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EFFECT OF ENVIRONMENTAL FACTORS ON THE GERMINATION AND GROWTH OF *PARTHENIUM HYSTEROPHORUS* AND *RUMEX CRISPUS*

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Abstract

Germination is the key feature for the establishment of weeds in agro-ecosystem. To confirm this, a laboratory experiment was performed to investigate the impact of temperature and salinity on germination and seedlings attributes of two foremost weeds i.e. *Parthenium hysterophorus* and *Rumex crispus*. The sterilized seeds of both tested weeds were grown on Petri-dishes inside a growth chamber. The temperatures (15, 25 and 40°C) and NaCl concentrations (0, 100, 200, 300, 400, 500 and 600 mM) were applied. The statistically prominent effect of salinity and temperature was observed on germination and growth-related variables of both the weeds. The optimum temperature for growth and germination related variables of *P. hysterophorus* and *R. crispus* was found to be 25°C. By increasing (40°C) or decreasing (15°C) the temperature, reduction in germination and growth traits of both tested weeds was noted. In case of NaCl concentrations, *R. crispus* proved slightly more susceptible to salinity compared to *P. hysterophorus*. Both the species (*P. hysterophorus* and *R. crispus*) showed fair tolerance against salinity up to 100 mM of NaCl, however, above this concentration a significant reduction in germination were observed and was completely inhibited at 500 and 600 mM NaCl, respectively. A significant decline in growth was perceived with an increase in NaCl concentration. Conclusively, it was revealed that the establishment of both tested weeds was influenced significantly by temperature and NaCl concentrations. Thus the growth pattern, competitive ability, infestation and spread of these weeds can be correlated with the temperature and salinity for their control in agro-ecosystems.

Key words: *Parthenium hysterophorus; Rumex crispus;* Salinity; Temperature.

Introduction

Weeds are considered a major pest that decrease the crop yield and interfere with human efforts. Among these weeds, *Parthenium hysterophorus* and *Rumex crispus* are major weeds of agro-ecosystem in Pakistan and are becoming a major weed of cropped and non-cropped areas in Pakistan (Adkins & Navie, 2006). These weeds infested almost all field crops, pastures, wastelands, yards, and rights-of-ways and when left uncontrolled, it could reduce crop yields by 40 to 97% (Tamado & Milberg, 2004; Zaller, 2004). It has been described that it can severely affect agriculture, animal and human health, environment, and biodiversity and thus contributes to social and economic insecurity (Kohli *et al.*, 2006).

Successful germination of seeds is imperative for the persistence of weeds. The weed seeds have more chances to survive if they alter their behavior in response to various environmental dynamics such as temperature, light and soil conditions. The seeds that do not respond to these conditions may diminish or die. However, the success of plants mainly depends on successful germination (Gorai & Neffati, 2007; Kashmir *et al*., 2016). Different biological and environmental dynamics regulate the germination of seed. The response of weed seeds to these factors is different and depends from species to species. The knowledge of optimal requirements for germination and growth of a plant is always useful to recognize the biology and ecology of different plants. Salinity and temperature are key abiotic factors that influence germination of seed (Gardarin *et al.*, 2010). Extreme temperature and salinity (Iqbal *et al.*, 2006) can prevent germination, whereas a higher level of salinity retarded the seed germination and decreases root growth (Koger *et al*., 2004). The increase in temperature causes inhibition in the seed germination of several plant species (El-Keblawy & Al-Rawai, 2005). Therefore for managing weeds, environmental factors need to be studied to avoid the repeated use of herbicides.

Environmental dynamics such as salinity and temperature influence the weed seeds in a similar pattern as to other crops. By reviewing the response of several seeds to these dynamics, can help to predict the growth, spread, and existence of these weeds species. While, the interaction between temperature and salinity can change these responses and the negative impact of salinity is stronger at high and low temperatures (Zia & Khan, 2004). In contrast, salinity tolerance in certain species, such as *Arthrocnemum indicum*, does not depend on temperature (Khan & Gul, 1998). Therefore, the interaction of salinity and temperature due to complex processes can have substantial ecological effects (Ungar, 1995).

The optimal temperature for most of the temperate species is 15-30°C for seed germination with an average of 21°C (Copeland & Mc-Donald, 2004). Even a minute variation in temperature, some species respond differently during germination (Khan *et al.*, 2000a), whereas other species show little effect (Khan *et al.*, 2002). Therefore, salinity and temperature have a substantial impact on the germination of seed (Khan & Ungar, 2001). Different phases of plants development may be affected by salt stress (Munns & Tester, 2008). The ability of seeds to withstand under salinity stress and high temperatures would provide an ecological advantage in extreme climatic conditions (Khan & Gul, 2006). In addition, the response of different species and their tolerance to salt and temperature is always different (Song *et al.*, 2006). Therefore, the environmental

factors individually or in combination can provide interesting results for weed management.

