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Research Article

THE EFFECT OF SALINITY STRESS ON GERMINATION PARAMETERS IN SUNFLOWER CULTIVARS

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ABSTRACT
Soil sanity in many arid and semiarid areas of the world including Iran is the most important environmental stress restricting agricultural production. This research aimed to investigate the effect of different sanity levels (0, 4, 8, 12 dS/m) on cultivation of three sunflower cultivars (Record, Sambora Azar Gol) in Shoosh. Therefore, the seed properties such as germination percentage, germination rate, and the average time required for germination under salinity stress were determined. The results showed that the rate and percentage of germination were significantly different at different levels of salinity ($P < 0.05$) so that as the salinity level increased, the percentage ($R^2 = 0.94$) and rate of germination ($R^2 = 0.96$) linearly decreased significantly. According to the obtained results, as the salinity level increased the required time for salinity increased in all three cultivars ($R^2 = 0.97$). The results also indicated that Record cultivar was more resistant to salinity than Sambor and Azar Gol cultivars. Therefore, with regard to germination characteristics of different cultivars Record cultivar is recommended to be planted in saline areas.

Keywords: *Salinity Stress, Sunflower Cultivars, Germination Percentage, Germination Rate*

INTRODUCTION
In most parts of the world, soil salinity through the decrease of osmotic potential and impaired absorption of some nutrients disrupts the yield of crops. Plants which grow in saline soils, due to osmotic properties face both salinity stress and lack of water which causes the reduction of plant growth rate and impairment of cell division and metabolic reactions of plant. The increase of sodium and chloride ions leads to the decrease of absorption of necessary ions such as potassium, calcium, ammonium, and nitrate and the disruption of cell walls and reduction of enzymes activities. High concentration of sodium hurts the roots and has an adverse effect on plant growth. In addition to decreasing the free potential of water through the toxic effects of ions such as Na^+ and Cl^-, salinity affects the seeds germination, as well (Kafi and Goldani, 2001). About 400 to 900 million kilometers of the world lands are facing salinity problems (Reddy, 2005).

This issue is especially important in arid and semiarid areas around the world. In such areas there is not sufficient rainfall to leach the salts from the root zone and often due to high rate of evaporation the concentration of salt in the soil increases (Almansouri and Kinet, 2001; Pesarrakli, 1999). Iran has a hot and dry climate and the total amount of saline and sodic soils in it is estimated to be 27 million hectares which is more than half of arable lands.

This had led to the evolution of salt tolerance mechanisms in native crops due to continuous contamination in such areas (Rezvani, 2001). In arid and semiarid areas salinity is known as the most important factor of seedbed which affects the plant establishment. Resistance to salinity stress is important in all stages of plant life and obviously the first step is germination stage. This stage of crops life has a significant role in appropriate establishment of plant and its ultimate yield (Almansouri and Kinet, 2001). Various studies have shown that germination percentage and rate decrease as the salinity increases (Akram *et al.,* 2007).

Lack of plants germination in saline soils is often due to high accumulation of salt in seed cultivation area which results from the upward movement of soil solution and subsequently the accumulation of salts in soil (Bajji *et al.,* 2002). The salts inhibit plant germination and establishment (Farokhi *et al.,* 2005). Examining the effect of salinity on germination percentage and rate and the growth of rootlet and stemlet

in many crops has shown that practicing salinity stress at germination stage decreases the growth of rootlet and stemlet (Demir and Patanea, 2006). Since there are some differenced between various species and cultivars in terms of sensitivity to salinity and drought stresses, this study aims to investigate the effect of salinity stress on germination and vegetative growth of different cultivars of sunflower. Sunflower with scientific name of Helianthus annuus L. belongs to compositae family and is an annual herbaceous cotyledon. Its seeds are edible and since it has oily seeds it can be used for producing oil. Oilseeds after cereals are the second food supplies. The cultivation and the need to this species in Iran is decreasing more and more due to the population growth and the rise per capita (Rastegar, 2006).
Considering the water shortage crisis and soil salinity in Iran, understanding the nature of salinity and alkalinity of soil can largely contribute to farm management and food supply through cultivation of compatible species. As various species and cultivars are different in terms of sensitivity to salinity and drought stresses, this study aims to investigate the effect of salinity stress on germination and vegetative growth of different cultivars of sunflower. Moreover, the research aims to: Compare germination rate of different sunflower cultivars (Record, Sambora, and Azar Gol), Compare germination percentage of different sunflower cultivars under salinity stress conditions.

