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Effect of salinity and temperature on seed germination indices of *Zinnia elegans* L.

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Abstract

Laboratory studies were conduced to determine the effect of salinity and temperature on seed germination of zinnia plant with two temperature regimes (25 and 30 °C) and 5 levels of salinity (distilled water as control and 3, 6, 9 and 12 dSm^{-1}) in a factorial completely randomized design. Analysis of variance showed significant difference ($P<0.05$) between different levels of salinity, and salinity and temperature interactions on germination percentage, germination rate and length of rootlet. But temperature treatment only influenced rootlet length ($P<0.05$). Mean comparison of seed germination percentage showed that increasing salinity decreased the seed germination. The highest rootlet length was recorded in the control (8.273 cm) and the lowest (1.92 cm) was at 12 dSm^{-1} of salinity. The effect of temperature on the germination percentage, germination rate and length of rootlet determined that the highest germination percentage and length of rootlet was at 25 °C temperature. The study on the interaction of temperature and salinity exhibited that highest percentage of germination, germination rate and length of rootlet were in control at 25°C, whereas it was lowest at 30°C and 12 dSm^{-1} salinity.

Key words: Germination percentage, germination rate, length of rootlet, salinity, zinnia

Introduction

Zinnia (*Zinnia elegans*) belongs to Compositae family and originated in north America and predominantly occurs in Mexico. This plant is tolerant to dry, warm and sunny environment and has broad leaves with acute tips that are opposite and petiolate. Colour of flowers also vary as white, yellow, pink and orange. The tall varieties have 60-80 cm and dwarf have 25-30 cm height. This species is used as cut flowers and bedding plant (Dole and Wilkins, 1999; Khalighi, 1991).

Propagation of this plant is by seed (Khalighi, 1991) which in the semi-arid and arid region is influenced by high temperature, evaporation and low precipitation and the soil salinity. Soil salinity reduces water potential of root zone and availability of water for plants and on the other hand, some of the toxic ions affect plant physiological and biochemical processes causing disorders in nutrient uptake of root and ultimately leads to reduced growth (Fenando *et al*., 2000; Khaleghi and Ramin, 2005). Sensitivity of plants (including agricultural and ornamental) to salinity are different at different growth stages (Maghtoli and Chaichi, 1999; Maibody and Gharehreyazi, 2002). In many plants, germination and flowering stages are most sensitive stage of plant life cycle to salinity (Shannon, 1984). Grime and Campbell (1991) reported that most sensitive growth stage to salinity is when plant seed germinates and attain early seedling growth. In addition to this it has been reported that between indices of seed germination, percentage of germination and germination rate are the most important factors that are affected by salinity induced stress conditions (Maibody and Gharehreyazi, 2002; Rajabi and Postini, 2005). Reports by Harabans (1994) on seed germination of turnips and canola showed that seed germination was reduced by almost 40% with increasing salinity from 10.1 to 16.2 dSm^{-1} in both plant speceis compared to control. Also there was a linear relationship between salinity levels and germination.

Stone *et al.* (1979) reported that alfalfa plants are extremely sensitive to salinity in the early stages of growth and in seed germination stage and interaction exists between salinity and temperature for germination and related parameters.

Fowler (1991) showed that *Crambe abyssinica* plant germination decreased with increasing salinity from 0 to 40 mμ cm^{-1} and reduction process was maximum when temperature was about 30 °C, while at 15 and 20 °C, salinity caused no significant reduction in seed germination. Gulzar *et al*. (2001) also reported that germination of *Urochondra setulosa* decreased with increase in salinity and decrease of germination percentage was severe at 25 and 35 °C as compared with 15 and 20 °C. Germination, length and dry weight of rootlet was different at different levels of salt in *Argania spinosa*, and there were significant differences between salt concentration effect at the time of germination. Time for germination was not delayed but the amount of germination, length of rootlet and root dry weight were reduced. There was no delay in start of germination by increase of salinity but the amount of germination, length of rootlet and dry weight were decreased (Aameur *et al*., 2001).