In Pakistan the land area that is affected by the salt is 6 million ha (Rafiq, 1990) in which 4.2 million ha under the irrigated region. Due to the large salt affected areas, it is therefore essential to investigate the weed response to salinity and temperature. Such studies will greatly help in predicting the possibilities of weed seed germination and growth that will consequently guide the famers to formulate weed management program. This study is useful for investigating the potential of temperature and salinity for the competitive ability, spread, growth and establishment with the associated crops. Two of the country's major weeds (*Parthenium hysterophorus* and *Rumex crispus*) were selected for the experiment to assess the impact of various temperature and salinity levels on their germination and growth. Studies are helpful for designing weed management and weed prevention programs in different ecological zones of the country.

Materials and Methods

Weed seed collection and experimental protocol: The seeds of two major weeds (*P. hysterophorus* and *R. crispus*) were obtained from the Weed Science department of Unversity of Agriculture, Peshawar, Pakistan. These seeds were well sterilized with the mixture of two fungicides Metalaxyl + Mancozeb at the concentration of 72% to avoid the fungal attack during experimentation procedures.

All the Petri dishes were sterilized for a period of one hour at the temperature range from 110-120°C in an autoclave (ST. Francis, Model STA-130). Twenty sterilized seeds of each weed species (*P. hysterophorus* and *R. crispus)* were placed on the double layer of Whatman filter paper No.1 in the Petri dishes having a diameter of 9 cm. Petri dishes were arranged in a completely randomized design (CDR) with four replicates. 10ml tested solution was applied to each petri dish. At 15°C, the Petri dishes were placed in a germinator (Nuaire, DS52SDF) for the germination of the seeds. The germinator was also fixed at the temperatures of 25°C and then at 40°C separately to test the germination of both species. The germination was also tested at 0, 100, 200, 300, 400, 500 and 600 mM concentrations of NaCl. Equal amount of water was added to all the treatments as per need. The seeds having 2 mm radical were considered as germinated.

Parameters studied: Seed germination of both the weed species were calculated for 20 days after starting the experiment and then percentage was obtained by using the following formula;

$$\text{Germination \%} = \frac{\text{No. of germinated seeds}}{\text{Total no. of seeds used}} \times 100$$

Data for mean germination time (MGT) of seedlings was calculated. Following formula (Scott *et al.,* 1984) was applied to get the MGT.

$$\text{Mean germination time} = \sum \text{Ti Ni/S}$$

where, Ti = Number of days after beginning of the experiment
Ni = Number of seeds germinated on the day
S = Total number of seeds germinated

Data for the germination index (GI) was recorded and the seeds having greater GI were considered more vigorous. Results were obtained by applying the following formula (Maguire, 1962).

$$\text{SG or GI} = n / d$$

where, n = Number of seedlings emergence on day'd'
D = Days after setting the seeds for germination

Data for the seed vigor index (SVI) of seedlings was recorded. The SVI was obtained by applying the following formula (Abdul-Baki & Anderson, 1973).

$$\text{Seed vigor index (SVI)} = \frac{\text{\% Germination (seedling)}}{\text{Seedling length in mm}}$$

Shoot and root length (mm) of each species were calculated by using measuring tape at 20 days after starting the experiments and average was recorded. The electronic balance was used for recording the root and shoot biomass (mg plant^{-1}) of the seedlings at 20 days after starting the experiment.

Statistical analysis

For testing the effect of salinity and temperature on the germination and growth of both species, three-way of variance (ANOVA) was applied and by using Statistix Version 2.0. The treatment means were separated by least significance difference (LSD) at 5% probability level (Steel *et al*., 1997).

Results

Germination (%): The effect of temperature and salinity on germination percentage of *P. hysteropuorus* and *R. Crispus* was significant (Tables 1 & 2). The highest seed germination of 37.77% was observed for *P. hysterophorus* and 38.21% for *R. crispus* at a temperature of 25°C. This temperature was considered the optimum temperature for the germination of both weed species. By decreasing the temperature to 15°C showed 8.8% decrease in the germination of *P. hysterophorus* and 14.5% in the germination of *R. crispus*. However, a quick decline in the germination of both weed species was observed with the increasing temperature up to 40°C. At this temperature, germination of *P. hysterophorus* and *R. crispus* was decreased by 83.7% and 85.3%, respectively. The results obtained from temperature illustrated that solarisation of the soil may be a productive step of managing these weeds in crop production at small scales such as fruit or vegetable nurseries. Soil temperature was increased by soil solarization up to a significant level which might alter the weed seed germination.

