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# TEMPERATURE AND SALINITY AFFECT THE GERMINATION AND GROWTH OF *SILYBUM MARIANUM* GAERTN AND *AVENA FATUA* L.

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**Abstract**

Two troublesome weeds like *Silybum marianum* and *Avena fatua* were exposed to different levels of temperature and salinity. Laboratory based experimented were conducted in the Department of Weed Science, The University of Agriculture Peshawar during 2015. Sterilized seeds of *S. marianum* and *A. fatua* were placed in petri-dishes in a growth chamber. The temperature levels studied were 15, 25 and 40°C while the NaCl concentrations were 0, 100, 200, 300, 400, 500 and 600 mM. Data revealed that germination and growth related traits responded differently to different levels of temperature and salinity. Optimum temperature (25°C) resulted in higher germination and growth of both the weed species. While highest temperature used (40°C) or lower temperature (15°C) resulted in poor germination and growth of *S. marianum* and *A. fatua*. Salinity level up to 100 mM did not affect the seed germination of *S. marianum* and *A. fatua*. NaCl concentration above 100 mM significantly decreased germination and ceased the germination of both the weeds at 600 mM. Like germination, the growth related variables were also decreased at very low or very high temperature and higher concentrations of NaCl. It is concluded that temperature and NaCl can affect establishment, growth and seed production potential of *S. marianum* and *A. fatua*.

**Key words:** *Silybum marianum, Avena fatua,* Salinity, Temperature, Weed, Germination, Growth.

## Introduction

Good seed germination and early emergence are important for weeds to efficiently utilize nutrients and moisture. These characteristics can effectively compete for an ecological habitat (Forcella *et al*., 2000) as temperature, light, soil water and pH could affect the germination process of seeds (Martins *et al*., 2000; Rizzardi *et al*., 2009). Among these environmental factors, temperature has a key role in defining the state of germination and that how much the plant species is distributed (Guan *et al*., 2009) in different regions. It has been believed that seed germination is increased directly with increase in temperature, within a well-defined range, and then decreased with the increase in temperature (Alvarado & Bradford, 2002). Like temperature, the light and moisture can greatly affect the overall seed germination process and initial growth of plants. Experimental results have shown that osmotic and salinity levels can result in delayed, decreased or failure of seed germination in many plant species (Zhou *et al*., 2005). The seed germination process and optimum conditions for specific weed species is an important factor in determining the competitive ability of a weed (Chauhan & Johnson, 2010). Because weed seeds react to environmental factors such as temperature, light, soil salinity and soil moisture (Chauhan, 2012). Thus, if the optimum condition required for the weed seed germination is known, then the management options can make the weed management process easy. Thus the knowledge of individual weed seed germination is important for their management in crops (Mennan & Ngouajio (2006). Linear increase in germination rate is correlated with an increase in temperature from base temperature to an optimum. However, any further increase in temperature from optimum may result in reduction in germination rate and might be zero at very high temperature (Clavijo & Medina, 2004). Thus, to effectively manage the weeds in crops, determination of base, optimum and maximum temperatures for weed seed germination can give important information in an integrated weed management program.

Wild oat (*Avena fatua* L.) is a major weed in more than 20 main crops in 55 countries (Sharama & Vanden, 2008). In Pakistan, it is the most important weed in wheat. It is reported as an important weed in irrigated and dry land cereal farms (Medd, 2006). It grows in various light and heavy as well as alkaline to acid soils having pH 4.5–9. The highest population of wild oat is reported in wheat farms with annual precipitation between 375 and 750 ml (Medd, 2006). Thus the favourable environmental and soil factors have resulted in the successfulness of this weed in the country. Like wild oat, Milk thistle (*Silybum marianum*) has become a major weed of wheat in irrigated areas of the KP province (Khan and Marwat, 2006).

Detailed information related to optimum growth conditions are needed for the germination of seeds of all the weeds before the implementation of weed management strategy. Prediction of germination and emergence in relation to environmental conditions is helpful to apply suitable weed management techniques (Ghorbani *et al*., 1999).

Due to diverse climate, the temperature is different in different ecological zones of Pakistan. Therefore it is necessary to investigate the response of major weeds of wheat to temperature and salinity for their management. Such studies will assist in predicting the chances of establishment and spread of weed species. Thus the two major weeds of wheat like *S. marianum* and *A. fatua* were selected to investigate the response of these weeds to different regimes of temperature and NaCl concentrations in a growth chamber.

