THE EFFECT OF PRIMING ON SEED GERMINATION CHARACTERISTICS OF MAIZE UNDER SALT STRESS

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Received 3 May 2017; accepted 15 June 2017

ABSTRACT
Salinity of water resources and agricultural lands is one of the most important factors limiting production and a threat to the sustainable production of numerous crops in Iran. To examine the effect of priming on seed germination characteristics of maize under salt stress a factorial experiment was conducted in a completely randomized design with three replications. Treatments consisted of three levels of priming (gibberellin 0.2 mg lit^{-1}, Marmarin a seaweed extract at a concentration of 2.5% by volume and KNO_3 3%) and three levels of salinity (0, 75 and 150 mM) examined on single cross 704 maize hybrid. The results showed that priming effect was significant for all traits measured. The interaction between priming and salinity on radicle length and mean of germination time was significant. Germination percentage in 150 mM salinity and hormone priming only decreased about 12% compared to the control, while the reduction for priming with Marmarin and potassium nitrate was 31 and 82%, respectively. Thus, we can conclude that the priming with gibberellin can largely ameliorate the effects of salinity on the germination of corn seeds.

KEY WORDS: *salinity, corn, priming, germination*

INTRODUCTION

Environmental stresses, especially drought and salinity are the major causes led to the decline of agricultural products in the world than other factors (Shiri *et al.,* 2009). Salinity damage in plants occurs usually through disorders in water absorption, the effect of ion toxicity and absorption of nutrients (Anvari *et al.,* 2009).Germination is the most important phase of plant life and tolerance to salinity has great importance for germination, emergence and establishment of plants that grow in saline soils (Haghighi & Milani, 2009). Salinity changes the balance of nutrients, soil water availability and reduces the quality of cultivated lands, alters the structure of ecological communities, induces physiological drought through osmotic stress and thus reduces the rate of photosynthesis and growth (Moons *et al.,* 1995; Ianovici, 2011; Khatami *et al.,* 2016). During salinity stress in addition to reducing water absorption, there is an accumulation of some ions at high concentrations in plant tissue which causes to toxicity or ionic imbalance (Fiehn *et al.,* 2002). Because of the abundance and dominance of Na^+ and Cl^- in saline water and soil uptake of many of micro and macronutrients will be reduced. So, the high proportion of ions Cl^-/Na^+, Ca^{2+}/Mg^{2+} and Na^+/Ca^{2+}present in plant tissues (Grarttan & Grieve, 1999). Many studies on the germination of crop seeds reflect the fact that with increasing salinity radicle and plumule length and also seedling dry weight significantly reduces compared with non-saline conditions (Alebrahim *et al.,* 2004). Corn resistance to salinity increases during growing season, so that seeds and seedlings are less resistant to salinity, but the established plants have appropriate resistance (Emdad & Fardad, 2000).

Seed priming is controlled hydration method until before of radicle emergence and is effective method to improve the rapid and homogeneity emergence of seedlings. This process has a positive effect in reducing the time needed for germination and seedling emergence, final germination and emergence under unfavourable conditions, especially for seeds with low vigour. Seed priming improves seed performance and quality, so can reverse some of the destructive events that occur during aging (Black & Bewley, 2000). Numerous reports has introduced seed priming as a factor of increasing ribosomal RNA synthesis, produce more mitochondrial DNA (Bradford, 1986), increasing the activity of alpha and beta amylase (Powell, 1998), improving germination under salt stress, drought and cold and also improving seed capability for completing germination process under low temperature conditions. Priming can change the amount of proteins, but their type remains unchanged (McDonald, 1999). Soaking seeds with the best concentrations of plant hormones, increase germination and growth as well as increase the efficiency and performance. Gibberellins are a group of hormones that are most directly involved in control and to facilitate germination. Increasing the synthesis and secretion of gibberellic acid (GA_3) in the seed causes to breaking down starch into embryo usable materials and beginning of germination.

Marmarin (seaweed extract) is a bio-stimulant and has been used commonly in horticulture. Marine plant extracts enhance the performance and quality of agricultural products in horticulture and because of containing cytokinin, have major physiological effects on crops (Amanpoor Balaneji *et al.,* 2011).

Studies on cucumber (Esmaielpour et al., 2006) and sunflower (Kaya *et al.,* 2006) showed that seed priming with different osmotic agents such as nitrate salts and polyethylene glycol caused to increase in salt tolerance and reduced the ionic toxicity under salinity. Bhattacharjee & Mukherjee (2002) reported that accumulation of proline and soluble carbohydrates in rice seedlings under salinity reduced the negative effects of salinity on the integrity of cell membranes.

The purpose of this study was to determine the effects of salinity on seed germination and seedling growth of maize and evaluation of priming effect to overcome salty conditions.