There was a gradually decreasing trend in the germination of these weed species when the concentration of NaCl was increased. A 100 mM NaCl concentration showed no effect on the germination (statistically at par with the control). A sharp decline in the seed germination of both weeds was observed with 200 mM concentration of NaCl. However, germination of both the weeds was greatly inhibited at 500 and 600 mM concentration of NaCl. From the current studies, it can be observed that those areas where the temperature remains higher than 40°C, the germination of *P. hysterophorus* and *R. Crispus* can be poor and these species may not become the major weeds due to high temperature. The optimum temperature and the concentration of NaCl in the soil of these regions are suitable for the germination and growth of these species. The interaction between temperature and the concentration of NaCl was very significant for both of these weeds (Figs. 1 & 2). However, salinity showed a negative effect on the germination percentage of these species which was severe at higher temperature as compared to lower. Similarly, the change in the optimum range of temperature and the concentration of NaCl may bound the germination and distribution of these weeds. The chances of these species to shift from one region to another due to ecological changes may become a severe problem. Thus it is suggested that such studies can greatly help in the preventive weed control programs.

Mean germination time (MGT), germination index (GI) and seed vigor index (SVI): There were substantial response of mean germination time (MGT), germination index (GI) and seed vigor index (SVI) of both weeds (*P. hysterophorus* and *R. crispus*) to temperature and NaCl concentrations (Tables 1 & 2). At 40ºC temperature, the MGT for the *P. hysterophorus* and *R. crispus* were 1.05 and 2.06 days that took less time as compared to the temperature of 25ºC and 15ºC. These results indicated that MGT of the seed germination of this weed was lower and higher as compared to optimum temperature. The GI of *P. hysterophorus* was highest (0.54%) under optimum temperature (25ºC) which was followed by 15ºC (0.38) and 40ºC (0.10%). In the case of *R. crispus*, temperature of 25ºC had the highest value of GI that was 0.33%. While at 15ºC and 40ºC, the values were 0.0.27 and 0.12%, respectively. The level of activity and performance of seeds during germination and seedling emergence was expressed by SVI. Highest SVI of 1213.9 was observed in *P. hysterophorus* and 1776.2 in *R. crispus* at the optimum temperature (25ºC) as compared to lower and higher temperature (15ºC and 40ºC). This indicated that a higher temperature could decrease the SVI of both tested weeds.

Table 1. Germination response of *P. hysterophorus* to temperature and salinity.

Treatments Temperature (ºC)	Germination (%)	Mean germination time (MGT)	Germination index (GI)	Seed vigor index (SVI)
15	34.46 b	2.95 b	0.38 b	767.1 b
25	37.77 a	3.47 a	0.54 a	1213.9 a
40	6.16 c	1.05 c	0.10 c	27.1 c
LSD0.05	*1.96*	*0.27*	*0.05*	*125.64*
NaCl Solution (mM)				
0	64.16 a	3.45 c	1.17 a	1862.5 a
100	62.29 a	4.63 a	0.75 b	1633.4 b
200	35.83 b	3.90 b	0.30 c	846.60 c
300	16.88 c	3.70 bc	0.15 d	254.31 d
400	3.75 d	1.75 d	0.02 e	88.69 de
500	NG	NG	NG	NG
600	NG	NG	NG	NG
LSD0.05	*3.00*	*0.41*	*0.08*	*191.92*

Means followed by different letters are significantly different at 5% (lower case) probability level. NG = No germination

Table 2. Germination response of *R. crispus* to temperature and salinity.

Treatments Temperature (ºC)	Germination (%)	Mean germination time (MGT)	Germination index (GI)	Seed vigor index (SVI)
15	32.68 b	3.24 b	0.27 b	895.1 b
25	38.21 a	4.91 a	0.33 a	1776.2 a
40	5.63 c	2.06 c	0.12 c	46.1 c
LSD 0.05	*2.24*	*0.27*	*0.03*	*178.68*
NaCl Solution (mM)				
0	55.42 a	5.23 b	0.63 a	2666.7 a
100	52.08 a	5.19 b	0.51 b	2002.7 b
200	39.58 b	6.21 a	0.35 c	1029.1 c
300	22.29 c	4.62 c	0.17 d	576.88 d
400	6.25 d	2.58 d	0.02 e	45.46 e
500	2.92 de	0.00 e	0.00 e	19.60 e
600	NG	NG	NG	NG
LSD 0.05	*3.42*	*0.42*	*0.05*	*272.92*

Means followed by different letters are significantly different at 5% (lower case) probability level. NG = No germination

Table 3. Growth response of *P. hysterophorus* to temperature and salinity.