## Materials and Methods

The seeds of *S. marianum* and *A. fatua* were collected in the previous years on the basis of their heavy infestation in wheat crop by surveying different fields. The seeds of both these weeds were stored and sterilized by using Metalaxyl + Mancozeb 72%. Petri-dishes used in the experiments were sterilized at 110 -120°C for 1 hour and then arranged in a completely randomized design, replicated four times. The size of each Petri-dish was 9-cm diameter with double layer of Whatman No.1 filter paper. 20 seeds of *S. marianum* and *A. fatua* each were placed at equal distance in separate Petri-dishes and 10 ml of test solution was added as per treatment. Petri-dishes were kept in the growth chamber at temperature of 15°C. After completing the first experiment, the growth chamber was then set at temperature of 25°C and then at 40°C separately. At each temperature studied (15, 25 and 40°C), the NaCl concentrations of 0, 100, 200, 300, 400, 500 and 600mM were applied. Seed germination was recorded for each weed species in all the treatments, after 20 days of starting the experiment and then the data was converted to percentage. Average of all the plants of the shoot length of the seedlings of both the species was determined and finally averaged. Similarly, root length and shoot and root biomass (mg plant$^{-1}$) of all the seedlings of both the species was recorded and average was calculated.

**Statistical analysis:** Analysis of variance (ANOVA) was used to determine the significance and LSD was applied by using Statistix Version 8.1.

## Results and Discussion

**Germination percentage:** The effect of temperature and NaCl concentration was significant on the seed germination of *S. marianum* (Table 1) and *A. fatua* (Table 2). Seed germination of *S. marianum* was highest (32.1%) at 25°C as compared to 17% and 16.1% at temperature of 15 and 40°C, respectively. This indicated that very high and very low temperature can decrease the seed germination of *S. marianum*. While in case of *A. fatua*, it was observed that germination was highest (38.5%) at temperature of 15°C which was statistically at par with 35.9% at temperature of 25°C as compared to 13.5% at 40°C, respectively. Keeping in view the present results, it could be concluded that in the areas where temperature is very low or very high (below 15°C or below 40°C, respectively), these weeds cannot become major weeds of the area due to their poor germination at these temperatures. In a seed germination test, Pourreza & Bahrani (2012) reported that highest germination was recorded at temperature between 21 and 27°C. It was noted that *S. marianum* was more sensitive to low temperature as compared to *A. fatua*.

There was a significantly decreasing tendency in the seed germination of *S. marianum* and *A. fatua* when levels of NaCl were increased. All the concentration used in the present studies, decreased the seed germination with no germination of *S. marianum* and *A. fatua* at 400, 500 and 600 mM solutions. Non salt treated seeds showed higher germination (65.4%) for *S. marianum* and 72.5% for *A. fatua*. These results were in line with Ghoulam & Fares (2001) and Xiao-Fang *et al*. (2000). They found that with the increase in salt concentration, the germination percentage was decreased. The interactions (Figs. 1 and 2) of temperature and salinity were also found significant for both the weed species. The negative effect of salinity on seed germination was more severe at low as compared to higher temperature. However, decreasing trend of germination with the increasing NaCl was consistent. Thus it is suggested that every individual weed species should be studied at various combinations of temperatures and salinity levels. This will enable the researchers to decide the most appropriate combinations for effective suppression of the weed species.

**Table 1. Effect of temperature and NaCl concentrations on germination and growth of *S. marianum.* Means followed by different letters in their respective columns are significantly different according to LSD test.**

| Treatments | Germination % | Shoot length (mm plant$^{-1}$) | Shoot biomass (mg plant$^{-1}$) | Root length (mm plant$^{-1}$) | Root biomass (mg plant$^{-1}$) |
|---|---|---|---|---|---|
| **Temperature (°C)** | | | | | |
| 15 | 17 b | 21.5 b | 936.8 a | 16.0 b | 598.8 a |
| 25 | 32.1 a | 40.1 a | 1106.1 a | 22.0 a | 714.8 a |
| 40 | 16.1 b | 0.9 c | 96.4 b | 0.4 c | 36.3 b |
| $LSD_{0.05}$ value | 2.57 | 1.35 | 239.16 | 2.42 | 282.90 |
| NaCl Solution (mM) | | | | | |
| 0 | 65.4 a | 64.8 a | 1812.9 a | 55.0 a | 1749.6 a |
| 100 | 56.0 b | 47.0 b | 1885.4 a | 24.9 b | 914.6 b |
| 200 | 21.0 c | 23.9 c | 802.9 b | 6.5 c | 354.6 c |
| 300 | 9.4 d | 10.31d | 490.42b | 3.06cd | 130.9 c |
| 400 | 0.0 e | 0.00e | 0.00c | 0.00d | 0.0 c |
| 500 | 0.0 e | 0.00 e | 0.00 c | 0.00 d | 0.0 c |
| 600 | 0.0 e | 0.00 e | 0.00 c | 0.00 d | 0.0 c |
| $LSD_{0.05}$ value | 3.92 | 2.05 | 365.32 | 3.69 | 365.32 |

