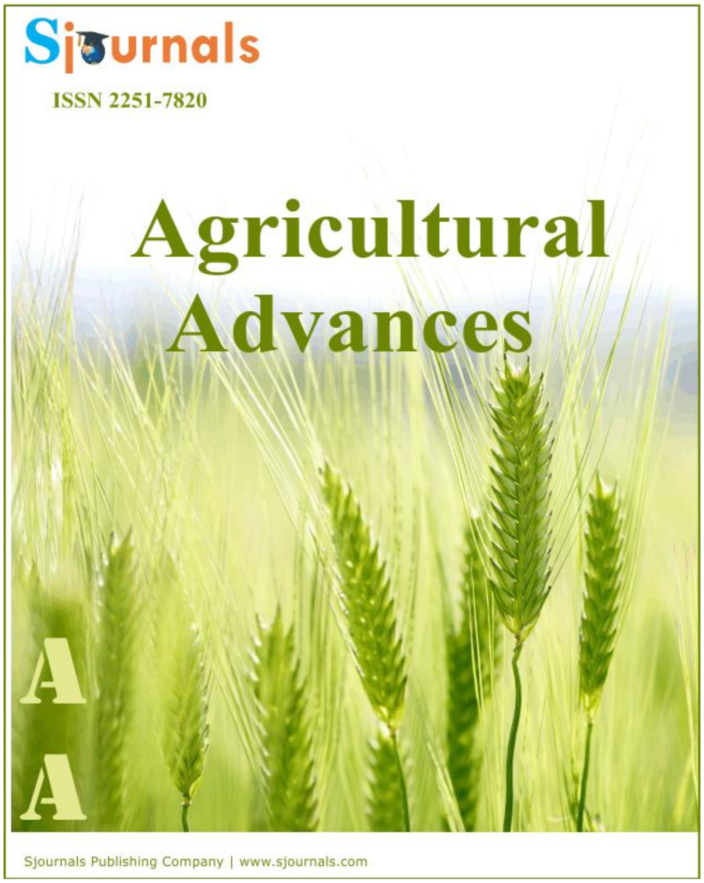
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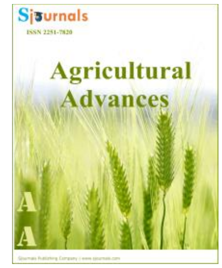

Original article

Evaluation of salt tolerance of tomato (*Lycopersicon esculentum*)

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The response of tomato genotype Chef against five salinity levels (distilled water or control, 25, 50, 75 and 100 mM) were studied at germination and early seedling stages. An experiment with conducted by using a completely randomized design (CRD) with three replications. Shoot and root length, shoot and root fresh weight, seed vigor, meangermination time, germination percentage and rate measured 14 days after germination. Results of data analysis showed that, there were significant differences between salinity stress levels for all investigated traits except mean germination time. Results of data analysis showed that, indicate that the maximum germination percentage during the test was related to the observer control (Distilled water) treatment and 25 mM. The maximum germination percentage at day 14, with an average of 84.34 and 58.8%, were related to the control (Distilled water) treatment and 25 mM treatments. The maximum root and shoot length, at day 14 of the test, was from the control (Distilled water) treatment, which show a significant statistical difference with the observer treatment.

1. Introduction

During their growth crop plants usually exposed to different environmental stresses which limits their growth and productivity. Among these, salinity is the most severe ones (Kaymakanova, 2009).

Salinity becomes a concern when an “excessive” amount or concentration of soluble salts occurs in the soil, either naturally or as a result of mismanaged irrigation water. The major inhibitory effect of salinity on plant growth and development has been attributed to osmotic inhibition of water availability as well as the toxic effect of salt ions responsible for salinization. Nutritional imbalance caused by such ions leads to reduction in photosynthetic efficiency and other physiological disorders (Hakim et al., 2010). In arid and semi arid regions, limited water and hot dry climates frequently cause salinity problem that limit or prevent crop production. It has also been reported that under saline conditions, germination ability of seeds differ from one crop to another and even a significant variation is observed amongst the different varieties of the same crop (Jamil et al., 2006).