Treatments Temperature (°C)	Shoot length (mm plant^{-1})	Shoot biomass (mg plant^{-1})	Root length (mm plant^{-1})	Root biomass (mg plant^{-1})
15	5.27 b	17.89 b	6.64a	7.64 b
25	10.06 a	37.29 a	6.76 a	24.73 a
40	0.89 c	1.19 c	0.40b	0.61 b
LSD Value	*0.78*	*6.67*	*1.77*	*13.32*
NaCl Solution (mM)				
0	12.29a	44.33 a	10.37 a	9.21 b
100	10.68b	47.63 a	9.33 a	30.21 a
200	7.35 c	25.83 b	6.44 b	16.92 ab
300	4.45 d	11.42 c	2.58cd	18.92 ab
400	2.90 e	2.33 cd	3.48c	1.71 b
500	NG	NG	NG	NG
600	NG	NG	NG	NG
LSD 0.05	*1.20*	*10.20*	*2.70*	*20.34*

Means followed by different letters in their respective columns are significantly different at $p \leq 0.05$ according to least significance difference (LSD) test. NG = No germination

Table 4. Growth response of *R. crispus* to temperature and salinity.

Treatments Temperature (°C)	Shoot length (mm plant^{-1})	Shoot biomass (mg plant^{-1})	Root length (mm plant^{-1})	Root biomass (mg plant^{-1})
15	10.72b	361.98 b	5.70a	131.50 a
25	17.95a	542.43 a	7.19a	105.61 a
40	1.27c	36.38 c	0.55b	1.54 b
LSD 0.05	*1.30*	*88.22*	*02.13*	*59.78*
NaCl Solution (mM)				
0	28.76a	878.08 a	9.37a	164.08 b
100	18.85b	664.71 b	9.39a	291.71 a
200	12.44c	389.04 c	5.51b	71.00 c
300	7.85d	239.75 d	5.47b	19.71 c
400	1.40e	21.92 e	1.05c	6.08 c
500	0.55e	1.67 e	0.57c	4.25 c
600	NG	NG	NG	NG
LSD 0.05	*1.99*	*134.75*	*3.25*	*91.31*

Means followed by different letters in their respective columns are significantly different at $p \leq 0.05$ according to least significance difference (LSD) test. NG = No germination

In case of NaCl concentrations, the MGT of *P. hysterophorus* and *R. crispus* was highest (4.63 and 6.21, respectively) at 100 and 200 mM of NaCl concentration, respectively (Tables 1 & 2). Zero germination was observed when the concentration was increased beyond 400 mMNaCl concentration. Data regarding the GI showed that the maximum values for GI with distilled water were (1.17% and 0.63%) for*P. hysterophorus* and *R. crispus*, respectively. However, by increasing the NaCl concentration from 100, 200, 300 and 400 mM the GI of both weeds was reduced significantly and at higher NaCl concentrations of 500 and 600 mM that totally inhibited seed germination and thus zero GI was recorded. Salt concentrations significantly affected the SVI of *P. hysterophorus* and *R. crispus*. Compared to all treatments, distilled water had the maximum SVI (1862.5 and 2666.7) which was followed by 1633.4 and 2002.7 in 100 mM NaCl concentration for *P. hysterophorus* and *R. crispus*. The SVI of both the weed species was significantly decreased due to higher levels of salinity (Tables 1 & 2).

Shoot length (mm) and biomass (mg): The shoot length and shoot biomass of *P. hysterophorus* and *R. crispus* also were significantly ($p \leq 0.05$) affected by temperature (Tables 3 & 4). The same pattern was followed as those of germination. At 25°C temperature, considered to be the best, produced maximum shoot length and shoot biomass (10.06 mm and 37.29 mg, respectively) for *P. Hysterophorus* while at the lowest temperature (15°C), there was a reduction in shoot length and shoot biomass by 47.6 and 52.0%, respectively. Greater reduction in shoot length (91.2%) and biomass of 96.8% were recorded at the highest temperature (40°C). Likewise, 25°C temperature produced the highest shoot length and shoot biomass (17.95 mm and 542.43 mg, respectively) for *R. crispus.* While at the lowest temperature (15°C), there was a reduction in shoot length and shoot biomass by 40.3 and 33.3%, respectively. The shoot length and biomass were also decreased by 92.9 and 93.3%, respectively at the highest temperature 40°C.

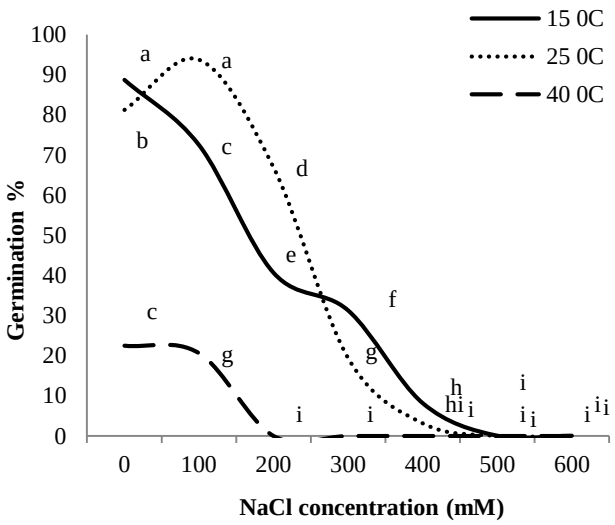

Fig. 1. Effect of temperature × NaCl concentration on germination (%) of *P.hysterophorus.* Means followed by different alphabets are significantly different from each other.