**Table 2. Effect of temperature and NaCl concentrations on germination and growth of *A. fatua*. Means followed by different letters in their respective columns are significantly different according to LSD test.**

| Treatments | Germination % | Shoot length (mm plant$^{-1}$) | Shoot biomass (mg plant$^{-1}$) | Root length (mm plant$^{-1}$) | Root biomass (mg plant$^{-1}$) |
|---|---|---|---|---|---|
| Temperature ($^{o}$C) | | | | | |
| 15 | 38.5 a | 33.7 b | 200.5 b | 28.1 b | 299.4 a |
| 25 | 35.9 a | 52.0 a | 283.9 a | 41.3 a | 1521.2 a |
| 40 | 13.5 b | 1.8 c | 6.7 c | 0.5 c | 0.4 a |
| $LSD_{0.05}$ value | 2.82 | 3.30 | Varies | 3.82 | 1884.4 |
| NaCl Solution (mM) | | | | | |
| 0 | 72.5 a | 91.6 a | 475.7 a | 75.9 a | 779.4 ab |
| 100 | 65.6 b | 75.4 b | 402.6 b | 61.9 b | 3195.4 a |
| 200 | 46.3 c | 28.6 c | 205.2 c | 20.6 c | 229.3 b |
| 300 | 20.6 d | 8.3 d | 62.6 d | 4.7 d | 44.9 b |
| 400 | 0.0 d | 0.0 e | 0.0 d | 0.0 d | 0.0 b |
| 500 | 0.0 d | 0.0 e | 0.0 d | 0.0 d | 0.0 b |
| 600 | 0.0 d | 0.0 e | 0.0 d | 0.0 d | 0.0 b |
| $LSD_{0.05}$ value | 4.31 | 5.04 | Varies | 5.84 | 288.4 |

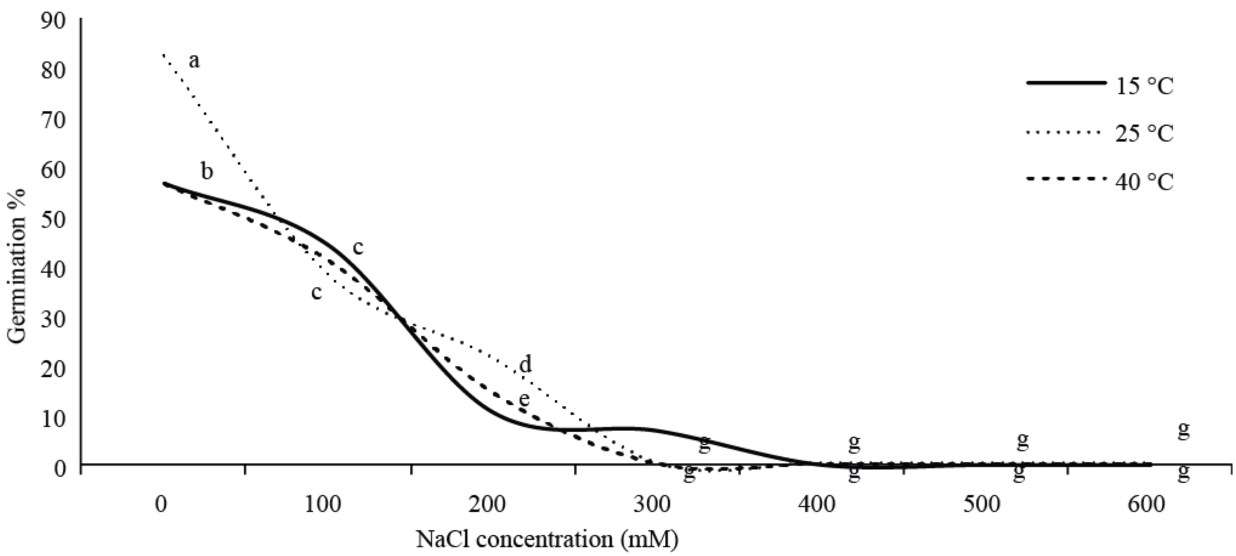


Fig. 1. Effect of temperature and NaCl concentration on germination of *S. marianum*.

