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Impact of Salt Stress on selected cultivars of Wheat (*Triticum aestivum* L.) Under laboratory condition

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The excess salts in the soil cause the inhibition of plant growth and development. The different cultivars (Atta-Habib, Ghanimat and Siran) of wheat (*Triticum aestivum* L.) are exposed to different level of salinity stress that is 0, 25, 50, 75,100,125,150 mM NaCl to find out the effect of salt stress on selected morphological parameters (Plumule length, Radicle length, germination percentage and days to germination) of wheat. The different concentration (0, 25, 50, 75,100,125,150 mM NaCl) of salinity on three cultivars of wheat viz., Atta-Habib, Ghanimat and Siran was utilized to study the effect of salt stress on wheat genotypes. It was observed that minimum difference recorded in days to germination in all the three cultivars. The Siran cultivar take less time for germination at all treatment except T5. Mean % germination were recorded highest (100%) at T0, T1 and T4 in Siran and Atta-Habib cultivars. Similarly, T2 in Ghanimat and T3 in Siran and Atta-Habib cultivars shows less (85%) germination percentage. Highest radicle length were recorded (8.7cm) at T0 in Siran cultivar followed by Ghanimat cultivar (7.8) at T0 and Atta-Habib (7.1). Lowest average radicle length were recorded for all the three cultivars of wheat at T1=25Mm (5.8cm). The average plumule length were observed in all treatments except T6=150mM NaCl which show zero plumule growth in all the three cultivars of wheat.

Keywords: Stress, wheat, germination percentage, plumule and radicle growth, laboratory condition

INTRODUCTION

Wheat crop is referred to as the "king of cereals." Because it is a major cereal crop in many region of the world. It is a member of the Poaceae family, and after maize the wheat is the cereal crop that is produced in the world's second-highest volume, while the rice rank as third (Rubio-Casal et al. 2003).From a botanical perspective, wheat is a large family of closely related grasses. The members of *Triticum* genus are characterized by more than two dozen individual species are identified till, of these, only four (*T. turgidum* L., *T. monococcum* L.,*T. aestivum* L., and *T. timopheevii* Zhuk.) are mostly cultivated. The common wheat species in respect of their cultivation are *T. turgidum* L. var. *durum* and *T. aestivum* L. are widely grown wheat species (Morris and Rose 1996). Carbohydrates, proteins, vitamins, fats, minerals and other nutrition are the main constituent of the wheat for human consumption. Almost 20% of all nutritional requirements worldwide are contributed by wheat (*Triticum aestivum* L.) and salinity has affected its cultivation in many region of the world, accounting for up to 60% of yield loss, which causes food shortage in those nations (Flowers annd Yeo 1995). In respect of food production, the sustainability and reliability are very crucial for sustainable crop production. Energy and water availability are crucial for the production of wheat, and they will continue to be so as to support reliable food production and agricultural sustainability (Rehman et al. 2015).

Salinity is an inhibitory abiotic stress factor. It is a major issue that reduce the plant productivity and food safety and a serious problem that cause restriction of the plant growth (Cherif-Silini, et al. 2019), hampers agricultural economy, and leads to serious land degradation in many countries (Slama, et al. 2019). With the impact of salinity on soil about one-third of the world's arable land resource are affected (Qadir et al. 2000). Salinity reduces plant growth, development and productivity because it makes water use more efficient and alters the metabolism of plants (Sahin et al. 2020).

