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Priming impacts on seed quality of tomato (*Lycopersicon esculentum*) under salinity condition

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Abstract

This study aimed to investigate the seed priming effects on the quality of tomato seeds under salinity and non-salinity conditions. The factorial design was carried out in the form of completely randomized design (CRD) with four replications. The treatments included priming (Control, tryptophan, proline and arginine with five mM concentration) and levels of salinity (0, 30, 60mM NaCl). As salinity increased, means of germination percentage, germination rate, length of radicle, plumule and seedling, and seedling dry weight decreased. Seed priming with proline compensated radicle length reductions caused by salinity. Seed priming had an improving effect on seedling dry weight and increased germination percentage, germination rate and length of radicle. Proline-primed seeds improved seed quality better than tryptophan and arginine-primed seeds.

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Introduction

Seed priming is a simple method for improving seedling vigor and establishment and also crop performance in the field (McDonald, 2000). The useful effects of priming have been proved for several crops such as barley (Abdulrahmani *et al*., 2007), maize (Parera and Cantliffe, 1994), lentil (Ghassemi-Golezani *et al*., 2008), chickpea and pinto bean (Ghassemi-Golezani *et al*., 2010). These priming effects are linked with nucleic acid repairing and building up, increased protein synthesis, and the membrane repairing (McDonald, 2000). In addition, priming improves anti-oxidative enzymes activities of the seeds treated (Hsu *et al*., 2003). Seed germination rate and uniformity and seedling emergence may be increased with the early improvements (Ghassemi-Golezani *et al*, 2010), particularly in stress conditions, especially under stressful conditions (Ghassemi-Golezani *et al*., 2008).

Two critical factors to crop production under salt-stress are rapid seed germination and stand establishment (Ashraf and Foolad, 2005). Seed germination may be affected by soil salinity through osmotic potential external to the seed preventing water uptake, or Na^+ and Cl^- ions (Khajeh-Hosseini *et al*., 2003). As previous studies showed, seed germination, seedling mergence and growth can be improved with priming under saline conditions (Sivirtepe *et al*, 2003). The results of the studies on the effect of salt stress on growth indicated a relation between plant length decrease and sodium chloride concentration increase (Memon *et al*., 2010).

The over salinity of the soil is one of the main factors that limits the spread of plants in their natural habitats. It is an ever-increasing problem in arid and semi-arid regions (Shanon, 1986). Fisher and Turner (1978) estimate that arid and semi-arid lands represent around 40% of the earth's area. The property of salinity tolerance is not a simple attribute, but it is an outcome of various features that depend on different physiological interactions, which are difficult to determine. Jamil *et al*. (2005) showed that concentration increase resulted in the adverse effects of salinity on seed germination rate and percentage, and leaf number (Jamil *et al*., 2005; Gama *et al*., 2007; Ha *et al*., 2008). Several studies show that changes in salinity concentration, type of salt present, or type of plant species affect the fresh and dry weights of the seedling either negatively or positively, (Saffan, 2008; Rui *et al*., 2009; Taffouo *et al*., 2010; Memon *et al*., 2010). Satisfactory stand establishment and higher yields can be ensured with high and rapid (Ghassemi-Golezani *et al*., 2010).

The morphological appearance presented by the plant in response to salinity, may not be enough to determine its effect, so it is important to recognize other physiological and biochemical factors, including toxic ions, osmotic potential, lack of elements and other physiological and chemical disorders, as well as the interactions between these various stresses (Hasegewa *et al*., 2000). Although tomato response to salt stress has previously been evaluated, but there is not so much information on the effects of priming on tomato performance under salt stress. So, this study aims mainly at investigating the effects of priming on tomato germination under saline and non-saline conditions.

Materials and methods

An experimental study was designed to evaluate tomato seed quality parameters under saline and non-saline conditions. The proposed study was conducted in the Vegetable Seed Laboratory, Research Center of Agricultural and Natural Resources of Eastern Azarbaijan Province, Iran, to determine Priming impacts on seed quality of tomato (*Lycopersicon esculentum*) under salinity condition.