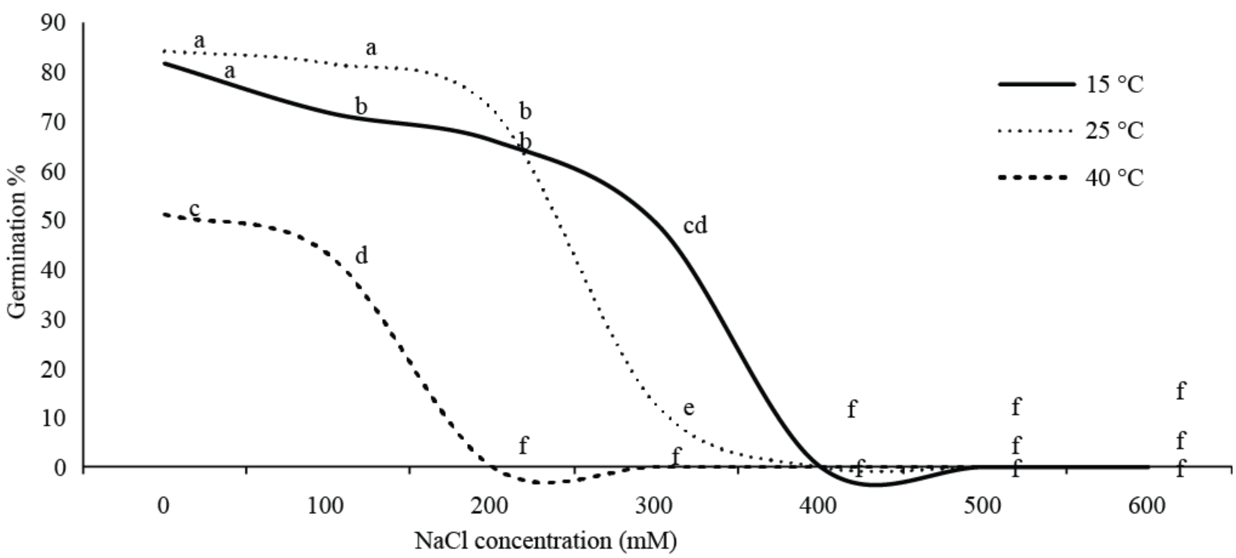


Fig. 2. Effect of temperature and NaCl concentration on germination % of *A. fatua*.

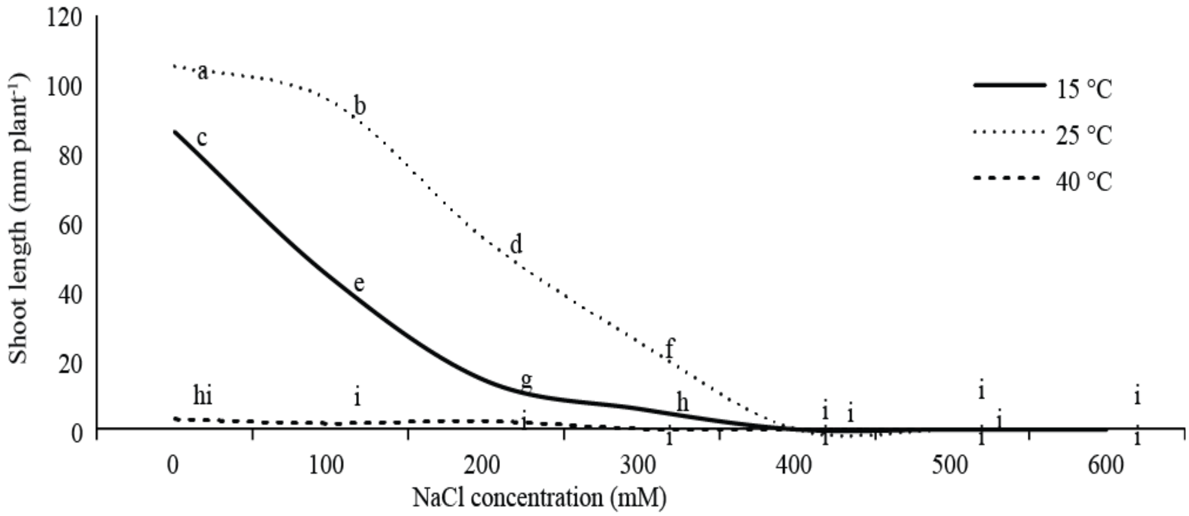


Fig. 3. Effect of temperature and NaCl concentration on shoot length (mm plant$^{-1}$) of *S. marianum*.

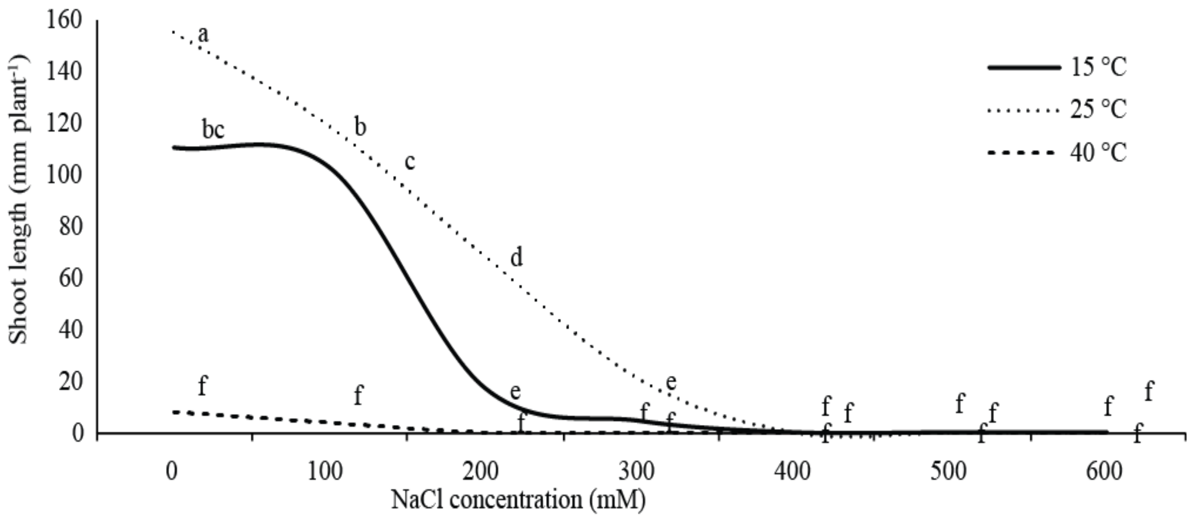


Fig. 4. Effect of temperature and NaCl concentration on shoot length (mm plant$^{-1}$) of *A. fatua*.

