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Research Article

IMPROVING ISABGOL (*PLANTAGO OVATA* FORSK) PERFORMANCE UNDER SALINITY BY SEED PRIMING

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ABSTRACT: An experiment was carried out in 2010 at the University of Tabriz, Iran, to evaluate the effect of seed salt-priming on isabgol (*Plantago ovata* Forsk) performance under saline and non-saline conditions. This experiment was arranged as factorial, based on RCB design with three replications. Treatments were salt-priming (Control, 0.8% NaCl and 0.8% KNO_3) and salinity levels (0, 4, 8, 12 $dS.m^{-1}$). Means of emergence rate, plant height, leaves, tillers, ears, grains per plant, biological and grain yields decreased with increasing salinity. Reductions in ears and grains per plant due to salinity were largely compensated by seed priming, especially by KNO_3 priming. The effects of salt-priming on increasing emergence rate and producing more tillers, ears and grains per plant led to considerable improvement in grain yield per plant. Seed priming with KNO_3 was more beneficial in improving grain yield per plant, compared with NaCl priming.
Keywords*:* Emergence rate, isabgol, salt-priming, salinity, yield components

INTRODUCTION

Isabgol (*Plantago ovata*) is a medicinal species of great importance cultivated in India, Pakistan and Iran. The seeds contain 20 to 30% mucilage, used by the pharmaceutical industry [23]. Abiotic environmental stresses especially salinity and drought may limit medicinal plant production including isabgol [15]. Salinity affects the growth, productivity and distribution of plants. Delayed germination, high rate of seedling morality, stunted growth and reduced yield are some of the most common effects of salted soils [20].

Rapid seed germination and stand establishment are critical factors to crop production under salt-stress [2]. Soil salinity may affect the germination of seeds either by creating an osmotic potential external to the seed preventing water uptake, or through the effects of Na^+ and Cl^- ions on the germinating seed [17]. Rahimi *et al* [24] reported that salinity can significantly reduce the seedling establishment of *Plantago ovata*. Ghassemi-Golezani *et al* [11] have demonstrated that salinity stress can cause to decrease the grain yield of *Plantago ovata*. Seed germination and seedling emergence under salt stress may be improved by seed priming [12].

Seed priming is a pre-sowing strategy for improving seedling establishment by modulating pre germination metabolic activity prior to emergence of the radicle and generally enhances germination rate and plant performance [9,14]. Effects of seed priming persist under sub-optimal field conditions, such as salinity [8,30]. The beneficial effects of priming have been reported for many field crops such as barley [1], wheat [22], sugar beet [26], soybean [17], pinto bean [10], rapeseed [13], lentil [9], chickpea [14], sunflower [28,27] and grain sorghum [19].

Previous studies showed that salt priming improves seed germination, seedling emergence and growth under saline conditions [29]. Salt priming can ensure satisfactory stand establishment in many crops such as rapeseed [13] lentil [9], cucumber [12] and sunflower [16]. Although, the response of isabgol to salt stress was previously evaluated, there is little information on the effects of salt priming on isabgol performance under salt stress. Therefore the main purpose of this research is to investigate the effects of salt priming on morphological traits and grain yield of isabgol under saline and non-saline conditions.

MATERIALS AND METHODS

An experiment was conducted to evaluate morphological traits, yield and yield components of isabgol under saline and non-saline conditions. Treatments were salt-priming (Control, 0.8% NaCl and 0.8% KNO_3) and salinity levels (0, 4, 8, 12 $dS.m^{-1}$). Seeds of isabgol (*Plantago ovata* Forsk) were divided into three sub-samples, one of which was kept as control (unprimed) and two other sub-samples were prepared for priming.
A sub-sample was soaked in 0.8% NaCl solution with electrical conductivity of 15.3 dSm^{-1} and another one was pretreated with 0.8% KNO_3 solution with electrical conductivity of 12.5dSm^{-1} at 15ºC for four hours. After priming, seeds were thoroughly washed with distilled water for a minute and then dried back to primary moisture at 20-23ºC in the laboratory.
The greenhouse experiment was conducted at the University of Tabriz in 2010. This experiment was arranged as factorial, based on RCB design with three replications. Ten seeds were sown 1 cm deep in each pot filled with 800 g perlite, using 36 plastic pots. Salinity treatments (0, 4, 8, 12 $dS.m^{-1}$) were applied immediately after sowing. Tap water and saline solutions were added to the pots in accordance with the treatments to achieve 100% FC.
After emergence, seedling emergence was counted daily with seeds recorded as emerged, when hypocotyls appeared on or above the surface of perlite and mean emergence rate was calculated according to Ellis and Roberts [7]. Then seedlings were thinned to keep four plants in each pot. During the growth period, the pots were weighed and the losses were made up with Hoagland solution (EC=2 dS/m). Perlites within the pots were washed every 20 days and non-saline and salinity treatments were reapplied in order to prevent further increase in electrical conductivity (EC), due to adding Hoagland solution.
At maturity, plants from each pot were harvested and plant height, tillers per plant, leaves per plant, ears per plant, grains per plant, 1000 grains weight and biological and grain yields were determined. Analysis of variance of the data was carried out using MSTATC software. Duncan test was applied to compare means of each trait at $p \leq 0.05$. EXCEL software was used to draw figures.