A large number of researches conducted on different crops indicate the fact that with increasing salinity, length of plumule and rootlet and dry weight of these parts are decreased as compared with control (Ejazrasell and Rahman Rao, 1997; Ghoulam and Fares, 2001). Keeping in aforesaid information in view it is clear that combined effect of salinity and salinity and temperature on seed germination are significant, while there is a limited information about interaction of salinity and temperature on ornamental plants. Therefore, experiments were conducted to study the effect of high salinity and temperature treatments on seed germination indices of zinnia.

Materials and methods

The study was carried out at the Department of Horticulture Science in the College of Agriculture, Shahid Chamran University in 2008. The experiment was laid in a factorial completely randomized design in which the salinity treatments with 4 salinity levels included 3, 6, 9 and 12 dSm^{-1} (adding specific amounts of salt to distilled water) and distilled water (control) and two temperature regimes included 25 and 30 °C with three replications. Each unit included a Petri dish experiment, the dimensions 10 × 10 cm square and contained 50 seeds. Seeds were immersed for 5 minutes in disinfectant solution of sodium hypochlorite (2.5%) and washed three times with distilled water and then passed between two layers of filter paper (Watman No.1). Five mL of salt solution was added to each Petridish and kept at different temperatures (25 and 30°C) in incubator. For maintenance of concentration of salt in Petridishes, salt solution of each Petridish was changed every 2 days. Germinated seeds were counted daily and after 15 days folowing indicators were measured:

Germination percentage: This index was obtained from division of number of germinated seeds with total number of seeds (Camberato and Mccarty, 1999; Hartmann and Kester, 1983).

$$GP(\%) = \frac{\sum G}{N} \times 100$$

G= number of germinated seeds

N=number of total seeds

Germination rate : It was calculated on number of germinated seeds in a day by following formula of Maguirw (1962):

$$GR = \sum_{i=1}^{n} \frac{S_i}{D_i}$$

S_i = number of germinated seeds in each count
D_i= number of day until nth count
n= number of counts

Length of rootlet (cm): After emergence of rootlet, its length was measured daily by ruler.

Means were compared using Duncans New Multiple Range Test (*P*=0.05).

Results and discussion

Analysis of variance presented in Table 1 indicated significant difference between salinity treatments in percentage and rate of germination and length of rootlet (*P*=0.05), and also between 2 levels of temperature for length of rootlet and percentage of germination but not for rate of germination. Interaction of temperature and salinity was significant (*P*=0.05) for all of indices.

Effect of salinity: Table 2 indicate that with increasing salinity level, germination percentage, germination rate and the length of rootlet was reduced. Increasing salinity from control to 12 dSm^{-1} reduced germination percentage from 92.17 to 57 %. This decline had a significant difference from other treatments while at 3 and 6 dSm^{-1} no significant difference was observed. Comparison of germination percentage in distilled water with salinity treatment at 3, 6, 9 and 12 dSm^{-1} showed that under these salinity levels, decreased germination percentage was 7.77, 9.94, 27.3 and 37.07 %, respectively.

Fenando *et al.* (2000) recorded similar effect for germination and growth of *Chenopodium quinona* under different salinity conditions and reported that at 0.4 mM NaCl, germination percentage was reduced to 14 % as compared to normal conditions (87 %). Rajabi and Postini (2005) reported that salinity levels of 0 and 3 dSm^{-1} had a significant effect on germination percentage and caused ionic poisoning and reduced germination percentage. Dotzenko and Dean (1959) recorded decline in alfalfa germination by applying three levels of salinity and decline in water absorption and increase of anions around seed. Highest germination percentage was recorded in distilled water (35.80 seed/day) with non significant (*P*=0.05) difference under 3 and 6 dSm^{-1} treatments. Minimum germination percent was 20.48 under 12 dSm^{-1} salinity.

Results of this research work are similar to that of Parasher and Varma (1992) who reported that the low levels of salinity just reduced the germination rate, but the upper levels of salinity caused decline in total percentage of germination too. This decline is because of extra cations and anions accumulate around the seeds that reduced water potential, thus water is available around the seed but because of existing ions, seeds are not able to absorb water (Singh *et al*., 1988).