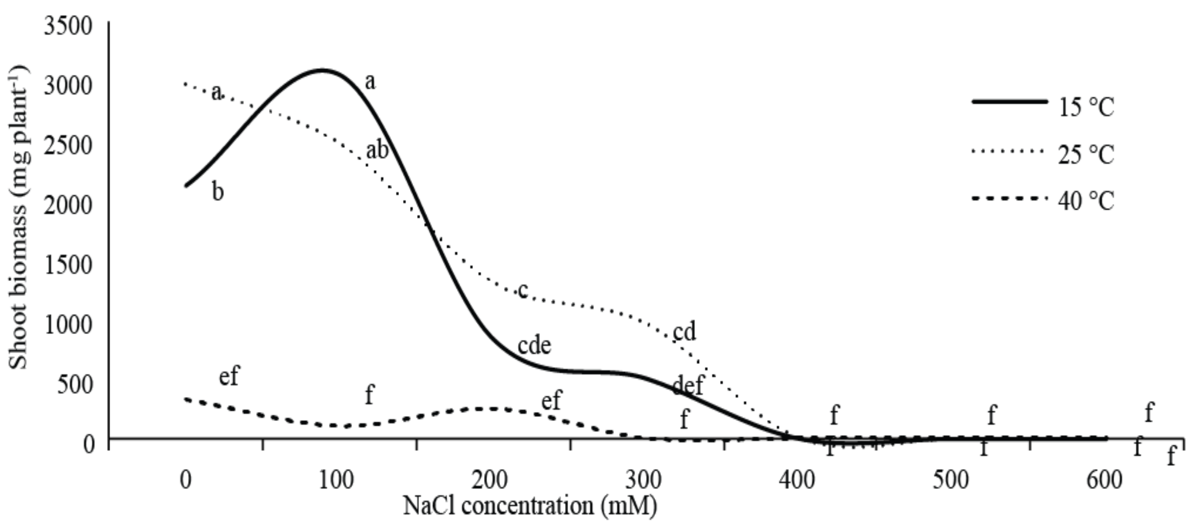


Fig. 5. Effect of temperature and NaCl concentration on shoot biomass (mg plant$^{-1}$) of *S. marianum*.

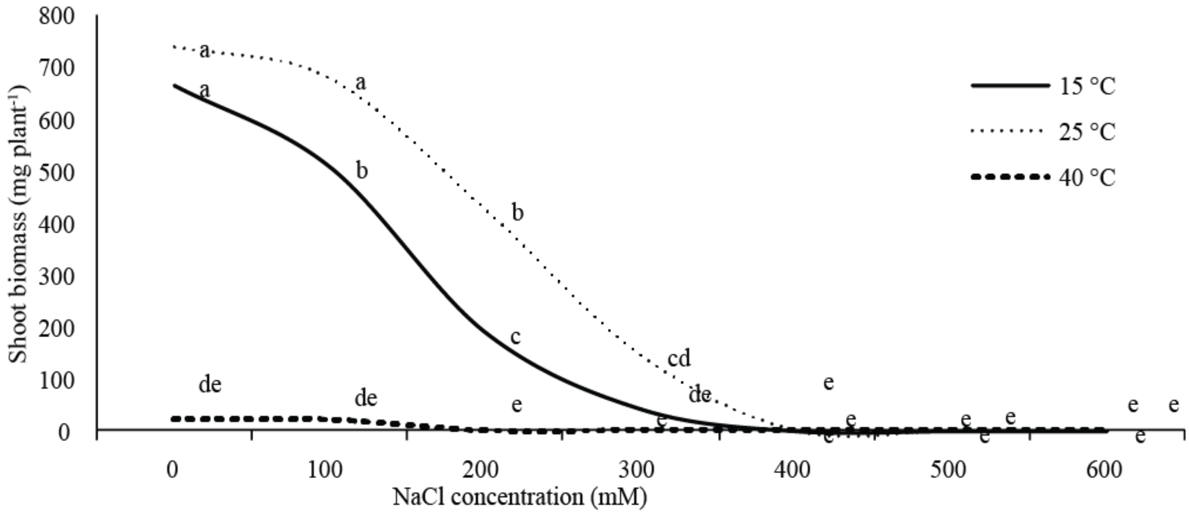


Fig. 6. Effect of temperature and NaCl concentration on shoot biomass (mg plant$^{-1}$) of *A. fatua*.