Salt stress affects many physiological aspects of plant growth. Shoot growth was reduced by salinity due to inhibitory effect of salt on cell division and enlargement in growing point. Early flowering reduced dry matter, increased root: shoot ratio and leaf size caused by salinity may be considered as possible ways of decreasing yield in plant under salt stress condition (Khaje-hosseini et al., 2003). Seed germination is usually the most critical stage in seedling establishment, determining successful crop and seed quality.It is necessary to identify the sensitivity and tolerance level of a production [5]. Crop establishment depend on an interaction between seedbed environment variety at early seedling stages for successful crop production in a saline environment (Hakim et al., 2010).

The present study was therefore, conducted with the objectives to determine the response of tomato genotype to salinity stress at germination and seedling stages under controlled conditions. Moreover, NaCl was used for salinity stress induction in tomato.

2. Materials and methods

In order to study the effects of salinity stress on germination and early seedling growth in tomato genotype, an experiment was conducted using a completely randomized design [CRD] with three replications. In this experiment, genotype inclusive *Chef fallat* were evaluated in five levels of salinity treatment (distilled water as control, 25, 50, 75 and 100 mM) by using different NaCl concentrations. This experiment was carried out at horticulture Laboratory, Department of Agriculture, University of Jiroft Branch, Iran.

The seeds were sterilized by soaking in a 5% solution of hypochlorite sodium for 5 min. After the treatment, the seeds were washed several times with distilled water. 30 seeds were put in each Petridish [with 9 cm diameter] on filter paper moistened with respective treatment in 3 replications. The petridishes were covered to prevent the loss of moisture by evaporation. The petridishes were put into an incubator for 14 days at 25 centigrade degrees temperature and 65% relative humidity. Every 24 hours after soaking, germination percentage and other traits were recorded daily. After 14 days of incubation, shoot and root length, shoot and root fresh weight, seed vigor, meangermination time, germination percentage and rate was measured. Seeds were considered germinated when the emergent root reached 2 mm length. Rate of germination, germination percentage and mean germination time were calculated using the following formulas (Salehi Sardoei et al., 2013a):

Formula 1: $GP = SNG/SNO \times 100\%$

Where: GC is germination percentage, SNG is the number of germinated seeds, and SNO is the number of experimental seeds with viability (Salehi Sardoei et al., 2013a).

Formula 2: $GR=\Sigma N/\Sigma(n\times g)$

Where: GR: Germination race; n: number of germinated seed on g^{th} day and g: Number of total germinated

Formula 3: Seed Vigor = [seedling length (cm) × germination percentage]

Analysis of variance was performed using standard techniques and differences between the means were compared through Duncan’s multiple Significant Difference test [$P < 0.05$] using SAS release 9.1 (SAS, 2002) software package.

3. Results and discussion

Results of the mean data comparison, indicate that the maximum germination percentage during the test was related to the observer control [Distilled water] treatment, and 25 mM. The maximum germination percentage at day 14, with an average of 84.34 and 58.8%, were related to the pure water and 25 mM treatments [Table 1]. Maggio et al., (2007) found out in their studies that by increasing the salinity, the percentage and speed of the germination decreases (Maghsoudi Moudand Maghsoudi, 2008). The maximum germination rate was seen in both the observer [Distilled water] and 25 mM treatments, which also their germination speed decreased further into thetest [Table2].

Table 1
Mean comparison of different salinity levels of studied trait germination percentage (GP).

	Germination percentage (day)				
Salinity levels (mM)	**6**	**8**	**10**	**12**	**14**
0	54.34a	72.12a	79.92	84.34a	84.34a
25	0b	24.40b	48.81b	58.8b	58.8b
50	0b	1.09b	1.09c	2.19c	2.19c
75	0b	0b	0c	0c	0c
100	0b	0b	0c	0c	0c

Means followed by same letter are not significantly different at P< 0.05 probability using Duncan's test.