There was significant difference in all treatments for length of rootlet. Furthermore, contrary to germination rate and percentage, there was a significant difference in the length of rootlet between 3 and 6 dSm^{-1}.

Maximum length of rootlet (8.27 cm) was observed in distilled water and minimum was under 12 dSm^{-1} (1.92 cm). These results are in agreement with the results of Rajabi and Postini (2005) who reported that by increase in salinity and electrical conductivity (EC) from 0 to15 dSm^{-1}, length of rootlet declined from 46.3 mm to 17.4 mm acounting for 37.5 % decline and these results are supported with the findings of Munns and Termaat (1986) who observed that salinity caused decline in the growth of rootlet and plumule. Further, decline is related to affects of sodium chloride on cell membrane and ionic poisoning (Bal and Chattopadhyay, 1985).

Effect of temperature: Data presented in Table 3. indicate that temperature levels had significant (*P*=0.05) effect on percentage of germination and length of rootlet whereas effect of temperature on germination rate was not significant. Reports show that the optimum temperature for germination of zinnia is 25°C (Nau, 1993). Percentage and rate of germination and growth of seedling are affected by temperature which implies that at temperature lower than the optimum for germination, percentage and germination rate was low and at optimum temperature germination rate is increased. However, with increasing temperature close to the lethal limit, seeds are damaged, thus germination percentage, germination rate and growth of seedlings are reduced (Kozlowski, 1959). Therefore, increase in temperature from optimum level (25°C) for germination to 30°C, germination rate and percentage and growth of rootlet decreased.

Interaction between salinity and temperatures: Table 4 indicates that with changing temperature from 25 to 30 °C, germination percentage declined (7 %) in distilled water treatment whereas in 3 and 6 dSm^{-1}, this percentage had no significant difference. There was a significant difference among 3 and 6 dSm^{-1}. Maximum percentage of germination was in control at 25 °C and the minimum was in 12 dSm^{-1} treatment. This indicated that by increase in temperature and salinity, a sever decline in germination percentage of seeds as compared with control is observed. Interaction effect of salinity and temperature show that in distilled water temperature was the effective factor responsible for decline in germination percentage, while at 3 and 6 dSm^{-1} salinity, in the same temperatures regimes, the salinity adversely influenced germination.

El-Keblawy and Al-Rawai (2005) documented that the salinity, temperature and light may have a negative effect on germination of *Prosopis juliflora*. They reported that by the increase in the levels of these factors, the germination percent of *Prosopis juliflora* decreased and its germination is dependent both on salinity and temperature, as in 400 mM at 40 °C germination was completely stopped, while at 15 and 25 °C there was no significant difference between 0 to 400 mM of NaCl on percentage of germination. These findings support the results of present investigation. Bewley and Black (1994) and Khan and Ungar (1996) stated that destructive effects of NaCl under high temperature is because of high toxicity of Na ion and sensitivity of cell membrane that can be very prejudicial for cells.

Results on temperature-salinity interaction indicate that by increase in salinity, germination rate of zinnia will decrease. By increase of 5 °C from 25 to 30°C minimum rate of germination was at 12 dSm^{-1} salinity at 30°C. While germination rate was maximum (38 seed in a day) in distilled water in 30°C. Furthermore, it is clear that the rate of germination at 3 dSm^{-1} at 30 °C had a decline by 26 % as compared with distilled water and 30°C. Bewley and Black (1994) also reported interaction between concentration of NaCl and temperature on the rate of germination. In their studies, the rate of germination in treated seeds with 500 mM NaCl at 25 °C had significant difference with control when compared to 15 °C and these results are corroborating with our findings.