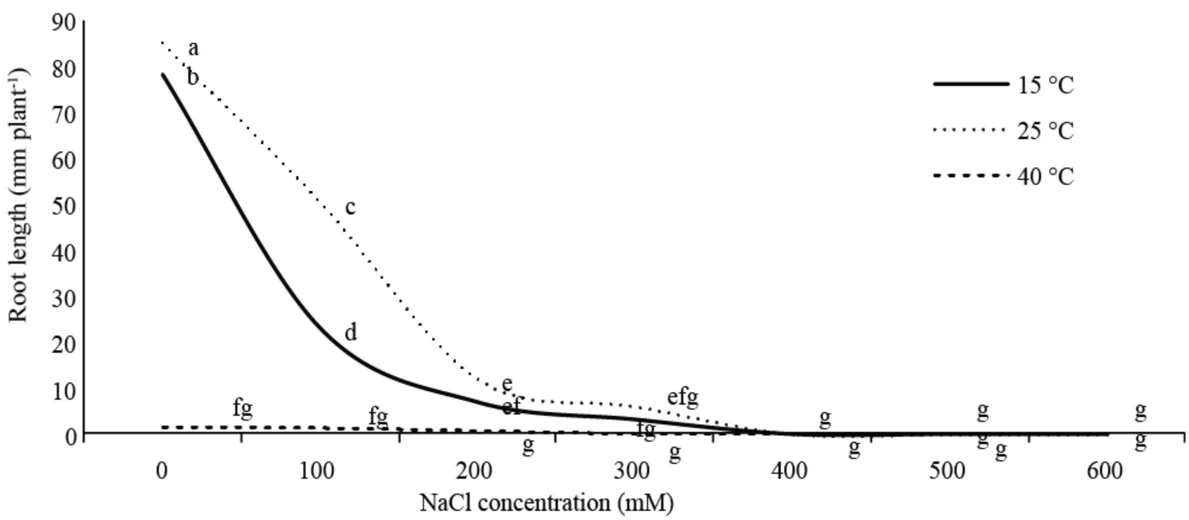


Fig. 7. Effect of temperature and NaCl concentration on root length (mm plant$^{-1}$) of *S. marianum*.

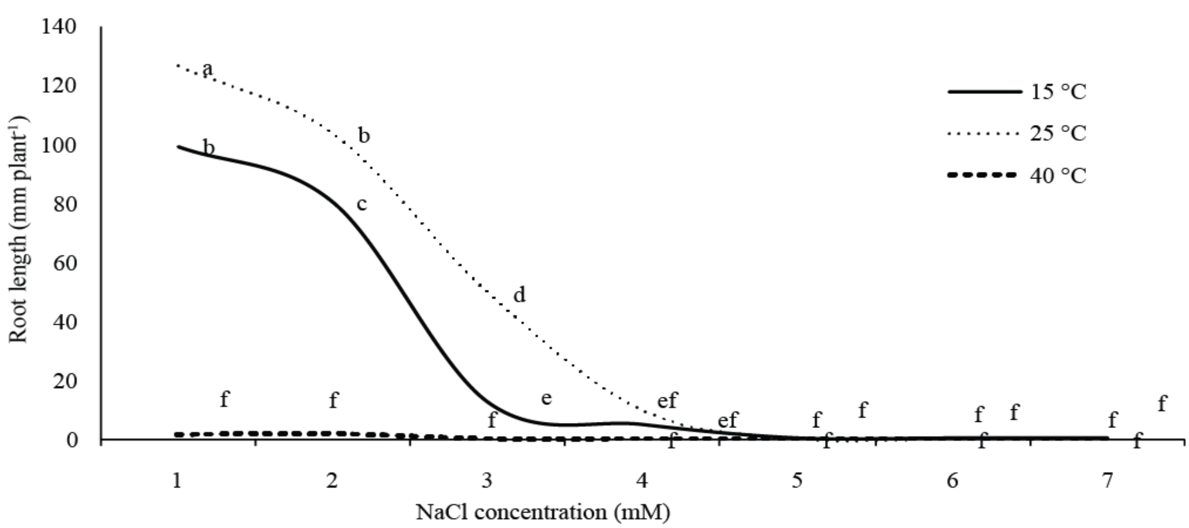


Fig. 8. Effect of temperature and NaCl concentration on root length (mm plant$^{-1}$) of *A. fatua*.