MATERIALS AND METHODS

This research was conducted in Shoosh located in northwest of Khuzestan at latitude 32˚12′ N and longitude 48˚17′. Its altitude from the sea level is 112 m and it has an arid and semiarid climate. It is extremely hot in the region (the absolute maximum temperature recorded in the region is 53˚C in Ahvaz). The average annual rainfall in the region is very low and yet very erratic. There is no rainfall in May, June, July, August and there are ineffective rainfalls in September and April. In this experiment, the effect of different salinity levels (salinity stress) on germination components of three sunflower cultivars was investigated in the form of randomized complete block design with four replications.
The studied sunflower cultivars included Record, Sambora, and Azar Gol and salinity stress included four levels of 0, 4, 8, and 12 dS/m. to create osmotic potential, the salinity solution was prepared from sodium chloride salt (NaCl) and distilled water.
The seeds of the same size were selected for cultivation in Petri dishes and in order to disinfect them, they were placed in sodium hypochlorite solution 10% for 30 seconds. In order to measure the germination percentage of experimented seeds 20 seeds were placed in germinator at 25˚C for 48 hours. It was done for 7 days every 12 hours (Mayer *et al.,* 2002). The rootlet length was the criterion considered for germination (2mm or more) (Bajji *et al.,* 2002). Mohammed *et al*., (2002) reported that germination percentage of sunflower varieties influenced by different levels of NaCl, because of reduction water flow for metabolic reactions of germination.
Jamil *et al*., (2006) reported that the osmotic effect of salinity on the germination of seeds is more effective and reduce the movement of water in seeds thus reducing the inflation of seeds. Other research also has been reported germination reduction of seeds with increasing soil salinity (Soltani *et al*., 2001; Irannezhad, 2009)

Germination Rate

Germination rate was calculated via the following formula:

Rate of Germination =∑n / ∑ (d * n)

Required Time for Germination

The average required time for germination is obtained through the following equation :

MTG=∑ (n * d)/ ∑ n

n: number of germinated seeds
d: number of days after the beginning of germination

Analysis

The analysis of variance of collected data as factorial experiment and in the form of randomized complete block design with four replications was done by SAS software and the means were compared by Duncan's multi range test at 0.05 level.

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RESULTS AND DISCUSSION

Like other vital activities, germination is affected by environmental and internal factors. Internal factors include issues related to seeds maturation, seeds energy, seeds shells, and preservatives or stimuli and external or environmental factors include humidity, ventilation, temperature, and light (Tajbakhsh, 1978). The present research has investigated the effect of different salinity levels (salinity stress) as an environmental factor on germination of three sunflower cultivars (Record, Sambora and Azar Gol). To do so, the effect of different levels of salinity on uniformity, rate, percentage, and mean of germination of different sunflower cultivars was examined. The research was conducted as randomized complete block design with four replications and at four levels of 0. 4, 8, 12 dS/m.

Germination Percentage

The ANOVA results showed that there was a significant difference between germination percentage and different cultivars ($F = 297.4$; df = 2.33; $p \leq 0.001$), and different levels of salinity ($F = 1121.8$; df = 3.33; $P \leq 0.001$) (Table 1). Mean comparison of the effect of cultivar and different salinity levels on germination percentage, germination rate, germination uniformity, and germination mean was done by Duncan's multi range test at 0.05 the results of which are displayed in Table (2).

