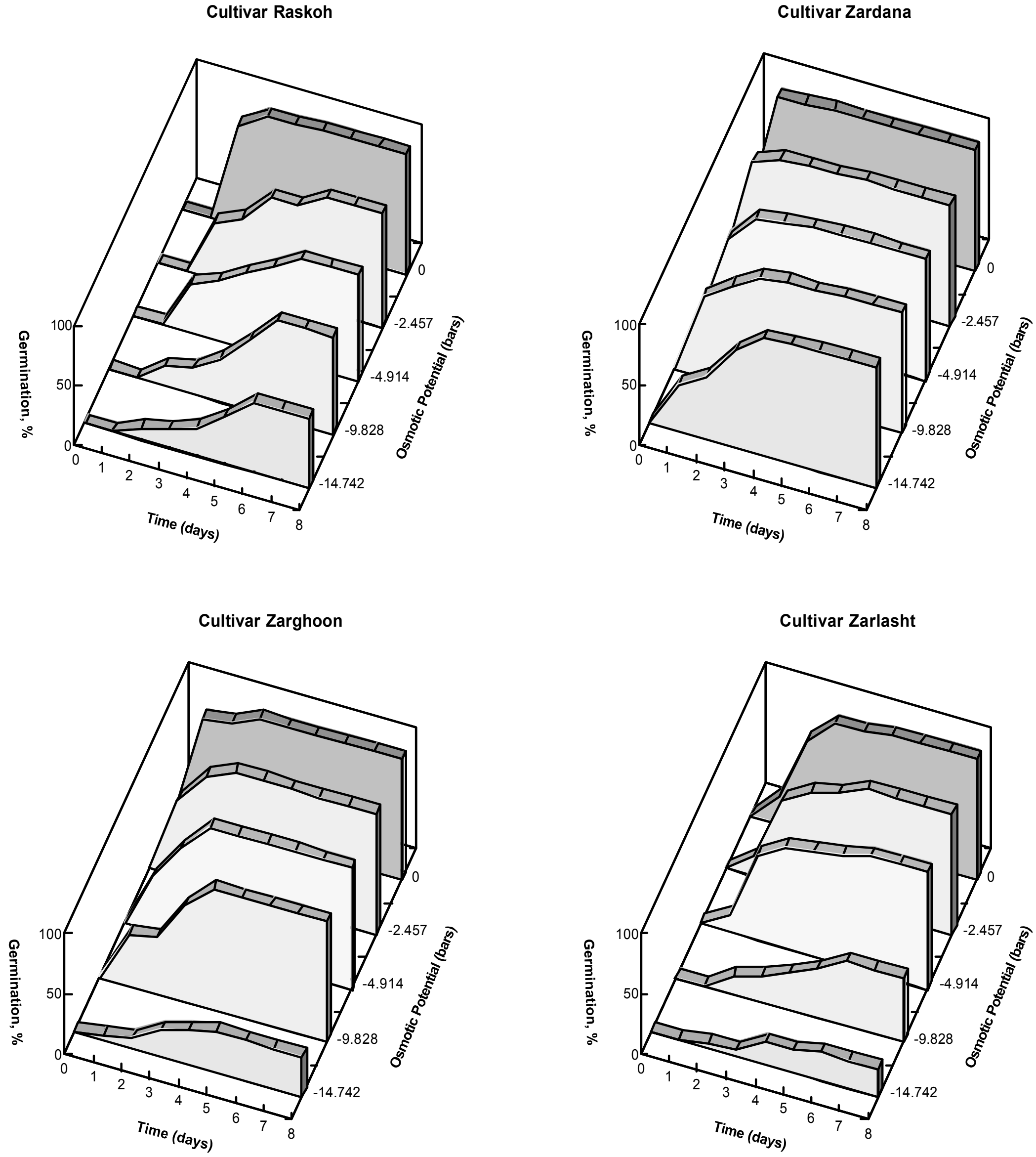

Fig. 2: Effects of NaCl salinity on germination of wheat (*Triticum aestivum* L.) cultivars

Table 2: Effects of salinity on salt tolerance index of wheat (*Triticum aestivum* L.) cultivars at germination and seedling growth stage