MATERIALS AND METHODS

In order to investigate the effect of seed priming on corn under salinity, a factorial experiment conducted based on completely randomized design with three replications. Treatments were priming including gibberellin (0.2 mg lit^{-1}), Mamarin (seaweed extract at a concentration of 2.5% by volume) and potassium nitrate (3%) and salinity levels as0, 75 and 150 mM on corn single cross 704seeds.Seeds primed for 24 hours in priming solutions and then were transferred into 9 cm diameter Petri dishes to culture. Each Petri contained 50 seeds. Seeds counting began from the day after planting and daily germinated seeds were counted (seeds considered germinated when radicle length reached to 2 mm at least). Germination rate in this study was calculated using the following formula (Ellis & Roberts, 1980):

$$GR=\sum_{i=1}^{N}\frac{Si}{Di}$$

Which GR is germination rate (number of germinated seeds per day), Si = number of germinated seeds per day, Di = the number of days to count n, N = number of counts.

In seedling growth test after the full emergence of cotyledon leaves, ten normal seedlings from each treatment were selected and radicle and plumule length (with ruler), and fresh and dry weight of plumule and radicle (using a digital scale, the accuracy of 0.001 g) were measured. To obtain the dry weight, samples were transferred to the oven with a temperature of 80°C for 24 hours. Mean of germination time was considered as the reverse of germination rate. Data analysis was performed using SAS9.1 software.

RESULTS AND DISCUSSIONS

Analysis of variance for the effects of treatments on the measured traits of corn is given in Table 1.The interaction of salinity and priming only was significant on radicle length and mean of germination time. Effect of salinity was significant on radicle fresh weight, germination percentage, germination rate and seedling vigour and priming effect for all traits. Priming with gibberellin was better than other types of priming for most of the traits (Table 2).

Rate and percentage of germination. Analysis of variance showed that the percentage and germination rate were affected by salinity and priming (Table 1). Germination percentage and rate declined under salinity. The highest germination percentage (53%) observed in non-stressed condition and the lowest germination percentage (38%) achieved in 150 mM salinity. Also, 150 and 75 mM salinity was not significantly different (Table 2).The highest and lowest germination rate obtained with gibberellin and KNO_3, respectively. Seeds primed with gibberellin had the highest germination percentage (73.3%) and rate (3.1 seed day^{-1}), while Priming with KNO_3caused to reduction of these traits compared to control. A reduction in the rate and percentage of germination in corn seeds exposed to salt may be due to salt accumulation in the tissues of the seed which has irreparable effects on seed germination and disturbs water uptake by the seed. Dahal et al (1990) also reported that the stress caused by NaCl and PEG inhibits germination of tomato cultivars. It seems that the higher percentage and rate of germination in gibberellin treated seeds may be due to the key role of this hormone in seed germination especially in releasing carbohydrate and protein degradation enzymes. Gibberellin treatment improves germination under salt stress (Ashraf *et al.,* 2008).

TABLE 1. Analysis of variance for the effects of salt and priming on the studied traits in maize

SOV	Df	GP	GR	PL	RL	RFW	PFW	RDW	PDW	MGT	SV
Salt	2	582.9**	0.743**	0.03	17.18*	0.049*	0.023	0.0001	0.0003	0.141**	18.69*
Priming	2	11531**	14.7**	57.61**	46.52**	0.157**	1.55**	0.004**	0.027**	0.134**	283.3**
Salt ×Priming	4	193.1	0.246	0.21	4.49**	0.01	0.015	0.001	0.0001	0.364**	6.743
Error	18	78.92	0.1006	0.18	0.34	0.013	0.017	0.0006	0.0002	0.004	3.705
C.V.%		20.25	15.48	12.71	18.66	16.69	13.44	4.84	2.53	7.69	29.92

*, **: significant at p≤0.05 and p≤0.01, respectively; GP: germination percentage, GR: germination rate, PL: plumule length, RL: radicle length, RDW: radicle dry weights, PDW: plumule dry weights, RFW: radicle fresh weight, PFW: plumule fresh weight, MGT: mean of germination time, SV: Seedling Vigour.

Radicle and Plumule length. Radicle length was affected by salinity and priming (Table 1). The highest radicle length (7.12 cm) observed in Mamarin under non-stress conditions and the lowest (0.5 cm) was related to 150 mM NaCl and KNO_3 treatment (Figure

1). Plumule length was only affected by priming (Table 1). The highest plumule length (4.9 cm) obtained with gibberellin and the lowest (0.5 cm) with KNO_3 (Table 2).

TABLE 2. Comparison of means for the simple effects of priming and salinity on studied traits in maize

		GP (%)	**GR** (Seed day^{-1})	**PL** (cm)	**RFW** (gr)	**PFW** (gr)	**RDW** (gr)	**PDW** (gr)	**SV**
	Gibberellin	73.3A	3.1A	4.9A	0.787A	1.26A	0.555A	0.598A	11.7A
Priming	Marmarin	54.1B	2.41B	4.86A	0.738A	1.16A	0.528B	0.592A	7.04B
	KNO3	4.05C	0.627C	0.5B	0.537B	0.5B	0.513B	0.5B	0.538C
		GP (%)	**GR** (seed day^{-1})	**RFW** (gr)	**SV**				
Salinity	0	53A	2.37A	0.74A	8.09A				
(ds m^{-1})	75	40.5B	1.92B	0.71AB	5.63B				
	150	38B	1.84B	0.6B	5.56B				

In each column means with the same letter are not statistically different at $p \leq 0.05$.

