Agrotechnology
ISSN: 2168-9881

Kumar et al., Agrotechnol 2017, 6:1
DOI: 10.4172/2168-9881.1000156

Research Article OMICS International

Effect of Saline Water Irrigation on Germination and Yield of Wheat (*Triticum aestivum* L.) Genotypes

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Received date: Feb 21, 2017; **Accepted date:** March 20, 2017; **Published date:** March 27, 2017

Abstract

The objective of the present study was to evaluate the relative tolerance of five wheat genotypes viz., K-8434, K-307, NW-1014, K-88 and HUW-468 in a pot experiment during Rabi 2008-09 and 2009-10 at five levels of irrigation water salinity viz. 3, 6, 9 and 12 dSm^{-1} with normal water in the department of crop physiology, C.S. Azad University of agriculture and technology, Kanpur. Grain yield of all varieties were significantly reduced along with increase in the irrigation water salinity, but the magnitude of reduction was found minimum of 40.57% in K-8434 and maximum of 67.52% in HUW-468 from normal to 12 dSm^{-1} salinity of irrigation water. Similarly, the reduction in germination percentage of sown seeds from control to 12 dsm^{-1} EC salinity was also recorded with minimum of 20% in K-8434 and maximum of 38% in variety HUW-468.

Keywords: Wheat; Genotypes; Salinity; Yield

Introduction

The term salinity commonly refers to solutions in which sodium ions are predominates. The most prominent anion is usually chloride. When the plants use the water, the salts are left behind in the soil and eventually begin to accumulate. Since soil salinity makes it more difficult for plants to absorb soil moisture, these salts must be leached out of the plant root zone by applying additional water. The brakish water can be broadly characterized as saline, sodic and saline sodic as per parameters such as Electrical Conductivity, Sodium Absorption Ratio and RSC [1]. This water is unfit for irrigation as its use leads to salinity, sodicity or toxicity problems. Such effects may adversely affect the crop production when brakish water is used for irrigation. In absence of canal water or good quality water, farmers use brakish water for irrigation of crops particularly in rabi season.

Salinity of growing media may harm the crop in different ways. It reduces uptake of water due to increased osmotic pressure of the soil water resulting from the increased concentration of salts. Salinity creates imbalance in uptake of essential mineral elements. Accumulation of salts especially sodium ions in root zone may be toxic. Excessive salts act as an environmental stress and decrease plant growth potential. Salinity decreases the rate of seed germination, growth and development of plant, photosynthesis per unit leaf area and the utilization of photosynthates in growth of plant.

Wheat is a major staple food crop for more than one third of the world population and is the main staple food of Asia. It is originated in South Western Asia. Salt stress causes huge losses of wheat productivity worldwide. Because salt stress is one of the most serious limiting factors for crop growth and production in the arid regions. About 23% of the world's cultivated lands are saline and 37% is sodic. Soils can be saline due to geo-historical processes or they can be man-made. The incoming water from the land brings salts that remain in soil because there is no outlet and the evaporation water does not contain salts. This is not only disturbs the plant water retention of the soil but also disturbs the cationic balance in root zone in most of the field crops.

In India, about 9.5 m ha area is affected by soil salinity. A major proportion of ground water in the states of Gujarat (30%), Madhya Pradesh (25%), Punjab (41%), Uttar Pradesh (63%), Haryana (67%) and Rajasthan (84%) is brakish and good quality of water is occasional for assured irrigation [1]. Various scientific reports suggested that such water is unfit for irrigation as it proposed to have badly salinity, sodicity or associated toxicity problems. When used for irrigation, brakish water would affects adversely to the crop production. In absence of canal water or good quality water, most of the farmers use brakish water for irrigating their crops particularly in Rabi season. Wheat crop is semi-tolerant crop to salinity thus it is found that might be grown with brakish water irrigation on the cost of some losses in yield. Different genotypes of wheat had varied limit to salt tolerance [2]. Therefore, it was considered necessary to test the newly evolved various wheat varieties against different saline irrigation water for evaluating the effects on crop productivity and its physiological parameters.

Material and Methods

All the experiments were conducted in green house of the department of crop physiology, C.S. Azad University of Agriculture and Technology, Kanpur during 2008-09 and 2009-10 in clay pots of 30 cm size with polythene lining. The soil used for the experimental study was clay loam textured alluvial having total N, P, K as 0.048, 0.080 and 0.573%, respectively. Recommended doses of 120 kg N, 60 kg P, and 60 kg K/ha through Urea, Di-ammonium phosphate and Muriate of Potash, respectively were applied. Half of the N and full of P and K were applied at sowing while remaining half N was top dressed in two equal parts each at tillering and heading stages of crop.

Irrigation water of 3, 6, 9 and 12 dSm^{-1} salinity was prepared in laboratory by adding NaCl and $CaCl_2$ (3:1) and tap water was used to maintain salinity levels. Five varieties of wheat viz. K-8434, K-307, NW-1014, K-88 and HUW-468 were sown each at five levels of irrigation water salinity viz. normal, 3, 6, 9 and 12 dSm^{-1} in Completely Randomized Design replicated five times. Irrigation was done at 7 days interval with one litre water per pot at a time. The effect of salinity was evaluated on germination and yield of wheat varieties.

Germination percent

Germination count was worked out after the complete emergence of seedlings above ground finally after complete germination at 15 DAS. It was presented in percent under different treatments.

Grain yield

Total number of grains from each sample plant was weighed and grain yield per plant was recorded.

Statistical analysis

Each experiment was carried out in three independent assays and was expressed as mean values ± Standard Deviation (SD). For statistical comparison, values were subjected to one way Analysis of Variance (ANOVA) with Bonferroni post-tests using GraphPad prism software version 4.01. Statistical significance was considered at $p<0.05$.