Priming Treatment

The treatments included priming (Control, tryptophan, proline and arginine with 5 mM concentration) and salinity levels (0, 30 and 60mM) . Tomato seeds (*Lycopersicon esculentum*) were grouped into four subsamples, and one of them was left as control (unprimed) and the other three sub-samples were prepared for priming Proline and arginine were Other sub-samples which were soaked in tryptophan, at 15C° for four hours Following priming, seeds were completely washed with distilled

water for one minute and then dried at 20-23 C° to its primary moisture in the laboratory.

Emergence Test

Laboratory tests were carried out as factorial, based on CRD design at the Seed Technology Laboratory of the University of Mashhad, Iran. Four replicates of 25 seeds of each sub-samples (Control, tryptophan, proline and arginine) were placed between moist filter papers and germinated in an incubator adjusted at 20°C for 10 days. Salinity levels were created by supplementing the Hoagland solution with NaCl; control (only Hoagland's solution), 0, 30 and 60mM NaCl.

Data Collection

Germination (protrusion of radicle by 2mm) was recorded in daily intervals. At the end, percentage of normal seedlings and seedling dry weight were determined. Mean germination rate was calculated based on the following equation of Ellis and Roberts, 1980:

$$\bar{R} = \frac{\sum n}{\sum D.n}$$

Where n is the number of seeds that germinated on day D, D is the number of days since the start of the test and $\bar{R}$ is the mean germination rate.

Statistical Analysis

MSTATC software was used to analyze the data variance. To compare the means of each trait, Duncan test was applied at p≤0. Excel software was used to draw Fig.s.

Results and discussion

The analysis of variance of the laboratory data showed significant effects of priming on germination percentage, germination rate, length of radicle and seedling dry weight. However, priming had no significant effect on length of plumule and length of seedling (Table 1). The highest germination percentage, germination rate, length of radicle and seedling dry weight were achieved by P_3. Seeds of P_2 and P_4 and P_1 germinated later than those of P_3 (Table 2). Germination percentage, germination rate, length of radicle, length of plumule and length of seedling and seedling dry weight significantly affected by salinity (Table 1). Germination percentage and length of radicle for $S_1$was significantly.

Higher than those for $S_2$and S_3. The highest germination rate, length of plumule, length of seedling and seedling dry weight were also recorded for S_1 followed by those for S_2 (Table 2).

Table 1. Analysis of variance of the effects of seed priming and salinity on seed quality parameters.

Source	d.f	MS					
		Germination percentage	Germination rate	Length of plumule	Length of radicle	Length of seedling	Seedling dry weight
Replication	3	29.688	0.0001	1.815	0.103	0.095	0.00001
Priming	3	78.299*	0.021**	1.326	0.248**	1.807	0.0001*
Salinity	2	228.646**	0.012**	15.319**	44.445**	42.173**	0.0002*
Priming × Salinity	6	43.924	0.0001	2.077	0.311**	4.610	0.00001
Error	33	28.551	0.001	1.470	0.028	4.172	0.00002
C.V (%)	-	6.14	8.00	22.04	4.39	26.26	14.99

*, **: significant at p≤0.05 and p≤0.01.

Table 2. Means of seed quality parameters affected by priming and salinity.

Treatments	Germination percentage (%)	Germination rate (per day)	Length of plumule (cm)	Length of radicle (cm)	Length of seedling (cm)	Seedling dry weight (mg)
Priming						
P_1	88.75b	0.250c	5.34a	3.601b	7.47a	0.0337c
P_2	93.33ab	0.300b	5.51a	3.802a	7.76a	0.0370b
P_3	94.58a	0.350a	5.77a	3.946a	7.87a	0.0396a
P_4	91.25ab	0.286b	5.54a	3.832a	7.56a	0.0351bc
Salinity						
S_1	96.25a	0.322a	6.234a	5.602a	9.234a	0.0394a
S_2	90.63b	0.300a	5.877a	3.470b	8.072a	0.0371a
S_3	89.06b	0.267b	4.389b	2.318c	6.028b	0.0325b

Different letters in each column for each treatment indicate significant difference at p≤0.05.

P_1, P_2, P_3 and P_4: unprimed seeds and priming for tryptophan, proline and arginine respectively.

