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Germination of Two Spring Wheat (Triticum aestivum L.) Cultivers Under Salt Stress Condition in Pot Trial

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Abstract— The response of two cultivars of wheat (Triticum aestivum L.) to NaCl salinity at germination and early seedling growth was investigated. Salinity treatments S1 =8.00 dSm-1, S2 =12.00 dSm-1, S3 =16.00 dSm-1were achieved by adding NaCl in deionized water. There was a decrease in the germination %age, fresh and dry weight of radical and plumule. Whereas fresh weight of endosperm increased and oven dry weight decreased with increase in salinity levels. Among the cultivars under investigation, response of both the varieties to external salt regimes was almost same.

Index Terms— Cultivars, Germination, salt, spring, stress, pot, Wheat

1. INTRODUCTION

Soil Salinity is a worldwide problem of arid and semi-arid regions, where rainfall is insufficient to leach salts and excess sodium ions out of the rhizosphere. Nearly 10% of the total land surface is covered with different types of salt affected soils. It is an enormous problem adversely affecting growth and development of crop plants and results into low agricultural production [1], [2]. Nearly 20% of the world's cultivated area and nearly half of the world's irrigated lands are affected by salinity [3]. In Pakistan, salt affected lands are estimated to be about 6.67 Mha [4].

Salinity is important problem affecting irrigated agriculture of Pakistan. It can lead to lower agriculture production, lower profitability due to costs of mitigation, reduced yield and changed land use. High concentration of salts has detrimental effects on germination of seeds [5], [6] and plant growth [7].

Many investigators have reported retardation of germination and growth of seedlings at high salinity [8]. However plant species differ in their sensitivity or tolerance to salts [9]. Salinity plays an important role in existence, behavior and distribution of plants. Plants that grow under saline conditions show certain intrinsic and extrinsic changes due to which they adapt to salinity. Salinity affects many morphological, physiological and biochemical processes, including seed germination, plant growth, and water and nutrient uptake [10]. Ascending salt concentrations not only prevent the germination of the seeds but also extend the germination time by delaying the starting of germination [11]. Generally, low salt concentration decreases the germination rate and high salt concentration decreases germinaton percentage [12].

Wheat (Triticum aestivum L.) is the staple foods for more than 35% of world population [13]. Seed germination and seedling growth of wheat, like other crops, were negatively affected by drought [14] and salinity stresses [15]. In many plant type, germination and seedling growing phase is very sensitive to salt stress. In general, the highest germination percentage occurs in non-salty conditions and it decreases depending on the ascending salt concentrations. [16]. Seeds' germination begins with water intake but it is decreased by the salt [17].

Wheat was more salt tolerant during vegetative phases but less tolerant with respect to grain production [18]. Wheat is extensively cultivated all over the World. Pakistan's population primarily hinges upon good harvest of wheat crop .The total wheat production in Pakistan during 2010-11 was 24213.5 thousand tonnes from a cultivated area of 8895.0 thousand hectares with the yield of 2722.15 kg per hectares in Pakistan [19].

One of the major environmental stress factors which adversely affect on uniform germination is salinity in arid and semi-arid regions [20].Many researchers have reported that several plants are sensitive to high salinity during germination and the seedling stage [21]. The source of the sensitivity to salinity is not fully understood. Some researchers have indicated that the main reason for germination failure was the inhibition of seed water uptake due to a high salt concentration [22], whereas others have suggested that germi-

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nation was affected by salt toxicity [22], [23].

Salinity is caused not only by NaCl but also by Na_2CO_3 and Na_2SO_4.The ionic composition of soluble salts in soil is predominantly due to cations and anions. The predominantly cations being Na^+,Ca^{2+} and Mg^{2+} while anions include Cl^-,SO_4^{2-} , HCO_3^{2-} [24] . The decrease in water intake of the seed in salty conditions, osmotically and by the ion toxity with accumulation of Na and Cl ions highly around the seed, prevents the seed germination [25], [26]. Ascending salt concentrations not only prevent the germination of the seeds but also extend the germination time by delaying the starting of germination [11]. Generally, low salt concentration decreases the germination rate and high salt concentration decreases germinaton percentage [12].

The present study is therefore, conceived with to investigate the effects of salinity on the germination and seedling growth of wheat seeds under different saline conditions.

2. MATERIAL & METHOD

The research work in this manuscript was undertaken to evaluate the effect of different levels of salinity on the germination of two wheat (Triticum aestivum L.) cultivars named Kohistan-97 and PAR-94.The research work was carried out in the research laboratory of Botany Department, University of Agriculture, Faisalabad.