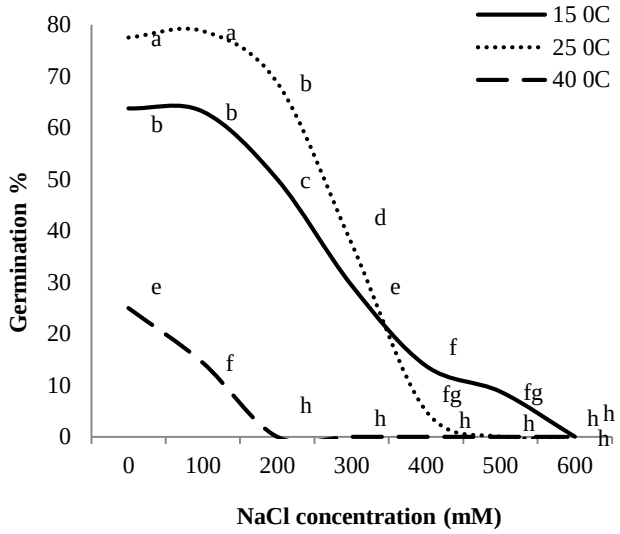

Fig. 2. Effect of temperature × NaCl concentration on germination (%) of *R. crispus*. Means followed by different alphabets are significantly different from each other.

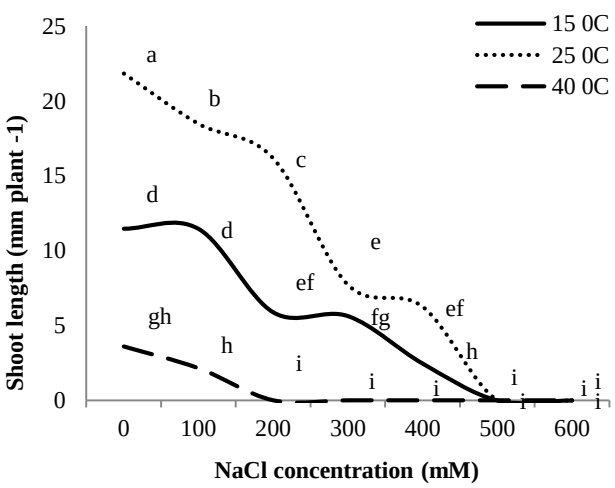

Fig. 3. Effect of temperature × NaCl concentration on shoot length (mm plant^{-1}) of *P.hysterophorus.* Means followed by different alphabets are significantly different from each other.

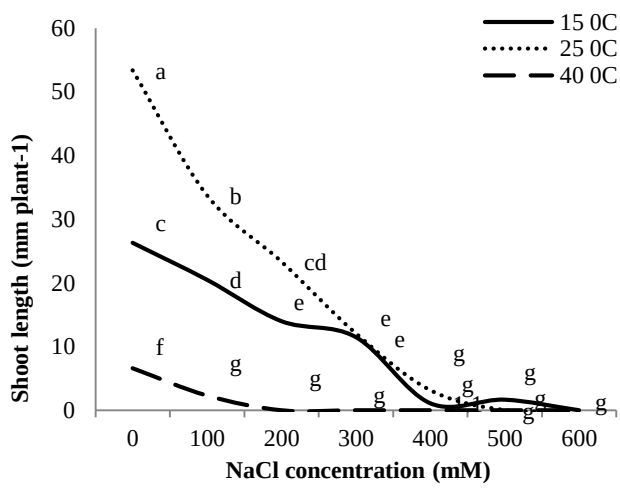

Fig. 4. Effect of temperature × NaCl concentration on shoot length (mm plant^{-1}) of *R. crispus*. Means followed by different alphabets are significantly different from each other.

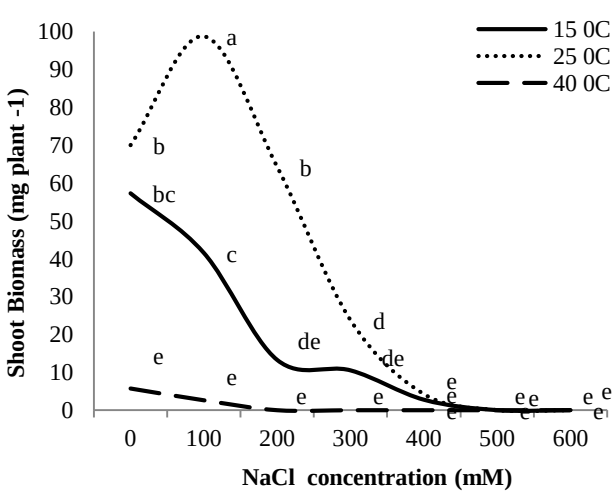

Fig. 5. Effect of temperature × NaCl concentration on shoot biomass (mg plant^{-1}) of *P.hysterophorus.*Means followed by different alphabets are significantly different from each other.