RESULTS AND DISCUSSION

Analyses of variance of the data showed that the emergence rate, tillers per plant, ears per plant, grains per plant and grain yield were significantly affected by both salinity and salt-priming. However, leaves per plant, plant height and biological yield were only affected by salinity. Neither salinity nor salt-priming had significant effect on 1000 grain weight. Interaction of salinity × salt-priming was also significant for ears and grains per plant (Table 1).

Table 1. Analyses of variance of the effects of salt-priming on morphological traits, yield and yield components of isabgol under salinity stress

Source of variation	Df	Emergence rate	Plant height	Leaves per plant	Tillers per plant	Ears per plant	Grains per plant	1000 Grain weight	Biological yield	Grain yield
Replication	2	0.001	4.63	2.20	0.093	0.31	2571.58	0.006	0.10	0.006
Salinity (A)	3	0.017**	25.06*	86.20**	1.236**	52.27**	496656.17**	0.021	2.99**	2.276**
Priming (B)	2	0.011*	3.92	30.50	0.402*	39.64**	242701.58**	0.005	0.72	0.536*
A*B	6	0.001	3.73	5.02	0.069	8.56*	77992.39*	0.001	0.11	0.064
Error	2	0.003	7.68	10.69	0.085	3.00	30959.97	0.028	0.34	0.148
%CV	-	9.68	9.84	9.05	12.10	11.36	10.66	10.76	8.63	18.48

* and ** : significant at 1% and 5% respectively.

Means of emergence rate, plant height and leaves per plant decreased with increasing salinity. Deductions in emergence rate and plant height up to 8 dS/m and leaves per plant up to 4 dS/m salinity were not statistically significant (Table 2). These traits were also positively and significantly correlated with each other (Table 4). This means that reductions in plant height and leaves per plant resulted from decreasing emergence rate, due to salinity. Emergence rate of isabgol was improved by salt-priming. The highest improvement was achieved by KNO_3 priming, which was not significantly different from NaCl priming (Table 3). However, this improvement was not sufficient to increase plant height and leaves per plant.

Table 2. Means of morphological traits, yield and yield components of Isabgol affected by salinity treatments

Salinity treatments	Emergence rate (per day)	Plant height (cm)	Leaves per plant	Tillers per plant	Ears per plant	Grains per plant	Biological yield (g)	Grain yield (g)
0	0.63 a	29.98 a	39.04 a	2.81 a	17.54 a	1870 a	7.43 a	2.58 a
4	0.61 a	28.97 a	38.11 ab	2.52 b	17.01 a	1821 a	7.21 a	2.39 a
8	0.59 a	27.67 ab	35.19 bc	2.36 b	13.94 b	1541 b	6.55 b	1.88 b
12	0.53 b	26.62 b	32.19 c	1.93 c	12.53 b	1374 b	6.19 b	1.47 c

Different letters in each column indicating significant difference at $p \leq 0.05$

Table 3. Means of morphological traits, yield and yield components of Isabgol affected by salt priming

Treatment	Emergence rate (per day)	Tillers per plant	Ears per plant	Grains per plant	Grain yield (g)
Control	0.56 b	2.20 b	13.27 b	1498 b	1.86 b
NaCl	0.59 ab	2.46 a	15.67 a	1778 a	2.11 ab
KNO_3	0.62 a	2.55 a	16.83 a	1778 a	2.28 a

Different letters in each column indicating significant difference at $p \leq 0.05$

Mean number of tillers per plant decreased as salinity increased, which is resulted in decreasing number of ears and grains per plant particularly under severe salinity (Table 2). Similar results have been reported by Bagheri and Sadeghipour [3] for barley. Bybordi [5] reported that plant height and yield components of canola were significantly reduced by salt stress. Ears and grains per plant were enhanced by salt-priming which were more evident under 8 and 12 dS/m salinity (Figures 1 and 2, respectively).

The highest tillers, ears and grains per plant were produced by the plants from primed seeds with KNO_3, which was not significantly different from those primed with NaCl (Table 3). It is obvious that increasing tillers per plant can enhance the number of ears and grains per plant. This also reflected in positive and significant correlations of these traits with each other (Table 4). The superiority of KNO_3 priming to NaCl priming is related to more nitrogen and potassium accumulation in seeds with KNO_3 [12]. Ghassemi-Golezani *et al* [13] reported that salt priming can increase pods per plant, grains per plant and grain yield per unit area in rapeseed cultivars. Similarly Khan *et al* [18] proved that salt priming can increase the pods per plant, 1000 grain weight and consequently grain yield in mung bean cultivars.