With the increase of salinity, the length of rootlet declined and temperature-salinity interaction was significant with changing temperature from 25 to 30°C between control and other treatments. Maximum length of rootlet was 8.36 cm in distilled water at 25 °C, while seeds at 12 dSm^{-1} and 30°C had minimum length of rootlet. Also it seems that upto 6 dSm^{-1} salinity, temperature has more effect on length of rootlet than salinity treatments. At 9 and 12 dSm^{-1}, the effect of temperature on rootlet length decreased. It is clear that effect of salinity in 30°C in decline of length of rootlet is more sever than at 25°C. Azarinvand *et al.* (2005) showed more length of rootlet and plumule in *Atriplex halimus* and *A. canescens* at 25°C as compared to 30 and 35°C at all levels of salinity. In general, decline in germination and growth of seedlings, by increase of salinity concentration in media, is a result of physico-chemical effects or by osmotic poisoning effects of ions in salt solutions. In other words, by increase of osmotic pressure (more negativity of osmotic potential) from increase of salinity in root media, one side, water intake of seed will be disturbed and on the other side presence of high concentration of anions and cations (especially Na and Cl) perevent the germination by poisoning in seed (Fenando *et al*., 2000; Khaleghi and Ramin, 2005; Postini, 2005). Furthermore, negative effects of salinity on permeability of membrane, cell division, protein synthesis and enzymatic activities, average time for germination, germination rate and length of rootlet are reported (Bal and Chattopadhyay, 1985;

Table 1. Analysis of variance for parameters

Source of variation	Degree of freedom	Mean squares		
		Length of rootlet	Germination rate	Germination percentage
Salinity	4	40.218*	195.2*	1188.783*
Temperature	1	3.989*	14.242 n.s	38.533*
Salinity * Temperature	4	0.338*	19.8580*	16.283*
Experimental error	20	0.247	2.382	7.0
C.V(%)		9.85	5.66	3.43

*: significant difference at 5% probability
n.s: non significant difference

Table 2. Mean comparison of parameters for different salinity levels

Parameter	Germination percentage (%)	Germination rate (Germinated seed/day)	Length of rootlet (cm)
Distilled water	92.17a	35.80a	8.273a
3 dSm^{-1}	85b	28.85b	7.07b
6 dSm^{-1}	83b	26.85b	4.368c
9 dSm^{-1}	67c	24.34c	3.610d
12 dSm^{-1}	58d	20.48d	1.92e

Mean within each column with the same letters are not significantly different at *P*=0.05 (LSD)

Table 3. Comparison of parameters at different temperature regimes

Teatment	Germination percentage (%)	Germination rate (germinated seed/day)	Length of rootlet (cm)
25°C	78.33a	27.95a	5.413a
30°C	76.07b	26.58a	4.684b

Mean within each column with the same letters are not significantly different at *P*=0.05 (LSD)

Table 4. Comparison of salinity and temperature interaction means

Tteatment	Germination percentage (%)		Germination rate (Germinated seed/day)		Length of rootlet (cm)	
	25°C	30°C	25°C	30°C	25°C	30°C
Distilled water	95.67a	88.67b	33.6b	38.00a	8.367a	8.180a
3 dSm^{-1}	86bc	85bc	29.6c	28.11cd	7.193b	6.950b
6 dSm^{-1}	84bc	82c	28.15cd	25.55de	4.893c	3.843de
9 dSm^{-1}	69d	65d	25.13e	23.55e	4.107cd	3.113ef
12 dSm^{-1}	57e	59e	23.29e	17.67f	2.507f	1.333g

Mean within each column with the same letters are not significantly different at *P*=0.05 (LSD)

Hardegree and Emmerich, 1990). By increase of temperature, above optimal level, germination rate and percentage and length of rootlet will be declined. In fact, high temperatures, in addition to reduced strength of hydrogen links and relationships between groups of electrostatic polar liquid phase membrane proteins that cause changes in cell membrane structure and cell leakage of ions prevent the breathing process (Hopkins, 1995; Tize and Zeiger, 1998). These conditions have negative effects on the process of germination.

The results of the present study indicated that at optimal temperature for germination (25°C), negative effects of salinity on germination indices was very low as compared to high temperatures. At 25°C upto 12 dSm^{-1}, 57% of the seeds germinated and this is considerable at high soil salinity and temperature regimes.

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