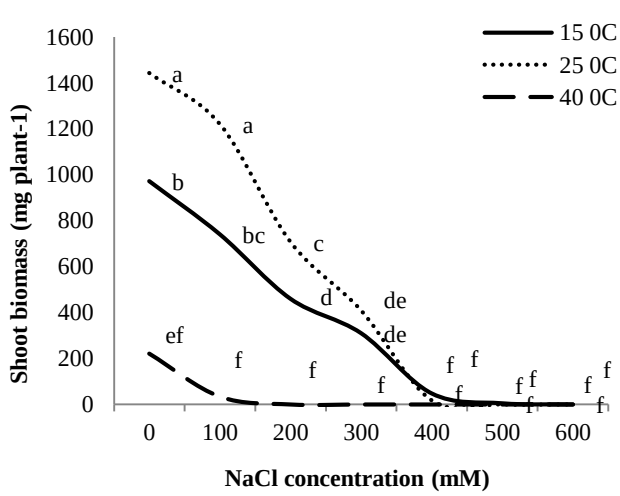

Fig. 6. Effect of temperature × NaCl concentration on shoot biomass (mg plant^{-1}) of *R. crispus*. Means followed by different alphabets are significantly different from each other.

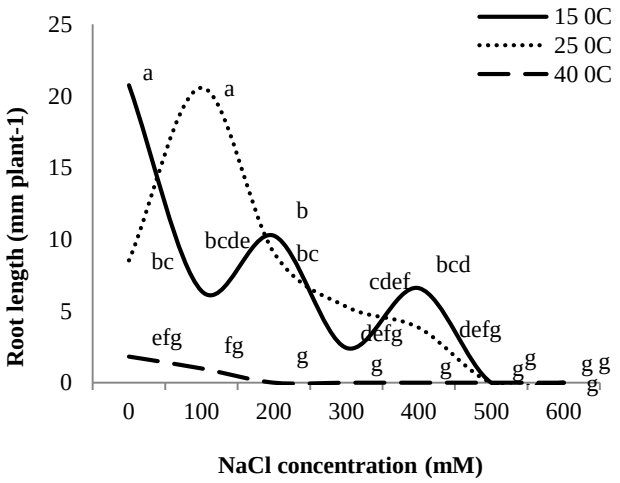

Fig. 7. Effect of temperature × NaCl concentration on root length (mm plant^{-1})of *P.hysterophorus.*Means followed by different alphabets are significantly different from each other.

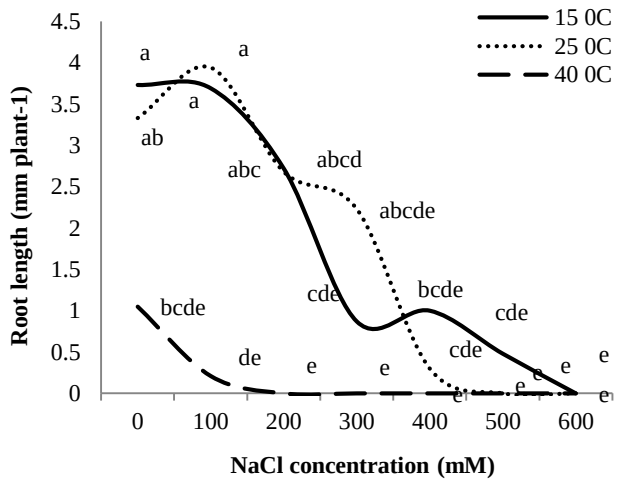

Fig. 8. Effect of temperature × NaCl concentration on root length (mm plant^{-1}) of *R. crispus*. Means followed by different alphabets are significantly different from each other.