Depending of plant species and concentration of salt stress, the salinity effects germination percentage, germination rate and seedling growth in different ways. (Gul et. al. 1999). High salt concentrations in irrigation water or soil have detrimental effects on plant metabolism, destroy cellular homeostasis, and have different deleterious effect on physiological and biochemical processes (AL-Saady, 2015). Low precipitation, high evaporation level, poor drainage and poor irrigation water containing significant amounts of salts accumulating in the soil surface layer are responsible for increased salinization in the fertile layer of the soil (Akladious and Mohamed 2018). The genetic potential yield of the plant is reducing by soil salinity which ultimately effect over almost 20% of the cultivated lands and almost half of the irrigated lands (Jones, 2007). Approximately 16% of the world's irrigated land is affected by salinity (Dadshani et al. 2019). Salinity decreases the osmotic potential of the soil solution, prevents the roots from absorbing water, and ultimately leads to water deficits (Fernández-Torquemada and Sánchez-Lizaso, 2013). In an arid and semi-arid region, the salinity stress is an intense threat to agricultural productivity (Al-Saady, 2015). Low precipitation and a high rate of evapo-transpiration rate are typically intercepted in these areas. Due to insufficient water for leaching, the soil in the root zones have abundance of salts (Akbari *et al.* 2013). The germination and seedling growth can be affected by salinity either by toxic effects of sodium and chloride ions on seed germination or by creating an osmotic pressure that prevents water uptake (Akbarimoghaddam et al. 2011). In the initial stage of the plant development the salinity exerts an osmotic potential which effect the plant growth at physiological and cellular level and thus the whole plants are suffered by the impact of salinity (Collado et al. 2016). The plant physico-biochemical process is altered by soil salinity and thus salinity is considered as one of the biggest problem that negatively influence the plant growth and plant development (Allakhverdiev et al. 2000). Nearly 20% of the world cultivated land are suppressed by soil salinity by the studies of different workers (Oproi and Madosa, 2014). The salt stress creates higher osmotic pressure in the water of soil as a result the plants uptake limit water through the root zone due to the high soluble salts in water. As a result, the turgor pressure influenced by the limited water in plant cells which lead to change the membrane stability (Sairam et al. 2002) and the plant cell absorbed higher concentration of ions which complete with the uptake of essential nutrients and ultimately cause the nutrient deficiency in the cell sap of the plant (Goudarzi and Pakniyat, 2008). The first symptoms of the salinity which appear on the plant is the reduction in the expansion of leaf surface and thus stop the growth of plant due to lower the content of chlorophyll in a thin and a less expanded leaf. As the salt stress decrease the growth of the plant again restarted. Carbohydrates and other substrates are prepared by the process of photosynthesis which will required for the growth of a cell, and the process of photosynthetic rate is usually slow for plants in contact with salts, especially when the stress is NaCl (Zhu, 2002).To get high yield productivity from the crops, the recommendation of salt tolerant varieties is the feasible option besides costly reclamation of saline soil (Kokten et al. 2010).

MATERIALS AND METHODS

Field experiment was conducted in laboratory condition at the Department of Botany, Islamia College Peshawar (34° 1' 33.3012" N and 71° 33' 36.4860" E.) with semi-arid climate District Peshawar has very hot summers and mild winters (Khan *et al.* 2018) during wheat growing seasons of 2020. Seeds of the three cultivars (Atta-Habib, Ghanimat and Siran) of the wheat (*Triticum aestivum*) were provided by Institute of Biotechnology and Genetic Engineering (IBGE), The University of Agriculture Peshawar, Pakistan. The crop is a high productive with a height range from60–130(–150) in cm. Leaf blade is flat, usually glabrous. Spike is a dense or lax, usually narrowed distally, square or subsquarein cross section, Spikelet having 4–9 florets (distal florets sterile). Lemma lanceolate or oblong, glabrous to pubescent, awnless to long awned; awn usually divergent. Palea sub equaling lemma. The color of Anthers is yellow or purplish. The caryopsis is free from lemma and palea (Cope, 1982; Stewart, 1967a; Stewart, 1967b). The seeds (five seeds) each were sown in petri dishes (Total= 63). In consideration to provide a proper air movement, the Petri dishes are 5 cm apart from each other with an area of 3 × 1.5 m^2 and planned a complete randomized block design (CRBD). The seeds were subjected with surface sterilization with 70% ethanol, 0.1% mercuric chloride (Shumaila & Ullah, 2020) to free the seeds from any contaminants. The intact seeds are free from wrinkle having identical size. The experiment included three cultivars, with seven treatments (T0=0mM, T1=25mM, T2=50mM, T3=75mM, T4=100mM, T5=125mM, T6=150mM NaCl) including control treatment (T0) as given in table 1. To maintain proper moisture, the watering was regularly checkup. The temperature fluctuation is 27-28˚C and each of treatments having three replicates. The 0mM is considered as distilled water for control. The growth and germination parameters (Days of germination, germination percentage, radicles length, and plumule) were measured in the upper part of the seedlings. The measurement of the parameters was taken in centimeters after the emergence of radicle and plumule of the wheat cultivars.

