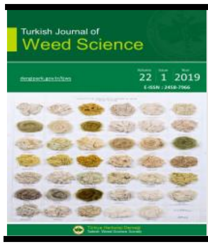

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Araştırma Makalesi / Research Article

Effect of Temperature, Salinity and Sodium Bicarbonate on Germination of Russian Tumbleweed (*Salsola ruthenica* Iljin.)

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ABSTRACT

Russian tumbleweed (*Salsola ruthenica* Iljin.) is a plant, which commonly places in agricultural areas, orchards, and roadsides. The aim of this study is to obtain information about seed germination physiology of Russian tumbleweed. The results may help improve control strategies for this weed, and enlighten to further studies. For this purpose, mature seeds of Russian tumbleweed were collected from the areas of near Lake Van in 2015. Experiments were conducted in the laboratory conditions to determine the effect of temperature, salinity (NaCl), and sodium bicarbonate ($NaHCO_3$) on seed germination of Russian tumbleweed. Seeds were germinated at five alternating temperatures (5/10, 10/20, 15/25, 20/30, and 25/35 ºC), five salt concentrations (0, 200, 400, 600, and 800 mM NaCl) and five sodium bicarbonate concentrations (0, 50, 100, 200, and 400 mM $NaHCO_3$) with a 12 h photoperiod. OGT obtained at 15/25 ºC and germination percentage was 71.5%. The highest germination rate was determined at 0 mM (control) NaCl and $NaHCO_3$, 71.5% and 65.5%, respectively. Finally, although it is known a halophyte plant, Russian tumbleweed hasbetter germination rates when it place salt or soda free mediums.

Key Words: Russian tumbleweed, *Salsola ruthenica*, salt, seed germination, sodium bicarbonate

INTRODUCTION

Russian tumbleweed (*Salsola ruthenica* Iljin.) spread from Central and South Asia to other part of the world such as, Asia, Europe, and North Africa, as well as in North America and Australia and was described by Modest Mikhailovich Iljin (Davis, 1967; TUBIVES, 2018). Russian tumbleweed stand along the road, especially in the poorly managed meadow and pasture areas, agricultural fields, in deserts, and also in destructed forests. It is commonly found in semi-arid regions with cold winter and dry summer and may survive up to 1750 meters (Mosyakin, 1996; CABI, 2018).

It is known that the Russian tumbleweed is an important weed in the agricultural areas, especially in the cereal fields near the lake shore of Van province (Tepe, 1989). In another study carried out in apple and pear gardens in Van, this species was considered as a weed (Yazlık and Tepe, 2001).

Having futher information about some physiologic characteristics of weeds provide opportunity to develop more accurate solutions on account of integrated weed control. In this study, it was aimed to determine some germination features of the seed of Russian tumbleweed.

MATERIALS and METHODS

Materials

Mature seeds of Russian tumbleweed (*Salsola ruthenica* Iljin.) were collected from the areas of near Lake Van, Turkey (38º 33' 45" N; 43º 17' 50" E; 1660 m ASL) during October-December 2014. The seeds collected from the fields were kept in ambeint conditions in the laboratory, and the studies were carried out in 2015 in the growth chamber and laboratory of Plant Protection Department.

The fields, in which the seed collected in, had low salt content and were slightly alkaline and were classified as 'regosol' according to the WRB classification system (Gulser et al., 2000; FAO, 2006). Climatic properties of this region was sorted as 'warm summer continental (Dsb)' according to the Köppen-Geiger climatic classification (Peel et al., 2007). The average temperature, annual precipitation and was relative humidity were 9.1 ºC, 387 mm and 59.0% over (for) the long-term period of Van (TSMS, 2014), respectively. Lake Van is the largest lake in Turkey and is also the largest soda lake of the earth (Degens et al., 1984). When the chemical structure of the lake is considered, the water is bitter, a saline lake exhibiting a distinct soda chemistry defined by the fact that alkali cations, in particular sodium and potassium, maintain the charge balance of bicarbonate and carbonate ions in addition to alkaline earth ions, naturally this structure is also seen in the soil near the lake (Reimer et al., 2009).

The equipments made from glass used in the experiments were sterilized at 200 ºC for two hours, and plastic materials were autoclaved at one atmospheres pressure and 121 ºC for one hour and sterile distilled water was used in all experiments.

Methods

The viability of Russian tumbleweed seeds collected from their habitat were TTC (evaluated triphenyl tetrazolium chloride) test in the laboratory and after that germination rates of the seeds were calculated.