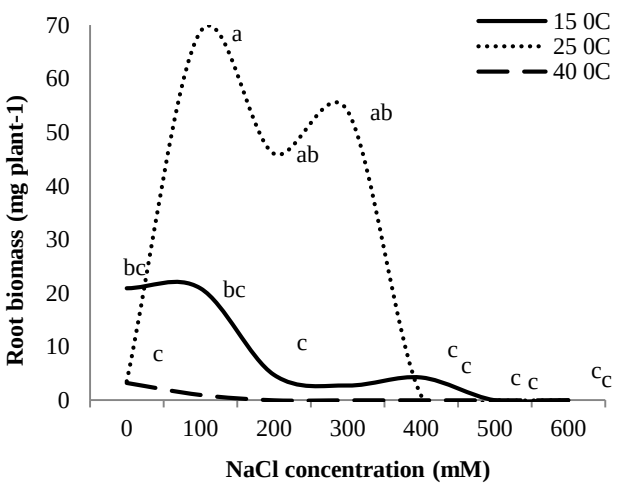

Fig. 9. Effect of temperature × NaCl concentration on root biomass (mg plant^{-1}) of *P.hysterophorus.* Means followed by different alphabets are significantly different from each other.

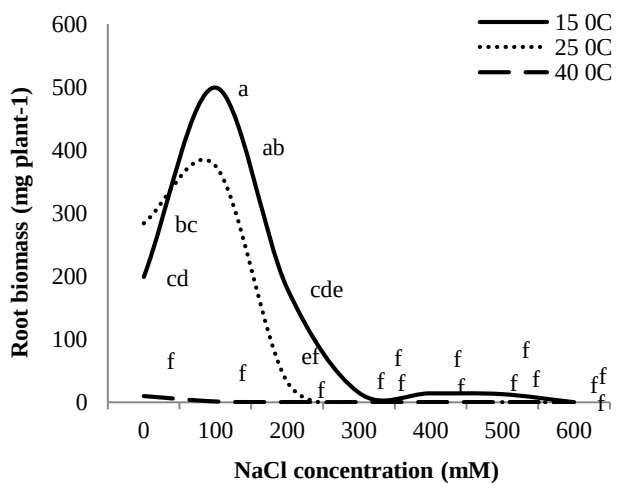

Fig. 10. Effect of temperature × NaCl concentration on root biomass (mg plant^{-1}) of *R. crispus*. Means followed by different alphabets are significantly different from each other.

Salinity also significantly ($p \leq 0.05$) affected the shoot length and shoot biomass of both weed species (Tables 3 & 4). All the concentrations of NaCl applied in these studies were very detrimental for the length and biomass of shoot of *P. hysterophorus* and *R. crispus*. At lower concentration, the shoot length and biomass of both species significantly decreased when there was no germination above 500mM concentration of NaCl. The effect of concentration of NaClwasmore effective on the germination of *R. Crispus* as compared to *P. hysterophorus.* Temperature and salinity interaction showed that at a temperature level of 25°C under the NaCl concentration of 0 mM maximum shoot length was observed (Figs. 3 & 4). While the lowest shoot length was recorded at 40°C temperature for *P. hysterophorus* and *R. crispus.* The seedling growth may have been reduced due to less absorption of water by radical and high soluble salt concentration in the cells. At 25°C temperature, maximum shoot biomass of *P. hysterophorus* was recorded with NaCl concentrations of 100 mM, while shoot biomass of *R. crispus* was highest at 0 mM of NaCl concentrations with 25°C temperature (Figs. 5 & 6). Reduction in the biomass is considered an important trait for the management of weeds. Therefore, the concentration of NaCl in the soil significantly affects the growth of *R. crispus.*

Root length (mm) and biomass (mg): The root length and root biomass of both weed species were also significantly ($p \leq 0.05$) affected by the temperature (Tables 3 & 4). The lower temperature of 15°C and 25°C had the same effect on the root length of *P. hysterophorus* and produced 6.64 and 6.76 mm long roots, respectively. On the other hand, the minimum root length (0.40 mm) of the same species was recorded at the highest temperature of 40°C. However, the root biomass of this weed followed the same trend as its shoot biomass. Maximum root biomass (24.73 mg) was recorded at 25°C temperature, while root biomass was reduced by 69.1% at 15°C and 97.5% at 40°C was noted. Similarly, the lower temperature of 15°C and 25°C had the same effect, while the highest temperature of 40°C drastically reduced the root length and biomass to 0.55 mm plant^{-1} and 1.54 mg plant^{-1}, respectively.

The root length and biomass of *P. hysterophorus* and *R. crispus* were significantly ($p \leq 0.05$) reduced by increasing NaCl concentration mostly beyond the 200 mM.While lower NaCl concentration (100 mM) did not affect the root length of both weed species but at this concentration root biomass of both weeds enhanced significantly over control. That's why the root biomass of *P. hysterophorus* (30.21 mg plant^{-1}) and *R. crispus* (291.71 mg plant^{-1}) were recorded which were significantly higher by 69.5 and 43.8% than distilled water and it showed that NaCl concentration at lower level increased the biomass of root. Whereas, all other higher concentrations of NaCl declined the root length and biomass of both tested weeds (Tables 3 & 4).The data showed that the suppression of root depended upon the concentration of salt. Interaction of temperature and NaCl concentration showed that maximum root length of both weeds was observed at 15°C under NaCl concentration of 0.00 mM while lowest root length was observed at a temperature of 40°C (Figs. 7 & 8). The root biomass was highest at 25°C and 15°C under 100 mM NaCl concentration for *P. hysterophorus* and *R. crispus*, respectively (Figs. 9 & 10).