Statistical Analysis

The Data of different parameters were analyzed statistically by ANOVA and t-test to find out the significant and non-significant difference. The α were taken as 0.05. When the p-value is greater than 0.05 the difference is non-significant and when the p-values are smaller than or equal to 0.05 the difference is significant.

Table 1: Experimental design for *Triticum aestivum* L. under induced salt stress

Treatments	Description
T0	Control
T1	25mM NaCl
T2	50mM NaCl
T3	75mM NaCl
T4	100Mm NaCl
T5	125mM NaCl
T6	150mM NaCl

RESULTS

Impacts of salt stress on 'days to germination' of wheat

There was minimum difference recorded in days to germination in all the three cultivars. The minimum germination duration is one days while the maximum germination time is 2 days in all the three cultivars. The Siran cultivar takes less time for germination at all treatment except T5. Table 2 shows the detail description of days to germination and germination percentage.

Impacts of salt stress on '% germination' of wheat

Results given in Table 2, fig 2 described the % germination of 3 different cultivars of wheat in different concentration of salt stress. Mean % germination were recorded highest (100%) at T0, T1 and T4 in Siran and Atta-Habib cultivars. Similarly, T2 in Ghanimat and T3 in Siran and Atta-Habib cultivars shows less (85%) germination percentage. T6=150mM NaCl showed zero % germination in all cultivars. % germination decrease from 100 to 85% in all the treatments and wheat cultivars.

Figure 1: Impact of Salt stress on Days to germination

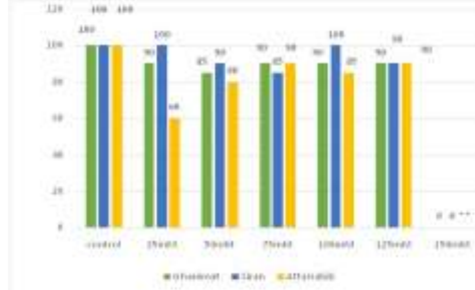

Figure 2: Impact of Salt stress on % Germination

Impacts of salt stress on radicle length of wheat

Results in table 3, fig 3 described the average radicle length of three cultivars of wheat in different treatment of salt stress. Average radicle length varies from 0 to 7.8 in Ghanimat cultivars, 0 to 8.7 in Siran cultivars and 0 to 7.1 in Atta-Habib cultivar. Our results revealed that highest radicle length were recorded (8.7cm) at T0 in Siran cultivar followed by Ghanimat cultivar (7.8) at T0 and Atta-Habib (7.1). Lowest average radicle length were recorded for all the three cultivars (Ghanimat, Siran and Atta-Habib) of wheat at T1=25Mm (5.8cm) in Ghanimat cultivar, (4.7cm) in Siran and (4.2) in Atta-Habib cultivar. Other lowest average values were recorded at T4=100Mm NaCl for Ghanimat cultivar (6.9), at T5=125mM NaCl for Siran cultivar (6.5) and at treatment T2=50mM NaCl for Atta-Habib cultivar (5.0). T6=150mM NaCl showed zero radicle growth in all three cultivars.