Table 2
Mean comparison of different salinity levels of studied trait germination rate (GR).

	Germination rate (day)				
Salinity levels (mM)	**6**	**8**	**10**	**12**	**14**
0	1.71a	2.70a	2.40a	2.11a	1.80a
25	0b	0.91b	1.46b	1.46b	1.25b
50	0b	0.04b	0.03c	0.46c	0.50c
75	0b	0b	0c	0c	0c
100	0b	0b	0c	0c	0c

Means followed by same letter are not significantly different at P< 0.05 probability using Duncan's test.

Table 3
Mean comparison of different salinity levels of studied trait root length (RL).

	Root length (cm)				
Salinity levels (mM)	**6**	**8**	**10**	**12**	**14**
0	0.32a	1a	1.34a	2.16a	2.76a
25	0b	0.46ab	0.61b	0.91b	0.96b
50	0b	0.03b	0.04c	0.06c	0.07c
75	0b	0b	0c	0c	0c
100	0b	0b	0c	0c	0c

Means followed by same letter are not significantly different at P< 0.05 probability using Duncan's test.

Table 4
Mean comparison of different salinity levels of studied trait shoot length and shoot (LS) and root fresh weight (FW).

Salinity levels	**Shoot length(cm)**			**Fresh weight(g)**	
(mM)	**10**	**12**	**14**	**Shoot**	**Root**
0	1.48a	1.76a	2.01a	0.08a	0.05a
25	0.40b	0.50b	0.90b	0b	0.05a
50	0b	0b	0b	0b	0b
75	0b	0b	0b	0b	0b
100	0b	0b	0b	0b	0b

Means followed by same letter are not significantly different at P< 0.05 probability using Duncan's test.

Table 5
Mean comparison of different salinity levels of studied trait mean germination time (MGT).

	Mean germination time				
Salinity levels(mM)	**6**	**8**	**10**	**12**	**14**
0	3.26a	5.77a	7.99a	10.13a	11.82a
25	0b	1.95b	4.88b	7.06b	8.24ab
50	0b	0.08b	0.11c	0.26c	3.42bc
75	0b	0b	0c	0c	0c
100	0b	0b	0c	0c	0c

Means followed by same letter are not significantly different at P< 0.05 probability using Duncan's test.

Table 6
Mean comparison of different salinity levels of studied trait seed vigor and germination percentage 50%.

	Seed vigor			
Salinity levels (mM)	**10**	**12**	**14**	**Germination percentage 50%**
0	224.18a	349.74a	378.95a	5.54a
25	42.02b	101.56b	100.42b	11.92a
50	0.44b	0.53b	0..53c	30a
75	0b	0b	0c	0a
100	0b	0b	0c	0a

Means followed by same letter are not significantly different at P< 0.05 probability using Duncan's test.

According to Ayaz et al., (2000), decrease of seed germination under salinity stress conditions is due to occur of some metabolically disorders. It seems that, decrease of germination percentage and germination rate is related to reduction in water absorption into the seeds at imbibitions and seed turgescence stages (Mortezai Nejadand Rezai, 2009).

Some studies referred that salinity stress can contribute to improve germination rate and seedling emergence in different plant species by increasing the expression of aquaporins (Janmohammadi et al., 2008), enhancement of ATPase activity, RNA and acid phosphathase synthesis (Abbasdokht et al., 2010), also by increase of amylases, proteases or lipases activity (Ashraf and Foolad, 2005). The maximum root length, at day 14 of the test, was from the treatment control [Distilled water], which did not show a significant statistical difference with the observer treatment, also the highest root length in other days of the test was still owned by the treatment control [Distilled water], which reached its height in comparison to other treatments, at day 14, 2.76 cm [Table 3]. In a test they inducted on 5 varieties of tomato (Salehi Sardoei et al., 2014), found out that by increasing the salinity, the shoot.