Table 1: The ANOVA results of the effect of different levels of salinity on germination homogeneity, germination rate, germination percentage, and germination mean at different sunflower cultivars

Sources of variation	Freedom degree	Mean of squares			
		Germination uniformity	Germination rate	Germination percentage	Germination mean
Variety (V)	2	8.98 ns	18.92 ns	297.45**	1.4658ns
Salinity (s)	3	135.28**	39284**	112187**	3.1424*
Variety × salinity	6	12.57*	1.59ns	13.56*	0.0272ns
Error	33	4.20	10.12	4.25	0.0484
Coefficient of changes	44	68	4.29	5.57	6.35

*ns, *, **, respectively indicate non-significant difference and significant difference at 5% and 1% levels.*

Table 2: Mean comparison of the effect of cultivar and different levels of salinity on germination percentage, germination rate, germination uniformity, and germination mean in sunflower

Treatmts	Mean of traits			
Variety	**Germination percentage(%)**	**Germination rate (number of seeds per day)**	**Germination uniformity (h)**	**Germination mean (day)**
Record	84.5279a	79.3919 a	32.2494 a	3.7138 a
Sambora	73.2115b	75.0175b	30.3569b	3.4875 b
Azar Gol	62.4625c	70.7688c	28.8725c	3.1144c
Salinity				
Control	86.7528 a	87.5750 a	42.7650 a	2.4750 d
Salinity 4	82.4869 a	77.4150 b	34.5873 b	3.3138 c
Salinity 8	61.8543 c	69.5858 c	23.9375 c	3.7250 b
Salinity12	41.7634 d	65.6617 d	19.3575 d	4.2358 a

According to Duncan's multi range test the means of treatments with similar letters are not significantly different at 5% level.

Investigating the effect of salinity showed that germination percentage at different levels of salinity (0, 4, 8, 12 dS/m) was significantly different in all three sunflower cultivars, so that germination percentage under different salinity levels was placed in four different statistical groups. The highest and the lowest germination percentage belonged to the levels of 0 and 12 by 86.75% and 41.76% respectively (Table 2).
According to the obtained results, there is a relatively strong relationship with negative slope between salinity and germination percentage, so that as the salinity percentage increases germination percentage decreases in all three cultivars and about 94% of changes of germination percentage is affected by salinity level (Figure 1). The results are consistent with the findings of Davazdah and Shahriari (2002) who stated that that as the salinity increased from 0.4 to 9 dS/m, germination percentage in sunflower decreased from 98 to 92% which was significantly different at 5% probability level. Delgado and Sanchez (1999) studied the salinity stress caused by sodium chloride on sunflower and reported that by applying 50 and 100 mM NaCl, germination percentage significantly decreased compared with control treatment. According to the conducted experiments there is a relationship between the reduction of germination rate and percentage in sunflower and the reduction of water absorption by seed at dehydration and turgor stages. As the salinity stress increases, the germination percentage in sunflower decreases (Bybordi and Tabatabaei, 2009).
Thus, it can be resulted that water salinity has a significant effect on germination behavior of sunflower seed. In summary, the mean comparison results showed that there was a significant difference between germination percentage in three cultivars of Record, Sambora, and Azar Gol at 5% level and the highest germination percentage was observed in Record cultivar and then in Sambora cultivar.

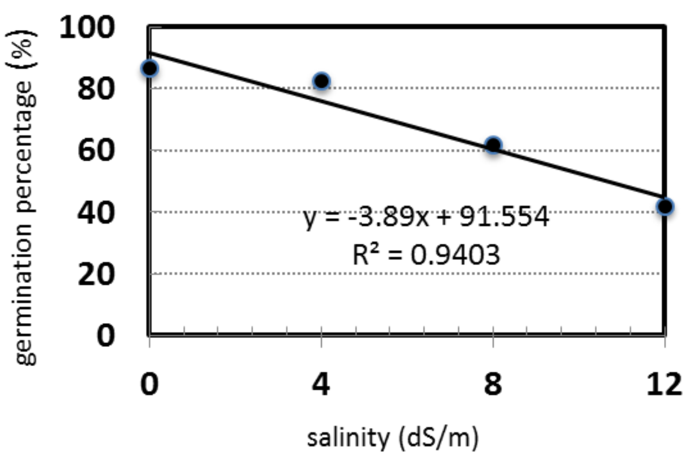

Figure 1: The relationship between germination percentage and salinity (dS/m)