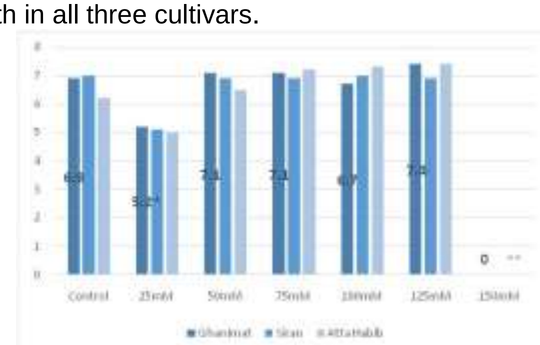

Figure 3: Impact of Salt Stress on Plumule Length

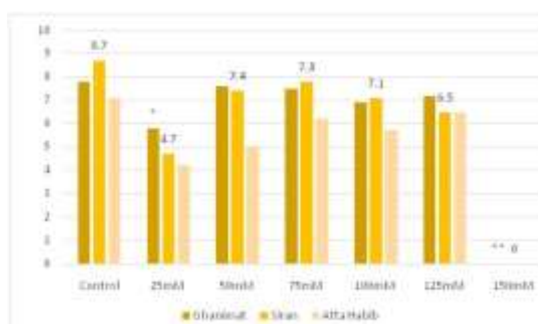

Figure 4: Impact of Salt Stress on Radicle Length

Table 2: Germination % and Days of Germination under the effect of salt stress

Treatments	Wheat cultivars					
	Ghanimat		Siran		Atta-Habib	
	Germination percent	Days of Germination	Germination percent	Days of Germination	Germination percent	Days of Germination
T0=Control	100	1	100	1	100	1
T1=25mM NaCl	90	2	100	1	100	2
T2=50mM NaCl	85	1	90	1	90	2
T3=75mM NaCl	90	2	85	1	85	2
T4=100Mm NaCl	90	2	100	1	100	1
T5=125mM NaCl	90	2	90	2	90	2
T6=150mM NaCl	0**	0**	0**	0**	0**	0**
P-values	0.520698	0.0001	0.87101	1	0.820879	0.770185
t-test values	0.1835	0.78	0.42265	0.59	0.42265	0.42265

Alpha value is taken as (0.05). (ANOVA followed by t-test)
Keys: **-Significant (P≤0.05), Non-Significant (P>0.05),

Table 3: An Average Length of Radicle and Plumule under salt stress

Treatments	Wheat varieties					
	Ghanimat		Siran		Atta-Habib	
	Length of Radicle (cm)	Length of Plumule (cm)	Length of Radicle (cm)	Length of Plumule (cm)	Length of Radicle (cm)	Length of Plumule (cm)
T0=Control	7.8	6.9	8.7	7.0	7.1	6.2
T1=25mM NaCl	5.8*	5.2	4.7	5.1*	4.2	5.0
T2=50mM NaCl	7.6	7.1	7.4	6.9	5.0	6.5
T3=75mM NaCl	7.5	7.1	7.8	6.9	6.2	7.2
T4=100Mm NaCl	6.9	6.7	7.1	7.0	5.7	7.3
T5=125mM NaCl	7.2	7.4	6.5	6.9	6.5	7.4
T6=150mM NaCl	0**	0**	0**	0**	0**	0**
P-values	0.722879	0.520698	0.785874	0.761278	0.527384	0.940376
t-test values	0.315079	0.777942	0.115584	0.70723	0.203024	0.161201

Alpha value is taken as (0.05). (ANOVA followed by t-test)
Keys: **-Significant (P≤0.05), Non-Significant (P>0.05)

Impacts of salt stress on plumule length of wheat

Impacts of salt stress on plumule length of three cultivars of wheat (Table 3, Fig 4) revealed that the average plumule length were observed in all treatments except T6=150mM NaCl which show zero plumule growth in all the three cultivars of wheat. Maximum plumule growth were detected in T5=125mM (7.4) in Atta-Habib and Ghanimat cultivar followed by T4=100mM NaCl (7.3cm) and T3=75Mm (7.2cm) in Atta-Habib cultivar while minimum plumule length were observed for T1=25mM NaCl (5.0cm) in Atta-Habib cultivar. Similarly, in Siran cultivar highest plumule length were described by T0 and T4 (7.0) followed by T2, T3, and T5 (6.9cm) and lowest plumule length were found in T1 (5.1cm). Cultivar (Atta-Habib) had varying plumule length which ranges from 5.0 cm to 7.4cm in all treatments.