2.1 Salinity levels:

There were 3 levels of salinity.

S1 =8.00 dSm^{-1}

S2 =12.00 dSm^{-1}

S3 =16.00 dSm^{-1}

Sodium chloride (NaCl) was the source of salinity. The salt used in this experiment was 99.1% pure (National Food Ind.).

24 Petri dishes of 12 cm diameter and 2 cm depth (12 for each variety) were used for germination studies. These petri dishes were washed and sterilized in autoclave before the filter paper was placed at the bottom of each petridish.25 seeds of each wheat variety were placed on filter paper at a uniform distance. Seeds were covered with other filter paper in each petridish.10 ml NaCl solution of different salinity level i.e. 8-12 and 16 dSm^{-1} were added in each Petri dish. Petri dishes were arranged in completely randomized design (CRD).

Seed germination was recorded daily up to seven days to calculate their germination percentage. In addition following data were recorded from the seedlings.

i. Germination %age
ii. Fresh weight of plumule, radical and endosperm (embryoless caryopsis) (g).
iii. Dry weight of plumule, radical and endosperm (embryoless caryopsis) (g).

2.2 Germination (%) =

$$\frac{\text{Seedling emerged by 7 DAP}}{\text{Total number of seeds planted}} \times 100$$

Where DAP = Days after planting

2.3 Fresh weight of plumule ,radical and endosperm (embryoless caryopsis) (g):

Fresh weight of plumule, radical and endosperm (embryoless caryopsis) were obtained in electrical balance in grams to compare the treatments and their mean values were calculated.

2.4 Dry weight of plumule,radical and endosperm (embryoless caryopsis)(g):

Plumule and radical were separated from the endosperm (embryoless caryopsis) and were wrapped in blotting papers separately and were placed in oven at 60 oC for 48 hours. After drying, their weights were noted on electrical balance in grams and mean calculated.

2.5 Statistical Procedure

The data collected was subjected to analysis of variance technique and Duncan's Multiple Range (DMR) test was applied at 1 % and at 5 % probability to compare the treatment means.

3. RESULT

Germination is a complex phenomenon involving many physiological and biochemical changes and leading to the activation of embryo [27]. The germination and seedling stages of the plant life cycle are more sensitive to salinity than the adult stage [29]. Wheat can usually germinate in saline media but at a delayed rate [30]. A lab experiment was conducted to evaluate the response of wheat to different salinity levels at the germination stage.

3.1 Germination percentage:-

Varying salt regimes of the growth medium had a significant effect ($P<0.01$) on germination percentage of both wheat varieties (Table1).Varieties also differed significantly

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(P<0.05).Variety x Salinity interaction was non-significant showing that the response of both varieties to increasing external salt concentration was uniform.

3.2 FRESH WEIGHT OF PLUMULE (G):-

Fresh weight of plumule of both the varieties decreased significantly (P<0.01) with the increase in salinity level as compared to the control treatment but the varieties did not differ significantly (Table 1).The response of both the varieties to external salt regimes was almost same.

3.3 FRESH WEIGHT OF RADICAL (G):

The mean squares from the analysis of variance of data for fresh weight of radical (Table 1) showed that different salinity levels had a significant effect (P<0.01) on these variables. Varieties did not differ significantly and their response to the saline medium was non-significant.

3.4 FRESH WEIGHT OF ENDOSPERM (G):

Addition of salt salt to the growth medium had a significant effect (P<0.05) on fresh weight of endosperm (embryoless caryopsis) (Table 1).Varieties differed significantly (P<0.05) in fresh weight of endosperm but the interaction term was non-significant which indicated the similar performance of both varieties at each salinity level.

3.5 DRY WEIGHT OF PLUMULE (G) :

From the analysis of analysis of Variance of data (Table 2).It is evident that different salinity levels had a significant effect (P<0.01) on plumule dry weight as compared to control. But variety x salinity interaction was non-significant. However, varieties differed non-significantly in these variables.

3.6 DRY WEIGHT OF RADICAL (G):

was also non-significant indicating that response of both varieties was almost uniform towards increasing levels of salinity of Increasing salt concentration resulted in a significant (P<0.05) decrease in dry weight of radicle as compared to control but varieties did not differ significantly (Table 2).The variety x salinity interaction the growth medium.