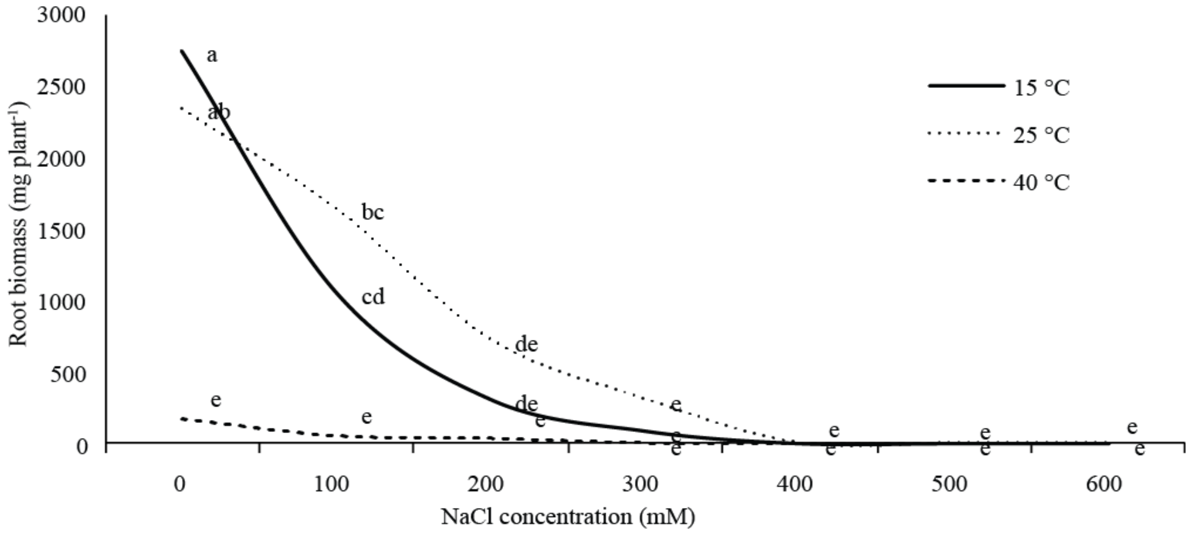


Fig. 9. Effect of temperature and NaCl concentration on root biomass (mg plant$^{-1}$) of *S. marianum*.

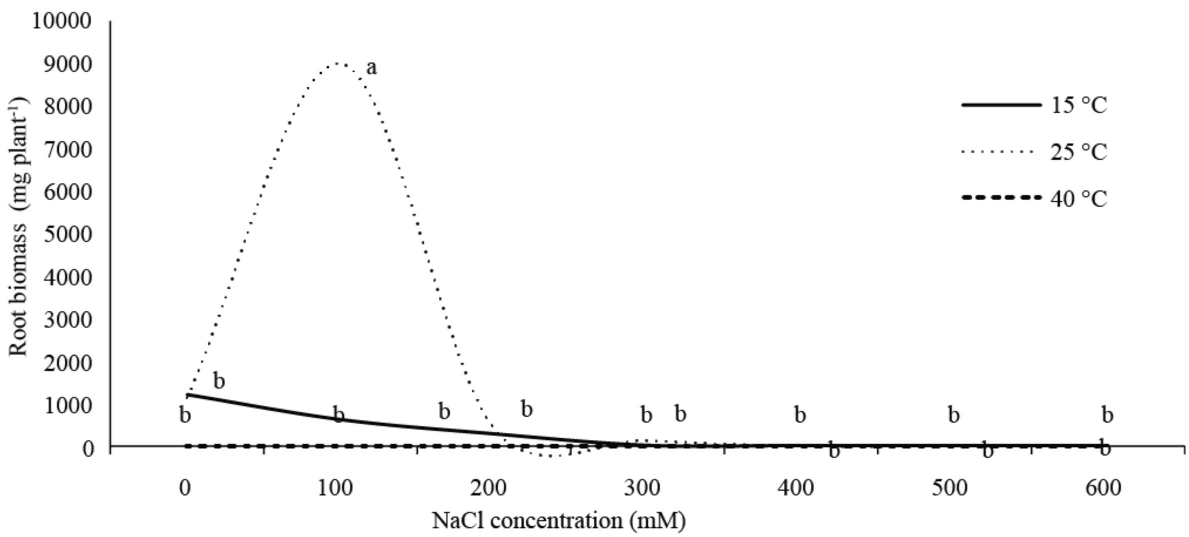


Fig. 10. Effect of temperature and NaCl concentration on root biomass (mg plant-1) of *A. fatua.* Means followed by different alphabets are significantly different from each other (in all the figures).