Results and Discussion

Germination

Germination percent of wheat seeds was significantly increased at irrigation water salinity of 3 dSm^{-1} over normal but there after germination, it was reduced significantly with each increasing level of salinity up to 12 dSm^{-1} EC during both years (Table 1).

On mean basis of years and varieties, reductions in germination from control to 6, 9 and 12 dSm^{-1} salinity levels were found 11.1, 19.3 and 30.6% unit, respectively. At increased salinity, moisture intake in seed may be reduced due to increased salt concentration of soil solution, which might have affected the germination adversely [3].

Variations in yield reduction of different varieties may be explained as tolerance capacity of variety to levels of irrigation water salinity which is a genetic character. These results are in accordance to other findings.

Salinity levels	0 dSm^{-1}		3 dSm^{-1}		6 dSm^{-1}		9 dSm^{-1}		12 dSm^{-1}	
Varieties	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
K-8434	88	88	90	90	80	82	74	76	66	70
K-307	90	90	92	92	78	80	72	72	58	60
NW-1014	90	92	92	94	80	82	72	76	60	62
K-88	87	88	88	90	76	76	66	66	53	54
HUW-468	87	89	88	90	70	74	60	62	49	51
SEM±	0.62	0.65	0.99**	0.89	0.72	0.65	0.80**	0.79	0.5	0.52
CD at 5%	0.79	0.86	1.06	1.1	0.98	0.87	1.02	1.06	0.88	0.68

Each value represented as mean ± SD. Statistical comparison was performed using One way analysis of variance (ANOVA) (GraphPad prism software version 4.01).
** p ≤ 0.01 with respect to baseline initial salinity level.

Table 1: Effect of saline water irrigation on germination percent of wheat varieties at 15 days after sowing.

Among varieties, K-8434 being at par with NW-1014 attained significantly higher germination than others. The data suggested that significant minimum germination was recorded in variety HUW-468. Such behaviour of varieties seems to be associated with the extent of adverse effect of increased salinity on varieties. The significant interaction effect of varieties and salinity showed that germination of variety K-8434 was least affected by increased salinity while that of HUW-468 was most affected.

On mean basis over years, reductions in germination from control to 12 dSm^{-1} salinity were computed to be significant ($p<0.001$) 20, 30, 31, 34 and 38% unit in varieties K-8434, NW-1014, K-307, K-88 and HUW-468, respectively. At higher salinity levels of 9 and 12 dSm^{-1}, variety K-8434 attained highest germination percent while lowest was recorded in HUW-468. These varietal variations might be due to gene effects which are responsible for tolerance capacity of varieties to salinity levels [4,5].

Grain yield

The grain yield was influenced adversely by increasing levels of irrigation water salinity beyond 3 dSm^{-1} and the extent of adversity varied in different varieties (Table 2). Although, grain yields of all the varieties were found to be declining with increased levels of irrigation water salinity above 3 dSm^{-1} during both years, the rate of reduction in grain yield of variety K-8434 was minimum and that of variety HUW-468 was maximum. On average basis of both year results, rates of yield reduction from normal to 12 dSm^{-1} salinity of irrigation water were found to be 40.57, 49.07, 55.91, 65.56 and 67.52% in varieties K-8434, NW-1014, K-307, K-88 and HUW-468, respectively. It may also be seen from Table 2 that grain yield of variety K-88 and K-307 reduced drastically beyond 6 dSm^{-1} salinity but that of HUW-468 showed drastic yield fall beyond 3 dSm^{-1} salinity. Such reductions in grain yield of different varieties due to increased salinity may be attributed to yield components viz., number of spikes, grains/spike and test weight of grains which also affected adversely by increasing salinity of irrigation water. Reduction in grain yield due to increasing irrigation water salinity might be because of higher Na and lower K content in ear husk [6]. Variations in yield reduction of different varieties may be explained as tolerance capacity of variety to levels of irrigation water salinity which is a genetic character. These results are in accordance to other findings [7,8].

Salinity levels	0 dSm^{-1}		3 dSm^{-1}		6 dSm^{-1}		9 dSm^{-1}		12 dSm^{-1}	
Varieties	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
K-8434	6.95	7.1	7.14	7.25	6.64	6.67	4.88	5	4.25	4.5
K-307	5.92	6	6.19	6.31	5.63	5.74	4.36	4.55	4.13	4.18
NW-1014	6.1	6.17	6.31	6.4	5.87	5.85	4.23	4.3	3.82	3.97
K-88	6.6	6.67	6.81	6.92	6.24	6.25	4.32	4.37	4	4
HUW-468	7.21	7.26	7.42	7.48	6.88	6.95	4.75	4.61	4.1	4
SEM±	0.5	0.5	0.8	0.63	0.62	0.72*	0.99***	0.83**	0.65	0.45
CD at 5%	1.49	1.47	2.39	1.86	1.84	2.13	2.95	2.47	2.15	2.06

Each value represented as mean ± SD. Statistical comparison was performed using One way analysis of variance (ANOVA) (GraphPad prism software version 4.01). ***$p \leq 0.001$, **$p \leq 0.01$, and *$p \leq 0.05$ with respect to baseline initial salinity level.

Table 2: Effect of saline water irrigation on grain yield (g/plant) of wheat varieties.

Conclusion

The results of present experiment may over all be concluded that variety K-8434 had sufficient salinity tolerance to grow with saline irrigation water up to 12 dSm^{-1} salinity level. Though variety NW-1014 had almost similar tolerance to irrigation water salinity but due to poor yield potential it is not suitable for cultivation, however it may be included in breeding programmes to evolve salinity tolerant genotypes of wheat.

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