3.7 DRY WEIGHT OF ENDOSPERM (G):

Dry weight of endosperm (embryoless caryopsis) of both the varieties decreased significantly (P<0.05) with the increase in salinity level as compared to the control treatment (Table 2) but the varieties did not differ significantly. The response of both the varieties to external salt regimes was almost same.

TABLE 1. ANALYSIS OF VARIANCE SUMMARIES (MEAN SQUARES) OF DATA FOR GERMINATION PERCENTAGE AND FRESH WEIGHT OF PLUMULE, RADICAL AND ENDOSPERM

S.O.V	D.F	GERMINATION %AGE	FRESH WEIGHT OF PLUMULE (g)	FRESH WEIGHT OF RADICLE (g)	FRESH WEIGHT OF ENDOSPERM
Salinity (S)	3	1771.00**	2.08**	1.67**	0.031*
Varieties (V)	1	24.00*	0.001N.S	0.024N.S	0.089*
V X S	3	1.00N.S	0.027N.S	0.060N.S	0.010N.S
Error	16	2.78	0.061	0.028	0.009
Total	23				

** = Highly Significant * = Significant
N.S = Non-significant

VARIETY X SALINITY INTERACTION (GERMINATION PERCENTAGE, FRESH WEIGHT OF PLUMULE, FRESH WEIGHT OF

RADICLE, PERCENT OF CONTROL)

Sr. No	S0	S1	S2	S3	Description
V1	94.00	81.00	68.00	53.00	Germination Percentage
	1.360	1.050	0.333	0.117	Fresh weight of plumule
	1.173	0.845	0.120	0.066	Fresh weight of radicle
	9.13	11.80	13.80	15.35	Percent of control
V2	95.00	83.00	75.00	56.00	Germination Percentage
	1.460	0.860	0.413	0.070	Fresh weight of plumule
	1.237	0.483	0.157	0.073	Fresh weight of radicle
	5.94	19.72	24.88	27.47	Percent of control

TABLE 2. ANALYSIS OF VARIANCE SUMMARIES (MEAN SQUARES) OF DATA FOR DRY WEIGHT OF PLUMULE, RADICLE AND ENDOSPERM

S.O.V	D.F	DRY WEIGHT OF PLUMULE (g)	DRY WEIGHT OF RADICLE (g)	DRY WEIGHT OF ENDOSPERM
Salinity (S)	3	0.014**	0.017**	0.153**
Varieties (V)	1	0.001N.S	0.000N.S	0.031N.S
V X S	3	0.001N.S	0.002N.S	0.019N.S
Error	16	0.002	0.004	0.017
Total	23			

** = Highly Significant * = Significant N.S = Non-significant

VARIETY X SALINITY INTERACTION (DRY WEIGHT OF PLUMULE,RADICLE AND ENDOSPERM)

Sr. No.	S0	S1	S2	S3	Description
V1	0.165	0.147	0.078	0.045	Dry weight of plumule
	0.164	0.130	0.116	0.072	Dry weight of radicle
	68.05	63.62	49.42	39.66	Dry weight of endosperm(Percent of control)
V2	0.144	0.101	0.086	0.043	Dry weight of plumule
	0.193	0.163	0.078	0.041	Dry weight of radicle
	69.60	37.18	30.09	28.06	Dry weight of endosperm(Percent of control)

4. CONCLUSION

The germination and seedling stages of the plant life cycle are more sensitive to salinity than the adult stage [29].Wheat can usually germinate in saline media but at a delayed rate [30]. Delayed germination has also been reported by [31] on Lactica sativa cultivars and [32] on peper under the salt stress condition. Salinity affects the seedling growth of plants [33], [34] by slow or less mobilization of reserve foods [5].

Germination percentage, fresh and dry weight of plumule and radicle decreased with increase in salinity levels in both the lines of spring wheat. Whereas the fresh weight of endosperm increased and oven dry weight decreased with increase in salinity levels. These results are similar to the findings of some earlier studies in which a decrease in germination percentage, fresh and dry weight of plumule and radicle due to salt stress was observed [35] , [36].

The decrease in germination percentage could be due to the combined effect of solute uptake and toxicity of salt [35].The decrease in weight of plumule and radicle according to [37] could be due to high salt concentration which had lowered the water potential of the medium thus suppressing the absorption of water by germinating seeds.

The result obtained from this study indicate that salinity significantly decreases the germination %age, fresh and dry weight of radical and plumule. Whereas fresh weight of endosperm increased and oven dry weight decreased with increase in salinity levels.

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