Germination Rate

The results of investigating germination rate at different salinity levels showed that there was a significant difference between germination rates at different levels of salinity but there was not a significant difference between different cultivars in this regard. The linear relationship between salinity and germination rate has a negative slope which indicates that as different salinity levels increase, germination rate will decrease (Figure 2).

Moreover, the mean comparison results showed that the highest and the lowest germination rate belonged to Record and Azar Gol cultivars respectively, and the salinity levels of 0 and 12 dS/m allocated the highest and the lowest germination rate to themselves by 87.55% and 65.66%, respectively.

The reduction of plants germination rate and percentage in saline environments could be due to the decrease of affective absorption resulting from the disruption of osmotic balance and toxic ions and ultimately the impaired absorption of elements. Moreover, according to the studies of other researchers germination damage could be due to the decrease or delay in water absorption which might facilitate the inflow of toxic concentrations of the ion. The results were consistent with the findings of Ramagopl (1990).

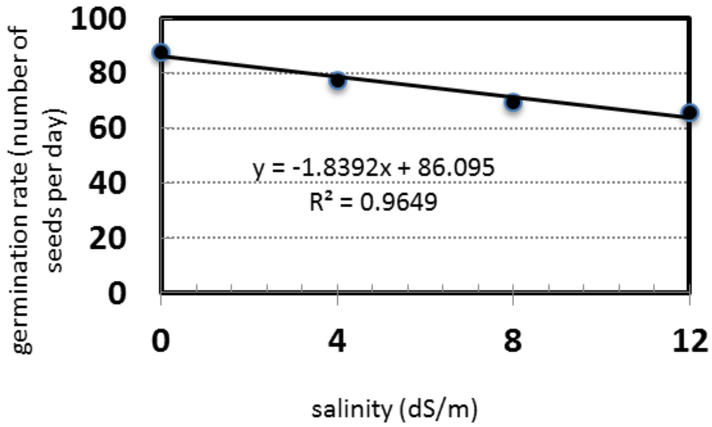

Figure 2: The relationship between germination rate and different levels of salinity

Germination Uniformity

The ANOVA results showed that there was a significant difference between germination uniformity at different salinit levels at 1% probability level (Table 1). Like germination percentage and rate, there was a signignifacant difference between three cultivars in terms of germination unifrmity and the highest and the lowest uniformity was observed in Record and Azar Gol cultivars, respectively. Moreover, germination uniformity at different salinity levels was placed in four different statistical groups, so that the highest germination uniformity belonged to the level of 0 dS/m and the lowest germination uniformity belonged to the level of 12 dS/m (Table 2). The inhibitive effect of salinity stress on the seed germination is due to the decrease of osmotic potential or toxi ion and of course the reduction of germination in halophte plants is usually because of osmotic effect while in non-halophyte plants it is because of ion toxicity, as well. The most important mutual reaction of water stress under salinity condition including the different pattern of peroten synthesis is the delay in the emergence of embryonic tissues and reduction of germination rate and percentage. The results were consistent with the findings of Pujol *et al*., (2000), Tob *et al.*, (2004), Baji *et al.*, (2002).