DISCUSSION

The outcome of the present study showed that the salinity has negative impact on the morphological and physiological parameters of the plant. The germination rate, germination percent, radicle and plumule length were decreases when the level of salinity increased which was reported by Singh and Gopal, (2019). The present study showed that the Ghanimat and Siran cultivar show more tolerance toward salinity than the Atta-Habit cultivar which were more susceptible. There was no negative impact obtained regarding germination, germination percent, radicle and plumule length in T0 (control). It was revealed from the result that the 125mM or above the salinity levels significantly affect the morphological parameters of wheat cultivars. The plant absorb high amount of salt inhibit their physiological and metabolic process even impacting their survival (Kumar et al. 2021). Many of the abiotic factor including salinity, temperature, drought, pesticides, soil pH, fertilizer application and heavy metal contamination also reduce the crop productivity (Ahmad, 2014). Days to germination of the wheat cultivars were recorded maximum at 125mM of saline concentration. The increasing level of salinity decrease the radicle and plumule length. The result revealed that the minimum days toward germination and maximum germination percent were investigated in the case of 25 to 75mM treatments. Almost all cultivars which are highly significant under the high level of salinity that is 150mM which was also studied by Datta et al. (2009) earlier. The different level of salinity that are (0, 25, 50, 75, 100, 125,150 mM NaCl) applied on five varieties of Wheat viz., HD-2689, HOW-234, RAJ-4123 RAJ-4101, and HD-2045 were also reported by Datta et al. (2009) which support our results. Seeds of 20 wheat genotypes germination in Petri dishes were tested at different salinity levels for 30 days were investigated by Alom et al. 2016. Under the salt stress the morphological traits (shoot and root length and yield attributes) of the plants were decreased which revealed non-significant effect compared with unstressed plants as stated by Ghonaim et al. 2021. Rao et al. 2013 also studied ten varieties of wheat (*Triticum aestivum* L.) under the tolerance of salt which acknowledged our work. It is also confirmed that total germination percentage (TGP) of 200 wheat genotypes were significantly reduced by the increasing levels of saline solution by Mamo et al. 2020. It can be concluded from the results of this present investigation that the seeds of five different wheat cultivars in germination stage were more susceptible toward higher concentrations of salt solutions which was concluded by the works of Datta et al. 2009; Gul and Weber, 1999. The plant growth processes are especially more sensitive to the effects of salt, so that growth rates and biomass production indicate the sensitivity of the plants toward the degree of salt stress to which a plant with stand it as documented by Amor et al. 2005. Germination percentage and growth decreased with increasing NaCl concentration as described by Ahmad et al. 1992. In the irrigation water the salinity level increasing with increase salt concentration. The osmotic potential of the root-zone soil solution is created due to increases level of salinity will lead reduction in crop production. Salt stress causing change in certain physiological activity and substantial reduction in crop production (Kalhoro et al. 2016). Soil salinity adversely affect the seedling at early growth stage as important determinants of the high yield. Therefore, the vigorous early growth and high germination rate under salty soils is preferred. The higher growth of the seedling under soil salinity suggests that they may have higher performance in salty soils (Moud and Maghsoudi, 2008).

CONCLUSION

The present study shows the impact of salinity on days to germination, germination percent, radicle and piumule length of wheat (*Triticum aestivum* L.) under the subjected of various level of salinity viz., 0, 25, 50, 75, 100, 125, 150 mM on three cultivars of wheat viz., Ghanimat, Atta-Habib and Siran was investigated. It was observed that minimum difference recorded in days to germination in all the three cultivars. The Siran cultivar take less time for germination at all treatment except T5. Mean % germination were recorded highest (100%) at T0, T1 and T4 in Siran and Atta-Habib cultivars. Similarly, T2 in Ghanimat and T3 in Siran and Atta-Habib cultivars shows less (85%) germination percentage. Highest radicle length were recorded (8.7cm) at T0 in Siran cultivar followed by Ghanimat cultivar (7.8) at T0 and Atta-Habib (7.1). Lowest average radicle length were recorded for all the three cultivars of wheat at T1=25Mm (5.8cm). The average plumule length were observed in all treatments except T6=150mM NaCl which show zero plumule growth in all the three cultivars of wheat. It was concluded that among all the cultivars under analysis, Siran cultivar appeared to be more sensitive under salinity level.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

KH and WMK designed and performed the experiments and also wrote the manuscript. MNK, FM and BA performed growth performance activities and data analysis. UUS, MI and MNK reviewed the manuscript. SW, RC and SK reviewed the gallery proof version. All authors read and approved the final version.

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