Treatments Osmotic Potential (Bars)	Cultivars							
	Raskoh		Zardana		Zarghoon		Zarlasht	
	Germination	Growth	Germination	Growth	Germination	Growth	Germination	Growth
-2.457	100.00	83.16	100.00	76.15	100.00	83.25	100.00	83.07
-4.914	98.33	65.23	100.00	63.42	100.00	66.19	96.66	72.62
-9.828	81.66	30.22	100.00	41.21	100.00	52.27	53.33	53.42
-14.742	58.33	11.56	100.00	10.34	33.33	15.18	23.33	32.18

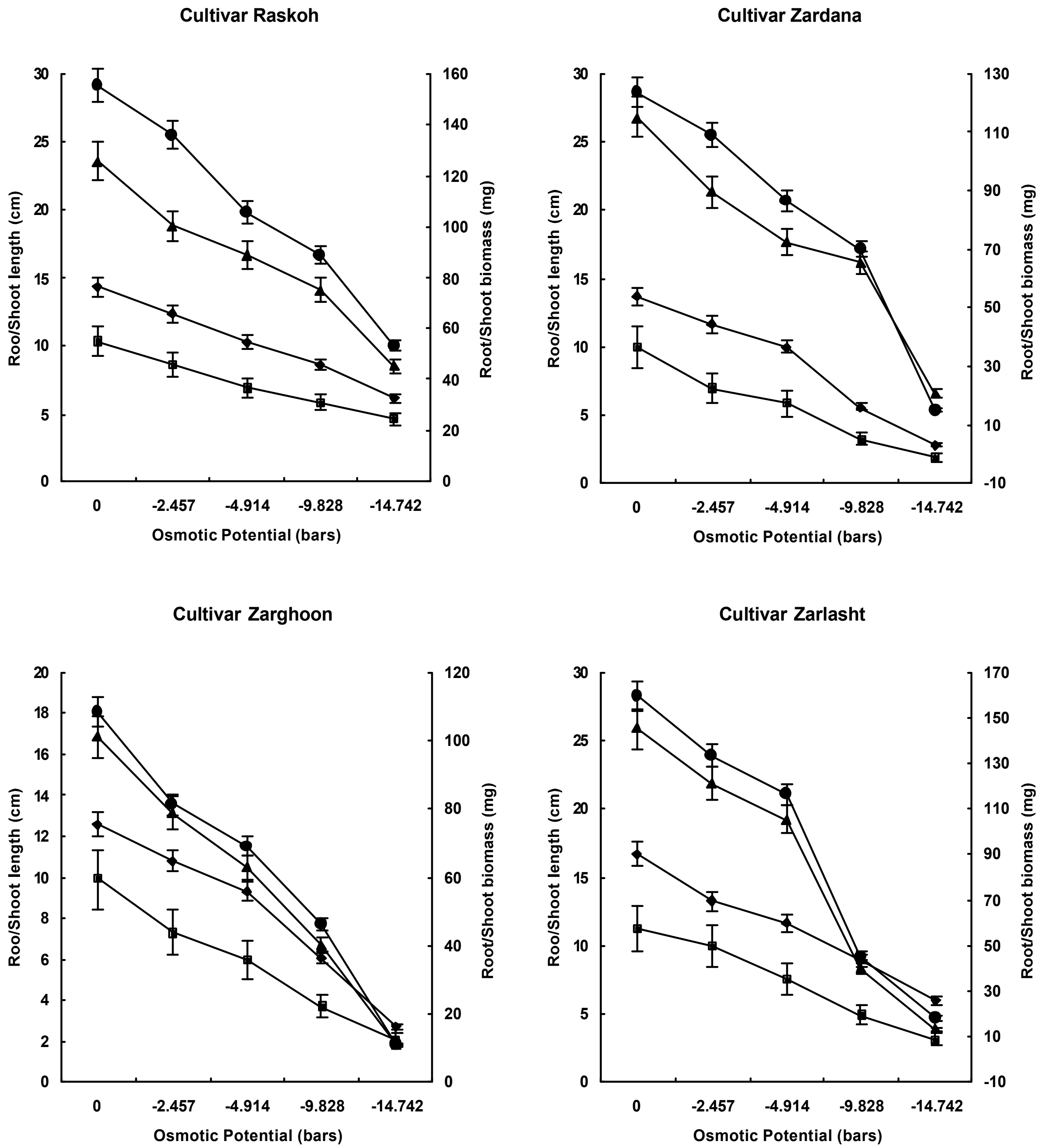

Fig. 3: Effects of NaCl salinity on seedling growth of wheat (*Triticum aestivum* L.) cultivars

three cultivars i.e., raskoh, zardana and zarghoon showed no recovery.