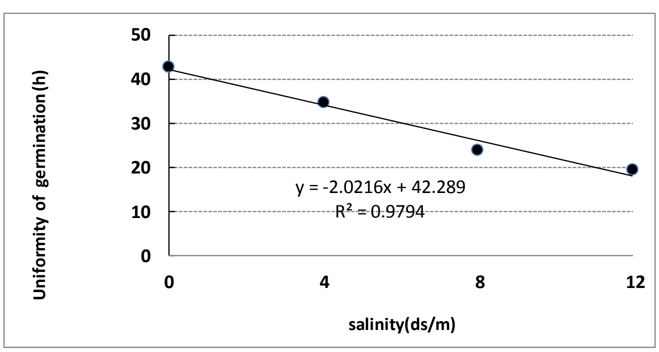

Figure 3: The relationship between germination uniformity and different levels of salinity

Germination Mean

Investigating the effect of different levels of salinity on germination mean showed that there was a significant difference between different salinity levels at 5% level, while there was no significant difference between different sunflower cultivars nor the intercative effect of cultivar and salinty (Table 1). The linear relationship between different salinity levels and germination mean showed that as the saliny level increased, the mean of germination percentage increased too and 97.4% of changes was related to germination under the effect of salinity level (Figure 4). Mean comparison results showed that there was a significant difference between three cultivars in terms of germination mean. The highest germination mean belonged to Record cultivar and the lowes one belonged to Azar Gol cultivar. The salinity level of 0 dS/m by 2.47% and the level of 12 dS/m by 4.23% germination allocated the lowest and the highest germination mean to themselves, respectively (Table 2). Salinity decreased the plant germination by decreasing the osmotic potentail of the solution, creating toic ions, and changing the balance of nutrients. Concentration of salt and the ions which form the solution are the basic factors in germination reduction. At high concentrations of ion toxicity and consequently by increasing the absorption of ions particularly sodium chloride, the imballance between nutrients are the important factors which impair and decrease germination and increase the required time for germination. The results were consistent with the findings of Maftuli and Chaei (2008).

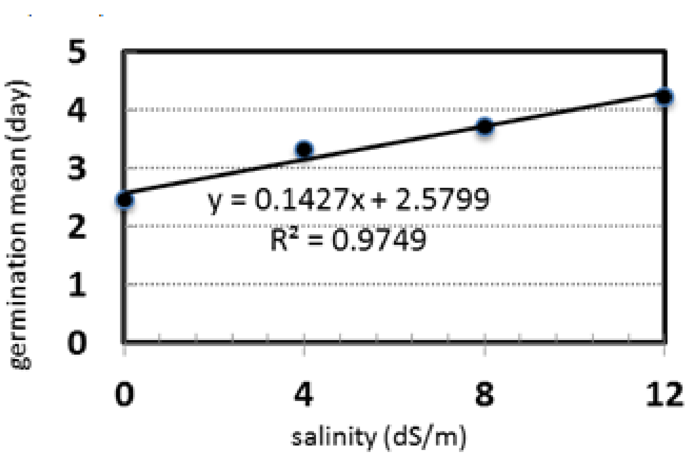

Figure 4: The relationship between germination mean and different levels of salinity

Investigating salinity stress at germination stage is a relaibel test for evaluation of many species because salinity reduces germination rate and percentage. Under salinity stress, plants use complicated mechanisms to adapt with osmotic stress and ioins toxicity which are different according to the type of plant and their sensitivity to salinity. Sunflower is categirized in plants which are relatively resistant to salinity. The yield of sunflower is not damaged at salinity of about 5 dS/m but the salinity of about 12 dS/m reduces the yiled to zero percent (Khaje, 2006). In this study, like the previous ones it was identified that salinity would decrease germination percentage and rate and the highest resistance to salinity among the three studied cultivars belonged to Record cultivar and formerly it had been proved that the differece in the tolerance of salinity stress by different sunflower cultivars was due to genetic diversity (Hossein *et al*., 2011). Germeination stage is an important stage for every plant and determines its future yield. Therefore, it is necessary to do various studies on different plants at different vegetative growth stages because full perception of the reaction of germination and seedling growth to salinity can influence the selection of salinity tolerant cultivars.

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