The interaction of priming × salinity was significant for length of radicle (Table 1). Length of radicle of tomato seeds with different levels of primingdecreased with increasing salinity, although this reduction in primed seeds (P_2, P_3 and P_4) was lower than that in unprimed seed lot (Fig. 1). However, the highest improvement in length of radicle due to priming was also observed in P_3 seed lot (priming with proline) (Fig. 1).

Germination percentage, germination rate, length of radicle, plumule and seedling length showed positive significant correlations with the seedling dry weight.

Germination percentage and plumule length had the highest positive correlation with seedling dry weight. Germination percentage and plumule length with radicle and seedling length also showed significant and positive correlation (Table 3).

Table 3. Correlation coefficients between seed quality parameters of tomato.

Traits	1	2	3	4	5	6
1. Germination percentage (%)	1					
2. Germination rate (per day)	0.782**	1				
3. Length of plumule (cm)	0.788**	0.631*	1			
4. Length of radicle (cm)	0.831**	0.565	0.720**	1		
5. Length of seedling (cm)	0.854**	0.554	0.715**	0.934**	1	
6. Seedling dry weight (mg)	0.888**	0.784**	0.82**	0.643*	0.696*	1

*, **: Significant at p≤0.05 and p≤0.01, respectively

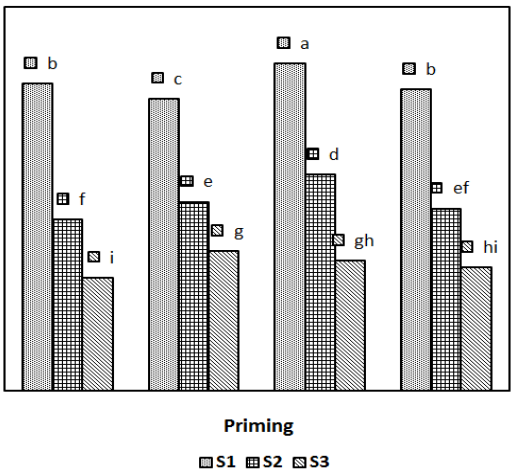

Fig. 1. Means of length of radicle affected by priming and salinity.

P_1, P_2, P_3 and P_4: unprimed seeds and priming for tryptophan, proline and arginine respectively.

S_1, S_2 and S_3: Control and salinity with 30 and 60 mM NaCl, respectively.

Seed priming improved germination percentage, germination rate, length of radicle and seedling dry weight (Table 2). It might be due to early synthesis of nucleic acids. Ultimately, DNA, RNA and proteins resulted in the improvement of seed germination energy (Bray *et al.,* 1989). Rapid seed germination can result in larger seedling production (Abdulrahmani *et al.*, 2007; Ghassemi-Golezani *et al.*, 2010a, b). Osmo-priming had also positive effects on barley seed germination and seedling growth (Abdulrahmani *et al.*, 2007), cucumber (Ghassemi-Golezani and Esmaeilpour, 2008), fennel (Neamatollahi *et al.*, 2009) and winter rapeseed (Ghassemi-Golezani *et al.*, 2010b).

Mean number of germination percentage, germination rate, length of radicle, length of plumule and length of seedling, which is resulted in decreasing seedling dry weight particularly under severe salinity (Table 2). Similar results have been reported by Bagheri and Sadeghipour (2009) for barley. Reduction in seedling dry weight due to salinity was also reported for maizeand sunflower (Katerji *et al.*, 1996) and wheat (Yildirimand Bilge, 2010).

Reduction in germination and seedling dry weightdue to salinity stress was also reported for cotton and wheat (Cullu, 2003), rice (Mahmood *et al.*, 2009). Salinity may delay the onset, reduce the rate, and increase the dispersion of germination events, leading to reductions in plant growth and final crop yield (Ashraf and Foolad, 2005). Significant and positive correlations among these traits (Table 3) indicate that improving each of the former traits can enhance tomato seedling dry weight. The highest positive and significant correlations were shown between germination percentage and plumule length and

seedling dry weight (Table 3) Proline-primed seeds improved grain yield per plant, better than arginine- and tryptophan-primed seeds. Thus, priming the seeds with amino acid can promote tomato seed germination rate and seedling dry weight, and can improve seed quality.

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