Seedling growth: Seedling growth was recorded in terms of Shoot/Root length and Shoot/Root biomass at different levels of NaCl salinity (Fig. 3). The increase in NaCl concentrations decreased the shoot and root length and biomass of all the wheat cultivars. All cultivars responded in same manner to salinity stress. However, the intensity of stress varied with the cultivars. It had been observed that those cultivars responded poorly at germination stage showed better response at seedling stage (Fig. 2 and 3). The reduction in shoot growth was greater than root growth. The reduction in biomass production was also greater in cultivar having higher germination rates. Maximum decrease in root and shoot length at osmotic potential -14.742 bars was recorded in cultivar Zardana which is

80 and 81%, respectively. Salinity had reduced the biomass (weight) in the range of 69 to 90 % in root and 68 to 90% in shoot of different cultivars.

Salt tolerance: Data regarding salt tolerance of different cultivars under investigation (Table 2) show that cultivar zardana is most tolerant at germination stage while cultivar zarlasht at seedling growth stage. On the basis of tolerance at germination and seedling growth stage, the cultivars can be arranged as follows:

Germination: Zardana>Raskoh>Zarghoon>Zarlasht

Seedling growth: Zarlasht>Zarghoon>Raskoh>Zardana

DISCUSSION

Salinity affects germination in two ways:

- There may be enough salt in the medium decrease the osmotic potential to such a point which retard or prevent the uptake of water necessary for mobilization of nutrient required for germination (Fig. 1).
- The salt constituents or ions may be toxic to the embryo.

Our results are in line with the findings of Kollar [12] and Rahman [3] that germination was directly related to the amount of water absorbed and delay in germination to the salt concentration of the medium. Decrease and delay in germination in saline medium has also been reported by Rahman [3] and Mirza [13].

After application of seeds which did not germinated (Table 1) probably their embryo was damaged due to the presence of Na^+/Cl^- ions. Physiologically absolute ratio of K^+/Na^+ in the tissue is important. It has been suggested that ion ratios are important in determining relative toxicities of various ions and can provide insight in to ion antagonisms [14]. The increase in salinity shortens this ratio [15] and probably caused injury to embryo. Greater recovery at lower osmotic potentials has been reported by Kayani and Rahman [16]. They suggested that this might be due to low concentration of ions. The salt tolerance of plants varies with the type of salt and osmotic potential of the medium [16].

Water availability is one of the main environmental factor limiting photosynthesis and growth [17]. Salinity affects the seedling growth of plants [18,19] by slow or less mobilization of reserve foods [20], suspending the cell division, enlargement [21] and injuring hypocotyls [22]. Our results contradict with Khan and Sheikh [23] that salinity depressed root growth more than shoot growth (Fig. 3). Other researchers [24, 25], have demonstrated that plants exhibit different sensitivities to salinity at different stages of growth.

Among the varieties tested zarlasht cultivar appeared to be more sensitive at germination stage then others. Although Zarlasht cultivar had comparatively low germination at higher salinity levels but performed quiet satisfactorily at seedling stage (Fig. 1 and 2). Ayers and Hayward [26] reported that there may not be a positive correlation between salt tolerance at germination stage and during later phases of growth as observed in the present studies (Table 2). Many plants are most sensitive to ion stress during germination [27] or young seedling growth [28, 29]. Mahmood and Malik [30] observed greater salt tolerance at growth than germination stage. It is clear from the results that behavior of cultivars varies both at germination and seedling growth stages. This shows that species /varieties can never be selected simply on the basis of higher germination %. According to Mass and Grieve [31] the ability of seed to geminate and emerge in saline soil not only depends upon the concentration of salts, but also upon various other biological factors i.e. viability of seed, seed age, dormancy, seed coat permeability, internal inhibitors and genetic makeup. While, George and William [32] have the opinion that greater tolerance to salinity during germination is associated with lower respiration rates and greater reserve of respiratory substances.

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