Radicle and plumule growth are the most important factors in the establishment of seedlings in the field. Seeds which produce a strong radicle and plumule can be established rapidly and have more competition ability. Some of researchers have mentioned that prevention of nutrient remobilization to the embryo is the reason for reduction of seedlings growth (radicle and plumule) under saline conditions. In addition, by increasing the salinity in the solution surrounded seeds, water absorption disrupted by seeds, secretion of hormones and activity of enzymes become less and therefore seedling growth is affected (Basra *et al.,* 2005).

Under high salinity levels, decreasing water potential or increasing the concentration of harmful salts cause to reducing radicle growth. In such circumstances, the main part of energy consumes for active absorbing of nutrients and energy requirements associated with radicle growth reduces. Also, salinity has negative impacts on respiration and photosynthesis processes and causes to reduction of plumule length (Munns, 2002).

Fresh weight of radicle and plumule. Analysis of variance showed that the simple effects of salinity and priming were significant on radicle fresh weight. Only simple effect of priming was significant on plumule fresh weight (Table 1).Comparison of means in different levels of priming showed the highest radicle and plumule fresh weight (respectively, 0.787 and 1.26 g) was related to gibberellin treatment. The lowest radicle and plumule fresh weight (respectively, 0.537and 0.5 g) was obtained from KNO_3 treatment (Table 2).Comparison of the effect of salinity showed that the highest radicle weight (0.74 g) observed in non-stressed control which was not different with 75 mM salinity. Due to the length of radicle and plumule was the lowest in these treatments, it can be expected to have a lower weight. Priming beneficial effects on the germination may be related to increased activity of hatching enzymes like endo-β-mannanase that weaken the cell wall and improve the appearance of the radicle. Priming increases the activity of hydrolytic enzymes and because of the accessibility of seedlings to reservoirs during germination, primed seeds will be able to complete the germination process in a short time (Nonami *et al.,* 1995).

Radicle and plumule dry weight. Priming had the significant effect on radicle and plumule dry weight (Table 1). The highest seedling dry weight observed in gibberellin treatment and the lowest was related to KNO_3. There were not significant differences between

KNO_3andMarmarin for radicle dry weight and gibberellin with Marmarin for plumule dry weight (Table 2).

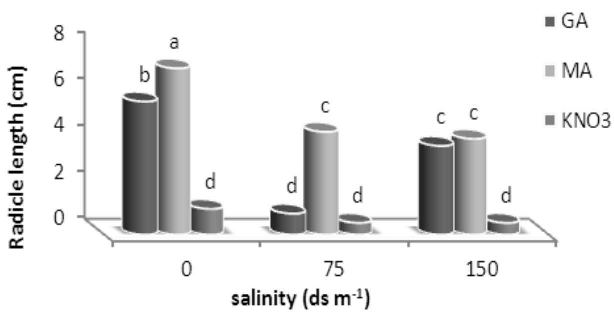

FIGURE 1. The interaction of salinity and priming on the radicle length of corn seedlings

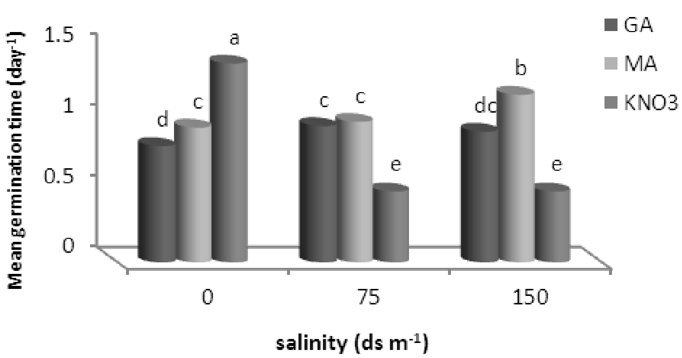

FIGURE 2. The interaction of salinity and priming on the mean of germination time of corn seeds

Mean of germination time (MGT). Analysis of variance showed a significant effect of the interaction of salinity treatments and priming on the MGT (Table 1).The highest MGT was related to KNO3 and control salinity (non-stressed) and the lowest MGT observed in the salinity of 75 and 150mM and KNO_3 treatment (Figure 2).Under salinity conditions, germination rate reduces and MGT increases (Kafi *et al,* 2010). Katemb et al (1998) reported that under salinity, increase in salt concentration leads to slowing of water absorption by seed and emergence percentage reduces as a result.

Seedling vigour (SV). Analysis of variance revealed a significant simple effect of salinity and priming on seedling vigour (Table 1). The highest SV (8.09) observed in non-stressed conditions and the lowest SV (5.56) obtained from 150 mM salinity. Also, 75 and 150 mM salinity had not significant difference. The maximum SV achieved in priming with gibberellin and the lowest was in KNO_3 (Table 2). If priming method could be able to improve germination under stress, we can increase the vigour of seeds, percentage and rate of emergence and finally plant yield (Esmaielpour *et al*, 2006).

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