The results from Table [4] indicate that the maximum shoot length is achieved at days 10, 12 and 14 of the test, observer [Distilled water] treatment [Table 4]. Maximum wet weight of the root was from the control [Distilled water] treatment and 25 mM treatment and the maximum shoot fresh weight was from the observer control [Distilled water] treatment [Table 4]. Reported that the wet weight of the fresh and root in the cowpea reduces, by increasing the salinity density (Zahediand Alamzade Ansari, 2011).

Results indicated that by increasing the test time, the Mean Germination Time also increases, which its height could be seen at the observer control [Distilled water] treatment, and its least from the 25 mM treatment, which indicated a significant statistical difference with each other. The maximum Mean Germination Time was at 14 day, related to the observer control [Distilled water] treatment and 25 mM treatments, which non siginficant show a significant statistical difference with each other [Table 5]. It seems that, NaCl consentration [salinity Stress] effects on seed germination via limitation of water absorption by seeds (Dodd and Donovan, 1999), excessive use of nutrient pool (Bybordiand Tabatabaei, 2009) and creation of disorders in protein synthesis. With the test time passing, the seed vigor stamina. Its height was at 10, 12 and 14 day of the test, in the control [Distilled water] treatment. There was significant difference between the control [Distilled water] treatment and 25 mM treatments. The results of the data mean comparisons indicated that the observer control (Distilled water) treatment had the least germination percentage 50%, and its height was from the 50 mM treatment [Table 6].

NaCl causes osmotic stress and could be used as a salinity simulator (Fooladand Jones, 1991). In the present experiment NaCl was used to create the osmotic stress, as most of the researchers (Hu and Jones, 2004) utilized it for the development of water salinity environment in laboratory studies. The variation among genotype showed that germination percentage decreased with the increase in NaCl concentration in all the genotype Chef (Salehi Sardoei et al., 2013b).

Present study the findings are very similar to the former case, in which germination decreased due to the increase in NaCl concentration. Present study strongly supports that germination percentage and root to shoot ratio can be utilized to screen tomato genotype for salinity tolerance. There are many reports which are in agreement with the present findings indicating that salinity stress severely reducing the seed germination and early seedling growth. But the varieties having genetic potential to maintain the higher growth under stress conditions are saline tolerant.

In this study, we analyzed the effect of NaCl salt, on the tomato's germination and bud growth indicators. In this study, the percentage and speed of the germination was analyzed as an index for the tomato seed's germination, and the plumule and radicle's wet weight and length as a criterion for the tomato bud's growth. As it was mentioned in the result section, the tomato's growth criterions follow a decreasing trend in various slat densities, which match the results achieved by other researchers. Furthermore, other researchers also reported a negative impact from the salinity on the germination of various plants, such as canola, soy, beans, cowpea, pea and tomato. Many saline inhibitors have be also reported (Dudeck et al., 1993; Dudeck et al., 1984; Egan et al., 1997; Egan and Ungar, 1998). Foolad and Jones (1991) also reported that the tomato varieties power for fast germination in the saline conditions, independent from the growth potency, is more in the growing stage, also a disaffiliation has been reported in other studies, between the saline resistance in one stage of growth. In this study, we analyzed the effect of NaCl salt, on the tomato seed's germination, stamina, and capability to achieve a 50% germination rate.

In this research, the tomato seed's average germination and stamina are analyzed as a criterion for the tomato seed's germination. As mentioned in the results section, in various salt densities, the tomato seed's germination and stamina faced a decreasing trend, which matches the reports from other researchers. Furthermore, other researchers also reported a negative impact from the salinity on the germination of various plants, such as canola, soy, beans, cowpea, pea and tomato. The saline-resistant types could benefit from the dilution mechanisms and its accumulation in the vacuoles, and therefore partially protect themselves from their ill-effects (Atmtan and Sanders, 1999).

4. Conclusion

In the entire measured traits, we achieved better results from the observer control (Distilled water) treatment and 25 mM treatments, in comparison to the 50 mM density, which indicates that the Chef tomato variety could grow properly in low-saline conditions, but this growth faces an extremely significant decrease with the increased salt densities.

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