Discussion

According to the mutation and adaptation theories, with the passage of time, gradual changes occur in plant species. Temperature plays an important role in the germination and growth of radical and plumule, which eventually effects the growth and establishment of plants. At higher temperature, this phenomenon may change the performance of *P. hysterophorus* and *R. crispus* via the germination process. Results of these studies showed that a temperature of 25°C was the optimum temperature for the germination of studied weeds. Many scientists checked the germination of different weeds at different temperatures. *Rorippa subumbellata* (tohoe yellow cress) germination was maximum at a temperature of 24°C and was significantly reduced little below or above this optimum temperature (Ingolia *et al.,* 2008).In a similar studies, Chandra (1991) explained that reduction in seed germination occurred when the temperature fell below 19°C because plants could feel cold temperature by membrane fluidity, whereas the involvement of heat shock proteins was responded by high-temperature (Jones *et al.,* 2013). Eslami (2011) stated that maximum germination (91%) of *Chenopodium album* L. was observed at 25°C and by increasing temperature reduction in germination was observed. Kashmir *et al*., (2016) revealed that the highest germination was recorded at a temperature of 25^{o}C. These results were also in accordance with Adegbaju *et al*., (2018) who found that under optimum temperature (25°C) the GI value was high for *Celosia argentea* L. *olitorus.* It is also reported that seed dormancy is regulated by temperature and light (Baskin & Baskin, 2004). A majority of the temperate plants germinate more vigorously when temperature range between 15-30^{0}C with an average of 21^{0}C (Copeland &Mc-Donald, 2004). Due to these reasons, these two weeds are well established and successful in the new environment. That's why, it is suggested that changing behavior of temperature may suppress the germination of these weeds.

In light of these findings, it can also be considered that different salinity levels can significantly affect the infestation and establishment of *P. hysterophorus* and *R. crispus.* A significant decline in growth was perceived with the increase in NaCl concentration. Both weeds showed a good tolerance against salinity up to 100 mM NaCl and growth was completely inhibited at 500 and 600 mM NaCl, respectively. The MGT was decreased when the NaCl concentration was increased beyond a certain limit. It is also observed that root biomass increased with decreasing the concentration of NaCl. However, weed competitive ability depends upon the widespread root system. In an analogous study, the decline in the germination was also observed at higher salinity as compared to no salt concentration (Jamil *et al.,* 2006). Khurshid *et al.,* 2012 also reported that the suppression in the germination of *P. hysterophorus* was up to 88% at a higher level of salt. Our results agreed with the findings of other researchers who noted a delay in seed germination with an increase in NaCl (Tanveer *et al.,* 2012). Sanchez *et al*., (2014) reported that mean germination time was generally increased as the salinity level increased. In analogous studies, Tanveer *et al.,* (2012) reported that the distilled water and lower concentration of salt had high SVI of *Cucumis melo*. In another study, it was noted that the shoot length of the plant was decreased by increasing the salinity level in the soil (Sanchez *et al.,* 2014). According to Bae *et al.,* (2006), seeds germinated under salinity reduced shoot growth of many weed species. The reduction in the shoot length and biomass by increasing the concentration of NaCl may be helpful in the management of weeds. Therefore, salt-tolerant crops may survive best as compared to weeds in salt-affected soils. Jeannette *et al.,* (2002) also reported that root fresh weight was significantly declined by increasing the salt stress. Similarly, Imada *et al.,* (2015) recorded maximum root length and biomass at 100 mM NaCl concentration. From this study, it can also be stated that the optimum temperature and the concentration of NaCl in the soil of these regions having these environmental conditions are suitable for the germination and growth of these species. That's why, it can be decided that less saline soil may favour these weed species against crop if the crop is sensitive to the salinity. Thus, additional studies are required to show the influence of temperature and concentration of salt on other weeds for the management of these species.

Conclusion

This results of the present studies concluded that temperature and NaCl concentration highly affected the growth of *P. hysterophorus* and *R. crispus*. The optimum temperature for germination of *P. hysterophorus* and *R. crispus* was 25°C. These weeds can withstand a wide range of salinity and have a potential to tolerate extreme salinity up to 100 mM NaCl concentration, however, above this concentration a significant reduction in germination was observed and completely inhibited at 500 and 600 mM NaCl, respectively. The germination and seedlings traits were also influenced by these environmental factors. Therefore, these weeds can be suppressed by the mentioned ecological factors in cropped and non-cropped areas. However, further studies are required to appeal successful results.

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