Glass Petri dishes (80 mm-diameter) were used in the germination experiment. A double layer of filter paper (MN 751/75/20) was placed at the bottom of each Petri dish. The experiment was established in one factorial design in four replications. The seeds were manually separated from perianths and then sterilized by soaking in 1% commercial bleach (sodium hypochlorite) for five minutes. The seeds were rinsed with distilled water and air dried, fifty seeds were placed in a Petri dish for each replication. A 5 ml of distilled water or with aqueous solutions of NaCl and $NaHCO_3$ were added on the seeds in the Petri dishes. Surroundings of Petri dishes are covered with 'parafilm' to prevent contamination and moisture loss. Based on the method used by Guma et al. (2010), the seeds were germinated at five alternating temperatures (5/10, 10/20, 15/25, 20/30, and 25/35 ºC), five salt concentrations (0, 200, 400, 600, and 800 mM NaCl) and five sodium bicarbonate concentrations (0, 50, 100, 200, and 400 mM $NaHCO_3$) with a 12 h dark/light photoperiod. Five different sodium bicarbonate concentrations (0, 50, 100, 200 and 400 mM $NaHCO_3$) were applied to the seeds at 15/25 ºC, which was determined as optimum germination temperature. The experiments were carried out in germination cabinets with adjustable temperature and light. Seed germination was monitored periodically throughout 20 days and germinated seeds were counted and discarded during every 2-day interval (Khan *et al*., 2002; Guma *et al*., 2010). The results are expressed as mean germination percentages. Radicle protrusion from the seed (2-3 mm) was the criterion for germination (Côme, 1982). Data obtained from the study were analyzed with the SAS (2015) statistical package and means were evaluated with Duncan's multiple range test at the $P < 0.05$ level of probability.

RESULTS AND DISCUSSION

Seed viability

The viability of Russian tumbleweed seeds collected from their habitat were TTC (evaluated triphenyl tetrazolium chloride) test in the laboratory and after that germination rates of the seeds were calculated. The viability rate of the seeds was 60% on average. In another study conducted on *Salsola grandis* Freitag, Vural & Adıgüzel, the viability of the seeds was found to be 94% (Cinar et al., 2016). As is known, the viability percentage of weed species varies greatly depending on the environmental conditions (Murdoch and Ellis, 2000).

Effect of temperature

To determine the optimum germination temperature (OGT) of Russian tumbleweed, 12 hours of dark and 12 hours of light of photoperiod was applied and the germination characteristics of the seeds were investigated in five different temperatures (5/15, 10/20, 15/25, 20/30, 25/35 °C). The lowest germination rate in Russian tumbleweed seeds was observed at 5/15 and 25/35 °C while the highest germination rate was 71.5% at 15/25 °C. According to this results, it can be said that the OGT for Russian tumbleweed is 15/25 °C (Table 1 and Fig. 1). In a study aiming to determine the germination temperatures of the seeds of *Salsola kali* L. which is closely related to Russian tumbleweed, the OGT is 15 °C, and the maximum germination temperature is 15–20 °C with a germination rate of 88% (Yigit and Guncan, 1997). In another study on the germination biology of Russian tumbleweed seeds in Konya (Turkey); the minimum, optimum and maximum germination temperatures of seeds were investigated, and the minimum germination temperature was found to be 2 °C, the OGT was 10–25 °C, and the maximum germination temperature was 40 °C (Obali, 2009). These results are similar to a great extent the results of the research.

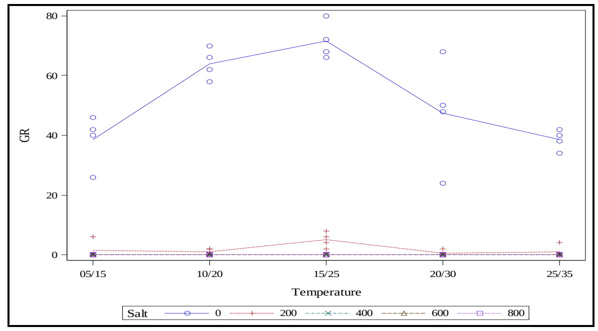

Fig. 1. Germination rates (GR, %) of Russian tumbleweed seeds at various temperature (dark/light, °C) and salt concentrations (mM NaCl).

Table 1. Germination rates of Russian tumbleweed seeds at various temperature and salt concentrations (%)

Salt (mM NaCl) **Temperature (D/L °C)**	**0**	**200**	**400**	**600**	**800**	**Mean ± SEM and Duncan Groups**
5/15	38.5 ± 4.3	1.5 ± 1.5	0	0	0	8.0 ± 3.6 C
10/20	64.0 ± 2.6	1.0 ± 0.6	0	0	0	13.0 ± 5.9 B
15/25	71.5 ± 3.1	5.0 ± 1.3	0	0	0	15.3 ± 6.5 A
20/30	47.5 ± 9.0	0.5 ± 0.5	0	0	0	9.6 ± 4.6 CB
25/35	38.5 ± 1.7	1.0 ± 1.0	0	0	0	7.9 ± 3.5 C
Mean ± SEM and Duncan Groups	52.0 ± 3.7 A	1.8 ± 0.6 B	0 C	0 C	0 C	