**Shoot length (mm plant$^{-1}$) and biomass (mg plant$^{-1}$):** Shoot length of *S. marianum* and *A. fatua* was highest (40.1 mm and 52 mm, respectively) at 25 $^{o}$C (Tables 1 and 2). During the study, it was also observed that higher temperature also resulted in increased seedling mortality. Data regarding the shoot biomass (mg) showed that the highest values for biomass was recorded at 25$^{o}$C (1106.1 mg) and 283.9 (mg) for *S. marianum* and *A. fatua*, respectively. Shoot biomass of both the weed species was significantly decreased due to higher levels of salinity. The shoot length of *S. marianum* and *A. fatua* was 64.8 and 91.6 mm at 0 mM (NaCl) which was followed by 47 and 75.4 mm plant$^{-1}$ at 100 mM NaCl, respectively. These results are similar to those reported by Sedghi *et al.* (2010) that increasing doses of salt had adverse effect on the shoot length. Interaction of temperature and salinity showed that lengthy shoot was observed at 25$^{o}$C under NaCl concentration of 0 mM, while shorter shoot was observed at temperature of 40$^{o}$C for *S. marianum* (Figs. 3 and 4) and *A. fatua* (Figs. 5 and 6), respectively. The decrease in growth of young seedling by increasing salinity was due to decrease in water absorption by radicle and by accumulation of soluble salts in the cell. It was observed that NaCl concentrations at zero and 100 mM produced similar biomass of shoot for both the weed species and were statistically at par with each other. The results of Ghanbari *et al.* (2013) are also in line with our studies that higher levels of salt negatively affect the growth of shoot of *S. marianum*. Sedghi *et al*. (2010) also reported that fresh and dry weight of plumule of *S. marianum* decreased with the increase of salinity. While Dinari *et al.* (2013) found that *A. fatua* had the longest shoots in 50 mM NaCl which was significantly different from other treatments. Decreasing trend was found in shoot length of *A. fatua* seedlings with increasing dose of NaCl. Khan & Khan (1978) had also found that sodium chloride and temperature had inhibitory effect on the growth. Thus the salt affected soils may not be ideal for the growth and establishment of *S. marianum*. Hence it is concluded that different combinations of temperature and NaCl concentrations can significantly affect the shoot length and biomass of the tested weed species.

**Root length (mm plant$^{-1}$) and biomass (mg plant$^{-1}$):** Root length and biomass of *S. marianum* and *A. fatua* were significantly affected by temperature and salinity (Tables 1 and 2). Regarding temperature, the root length was higher (22 and 41.3 mm) at 25°C which was followed by 16 and 28.1 mm plant$^{-1}$ at 15°C for *S. marianum* and *A. fatua,* respectively. Similarly at 25°C the highest biomass was recorded for *S. marianum* and *A. fatua* (714.8 and 1521.2 mg plant$^{-1}$), respectively.

Salt concentrations significantly affected the root length (mm plant$^{-1}$) of *S. marianum* and *A. fatua*. Distilled water had the maximum root length (55 and 75.86 mm plant$^{-1}$) followed by 24.91 and 61.90 mm plant$^{-1}$ in 100 mM NaCl concentration for *S. marianum* and *A. fatua*. With the increase of salt concentration, there was gradual decrease in the length of root (Tables 1 and 2). As roots are the primary organs that absorb nutrients, water and salt therefore, the negative effect of NaCl on root might be effective in weed management program for this weed. Root biomass was found highest (1749.6 mg) at distilled water which was followed by 914.63 mg at 100 mM NaCl concentration for *S. marianum*. In case of *A. fatua* the root biomass was recorded highest (3195.4 mg ) at 100 mM NaCl concentration while in distilled water it was 779.42 (mg). With increasing dose of salt the root biomass was found decreased. Interaction of temperature x NaCl concentration (Figs. 7-10) showed that highest root length (mm plant$^{-1}$) was observed at 25°C under NaCl concentration of 0.00 (mM) while lowest root length (mm plant$^{-1}$) was observed at temperature of 40°C for *S. marianum*. Sedghi *et al.* (2010) observed that the root length of *S. marianum* was decreased with the increasing concentration of NaCl. In a study related to salinity against other plants, Mer *et al.* (2000) observed that by increasing the level of salinity, radicle length was decreased in wheat, barley, pea and cabbage. Interaction of light, temperature and salinity was found significant and thus more studies are required by using different combinations of these factors for individual plant species. Dinari *et al*. (2013) reported that with increasing concentration of NaCl, the root length of *A. fatua* was decreased.

Sedghi *et al.* (2010) found that increasing dose of salinity negatively affected the fresh and dry weight of radicle. While Ghanbari *et al.* (2013) observed decreasing trend in the root weight of *S. marianum* with the increasing amount of salinity. These results showed that this plant is sensitive to salinity. However, this approach of salinity can be used if this plant is treated as weed. While as a crop, the increasing salinity may decrease the yield of this plant. Our resulted are in line with those reported by Zahedi *et al.* (2011) who communicated that salinity had decreased the root weight in basil seeds. The present results revealed that temperature as well as NaCl can greatly affect the root biomass. As roots are the organs that are responsible for absorption of nutrients and water therefore, any decrease in root biomass can significantly affect the growth and development of any plant.

## Conclusion

Keeping in view the present results, it is concluded that different regimes of temperature and NaCl concentration can affect the germination and growth of *S. marianum* and *A. fatua*. The germination, establishment, spread and infestation of an area by these weeds could be predicted by using such studies. By studying the response of all other major weeds to different level of temperature and salinity might be helpful in weed management approaches.

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