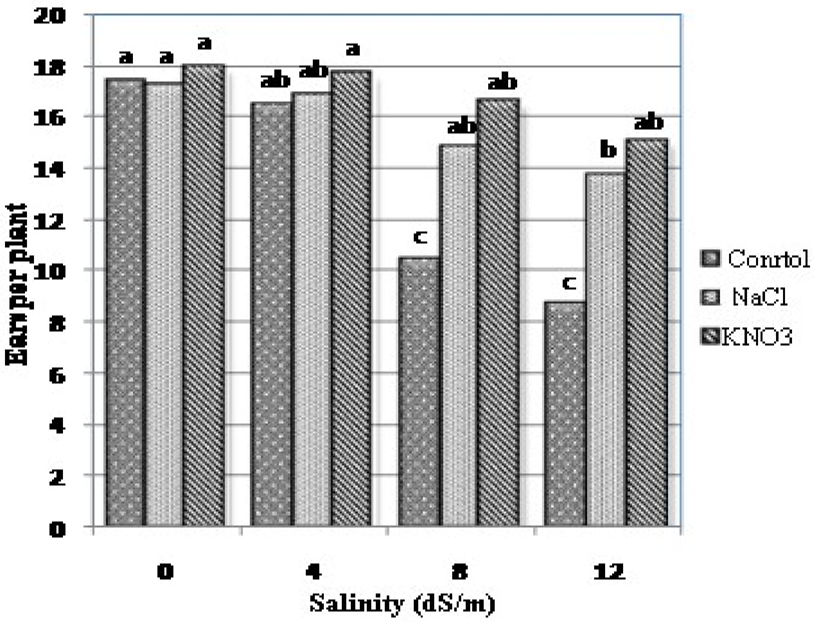

Figure 1. Means of interaction of salinity × salt priming for ears per plant in isabgol
Different letters in each column indicating significant difference at $p \leq 0.05$.

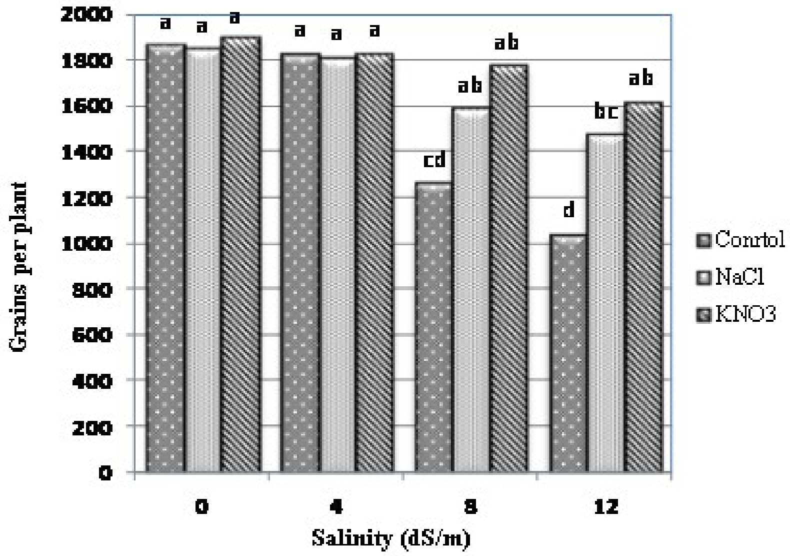

Figure 2. Means of interaction of salinity × salt priming for grains per plant in isabgol Different letters in each column indicating significant difference at p≤0.05.

Table 4. Correlation coefficients of different traits.

Traits	1	2	3	4	5	6	7	8	9
1- Emergence rate	1								
2- Plant height	0.871**	1							
3- Leaves per plant	0.960**	0.939**	1						
4- Tillers per plant	0.942**	0.919**	0.955**	1					
5- Ears per plant	0.908**	0.853**	0.952**	0.872**	1				
6- Grains per plant	0.939**	0.892**	0.979**	0.917**	0.989**	1			
7-1000 grain weight	0.808**	0.739**	0.813**	0.881**	0.711**	0.783**	1		
8- Biological yield	0.894**	0.896**	0.968**	0.911**	0.952**	0.975**	0.833**	1	
9- Grain yield per plant	0.931**	0.941**	0.985**	0.962**	0.924**	0.964**	0.853**	0.977**	1

**: Statistically significant at p≤0.01, respectively.

Biological and grain yield decreased with increasing salinity. This reduction in 12 dS/m salinity was more evident (Table 2). The hieghst grain yield was obtaind by plants primed with KNO_3 which was not significantly different with plants primed with NaCl (Table 3). The effects of salt-priming on increasing emergence rate and producing more tillers, ears and grains per plant led to considerable improvement in grain yield per plant (Table 3). Significant and positive correlations among these traits (Table 4) suggest that improving each of the former traits can enhance grain yield of isabgol. Leaves per plant and biological yield had the highest positive and significant correlations with grain yield per plant (Table 4).

Seed priming with KNO_3 was more beneficial in improving grain yield per plant, compared with NaCl priming. The superiority of KNO_3 priming over NaCl priming was also reported for watermelon [6,21,25], muskmelon [4], cucumber [12] and rapeseed [13].

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