CV = 32.71

D/L = 12 h dark/12 h light

SEM = Standard error of mean

Effect of salinity

Russian tumbleweed seeds were investigated. The highest germination percentage was obtained from non-treated control group (0 mM NaCl). The low germination was observed at a concentration of 200 mM of sodium chloride, but no germination was seen at higher concentrations of the salt (Table 1 and Fig. 1). As a result of the study, although the Russian tumbleweed was known as a halophytic plant (Ghazanfar et al., 2014), it was observed that the seeds germinated the highest rate in the control group (0 mM NaCl), that is, in the salt-free environment. As the salt ratio increases, germination rapidly decreases, and there is no germination even at high salt concentrations. In a study conducted by Xing et al. (2013), were treated with 0, 100, 300, 400, 500, 600, 800 and 1000 mM NaCl concentrations to *Salsola ikonnikovii* Iljin., the highest germination percentage was

Efficacy of the various NaCl salt concentrations (0, 100, 200, 400, 600, 800 mM) on the germination of

detected at concentrations of 0–100 mM NaCl. Zhang et al. (2015) conducted a study on 12 halophyte plant species on seed germination and in different salt (NaCl) concentrations between 0 and 500 mM, the highest germination rates were observed in the control group (0 mM) with all species. Rasheed et al. (2015) reported in another study with seed germination of *Salsola drummondii* Ulbr. that light has a positive effect on germination; however, in the light and dark period the highest germination occurred at 0 mM NaCl concentration (control group) and that the germination rate decreased as the salt ratio increased at all temperatures.

Effect of sodium bicarbonate

To determine the effect of soda or also called sodium bicarbonate ($NaHCO_3$) on the seed germination of Russian tumbleweed, it is studied at the OGT of 15/25°C in a 12 h dark: 12 h light photoperiod. It was determined that the highest germination rate (65.5%) was in the control group (0mM $NaHCO_3$), which contained soda-free water. As the sodium bicarbonate concentration increased, the germination of the seeds decreased until at 400 mM $NaHCO_3$, where the germination of seeds ceased utterly (Table 2 and Fig. 2). Wang et al. (2013) investigated the effects of sodium bicarbonate at 0, 25, 50, 100, 400, 600, 800 mM $NaHCO_3$ concentrations on seed germination on another halophytic species which is *Salsola fergenica* Drobow. In this study, it was noted that the highest germination rate was observed in the control group (0 mM $NAHCO_3$) and a significant decrease in seed germination higher than 50 mM. In another study conducted to understand the effect of soda on the germination of oak-leaved goosefoot (*Chenopodium glaucum* L.) seeds, which are in the same family with *Salsola*, it was determined that the germination rate was high in the range of 0-300 mM $NaHCO_3$, and it started to decrease after 400 mM $NaHCO_3$ concentration (Chen et al., 2012). Zhang et al. (2015) also obtained similar results in their study of 12 halophytic plant species. The researchers noted that the highest germination rates in seeds were in the range of 0–100 mM $NaHCO_3$ in all species, while the germination rates decreased as the sodium bicarbonate concentration increased. It was understood that this study has similar results with the mentioned studies.

Table 2. Germination rates of Russian tumbleweed seeds at 15/25 °C and various sodium bicarbonate concentrations (%)

Sodium bicarbonate (mM $NaHCO_3$)	Mean ± SEM and Duncan groups
0	65.5 ± 2.5 A
50	16.0 ± 3.3 B
100	7.5 ± 2.6 C
200	1.0 ± 1.0 D
400	0 D

CV = 25.21
D/L = 12 h dark/12 h light
SEM = Standart error of mean

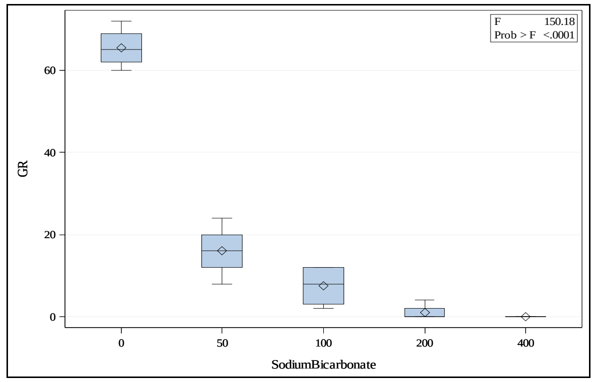

Fig. 2. Germination rates (GR, %) of Russian tumbleweed seeds at 15/25 °C temperature and various sodium bicarbonate concentrations (mM $NaHCO_3$).

CONCLUSIONS

As a result of the laboratory tests carried out, it was observed that the OGT of Russian tumbleweed (*Salsola ruthenica* Iljin.) seeds were determined as 15/25 °C during the day/night photoperiod, and the lowest germination at 5 °C and the highest at 35 °C. These values are also parallel to the climatic features of the region. Although it is known that Russian tumbleweed is well adapted to the salty and sodic soils (halophyte), as the results of the study, it was understood that the seeds are better germinated in salt- and soda-free conditions. In the mediums contain salt (NaCl), the germination rate decreased rapidly as the salt concentration increased. Higher rates of 200 mM NaCl did not allow seed germination. As in the case with salt, germination decreased as sodium bicarbonate ($NaHCO_3$) ratio increased, and there was no germination above the concentrations 400 mM $NaHCO_3$. Accordingly, it is determined that the Russian tumbleweed can be better germinated in soda-free conditions even being tolerant to sodium bicarbonate.

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