



EFFECT OF SALINITY AND LIGHT ON GERMINATION OF *SALSOLA GRANDIS* FREITAG, VURAL & N. ADIGUZEL (CHENOPODIACEAE)

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ABSTRACT

Salsola grandis (Chenopodiaceae) is a xero-halophytic and local endemic species from Nallıhan-Turkey and has IUCN threat category of CR. The aim of the study was to determine the influence of light and salinity on germination of *S. grandis* which could be the explanation of the small population size and distribution area. Seeds were collected at fall of 2011 and used without perianth segments. All the trials were conducted at (12 h/12 h) 20/8 °C day and night temperature regime. For the influence of salinity different NaCl concentrations were used, distilled water (as control), 100, 200, 300, 400, 500, 600 and 800 mM NaCl. Seeds that did not germinate under saline conditions were taken into recovery tests. After recovery the un-germinated seeds were tested for viability with TTC test. As a result light did not have any influence on germination. As in other halophytes increase in NaCl concentration results decrease in germination ratio. The best germination was observed in distilled water. Although salinity repress the germination of *S. grandis* seeds even at 800 mM NaCl there was 11.6% germination percentage, so it can be concluded that the seeds of *S. grandis* are salt tolerant.

KEYWORDS: Chenopodiaceae, *Salsola grandis*, Endemic, Xero-halophyte, Germination.

1. INTRODUCTION

Salinity is one of the main problems especially in agricultural areas. Global warming, aridity, wrong irrigation policies cause an increase in human induced salinity in soils. Increase in soil salinity makes halophytes important gene source for crops and many studies have been conducted on the germination ecology of halophytes under saline conditions [1, 2]. Although halophytes complete their life cycles under saline conditions they prefer to germinate in low salinity or un-saline conditions.

Salsola grandis a local endemic from Nallıhan-Ankara is an annual halophytic species of family Chenopodiaceae [3]. It grows in clayey saline and gypsaceous soils and prefers semiarid cold Mediterranean climate. Anthesis occurs between June and late July and seeds mature at September and October. Seeds of some *Salsola* species have wings which inhibit or retard the germination chemically or mechanically [4, 5]. Winged seeds of *S. komarovii* contain ABA that inhibits the germination [6].

S. grandis has spiral embryos without endosperm as many other *Salsola* species, the addition of water at suitable temperature resulted in germination within minutes by uncoiling of spiral embryo. It was reported that *S. tragus* can germinate less than 29 min [7]. Elongation of embryo cells result in rupture of seed coat [7, 8].

Temperature, salinity and alkalinity are some of the factors that affect the initial and maybe the most important life cycle stage of plants; germination [1, 9]. Salinity may inhibit the germination or causes some delays and after decrease of salinity many of the halophytes seeds can recover and germinate [1, 4, 9, 10]. The response of seeds to salinity, whether salinity cause death of seeds or prevent germination, depends on species.

It has been reported that many *Salsola* species have salt tolerance at the germination stage eg. *S. kali* [10], *S. baryosma* [11], *S. villosa* [12], *S. iberica* [1], *S. chandharyl* [13], *S. imbricata* [14, 15] and *S. affinis* [4].

The aim of this study is to determine the effect of NaCl concentration and light on germination of seeds of *S. grandis*.

2. MATERIALS AND METHODS

Seeds were collected from Nallihan in autumn of 2011 and stored in paper bags at room temperature. The perianth segments were removed before the sterilization of seeds with 0.1% sodium hypochlorite. Germination was carried out in 10 cm diameter plastic petri dishes. Two layers of Whatman No 1 filter paper wetted with 4 ml distilled water were placed in petri dishes. 15 seeds without perianth segments were placed on filter papers and the petri dishes were sealed with parafilm. The trials were done in 4 replicates. For determination of the influence of light on germination, petri dishes were placed in incubator at 20/8 °C in complete dark and 12/12 h thermoperiod for 14 days. These temperatures are the mean day and night temperatures of the species distribution area. Emergence of radicle is accepted as germination. The germinated seeds were removed from petri dishes. Everyday germination was recorded for light and at the end of 14th day for dark. The light intensity was 1200lux \pm 10%.

Seeds were germinated in distilled water and 100, 200, 300, 400, 500, 600 and 800 mM NaCl solutions under above mentioned conditions. Germination was recorded every day for 14 days and the germinated seeds were removed from petri-dishes. Seeds that did not germinate during the experiment for NaCl treatments were included in recovery tests. They were washed with distilled water and then incubated at the same conditions for 14 days with distilled water. The recovery percentage was determined by the formula below:

$$(a-b)/(c-b) \times 100$$

a: total number of seeds germinated in saline solution and after being transferred to distilled water

b: total number of seeds germinated under salinity

c: total number of seeds [1].

After recovery the seeds still ungerminated were included in TTC test for viability [16].

Total germination percentage after the trials was calculated with the formula $(a/c) \times 100$. Because of increase in salinity germination decreased, but to find out whether it is caused by high salinity or the non-viable seeds the formula “[$(a+d)/c$] \times 100” used and the viability percentage of seeds was calculated.

Modified Timson index was used to calculate germination rate; $\sum G/14$. G is the percentage of seed germination at 1 day intervals, t is the total germination period [17]. The highest value means the highest germination rate.

After recovery, the seeds still ungerminated were included in TTC test for viability [16].

Decreasing germination percentage (DGP) gives information about salinity tolerance and calculated by using the following formula:

$DGP = [(Germination\ percentage\ at\ distilled\ water - Germination\ percentage\ at\ salinity) / (Germination\ percentage\ at\ distilled\ water)] \times 100$ [18].

All the data were arcsin transformed and for the influence of trials ANOVA was used (SPSS Inc., 2003). T test was used for importance control ($p < 0.05$).

3. RESULTS AND DISCUSSION

The germination ratio of *S. grandis* seeds was 98.3 % for both light and dark at 8/20° C night and day temperature. The mean germination percentages can be seen from Table 1.

Table 1. Summary of germination characteristics of *S. grandis* at different NaCl concentrations.

Salinity	Initial germination %	Recovery %	Last germination %	Timson germination velocity index	Total viable seed (%)	Unviable seed (%)	DGP
Distilled water	98.3 ^c	* -	98.3	38.92	98.3	-	-
100 mM NaCl	91.6 ^d	100	100	35.5	100	-	6.81
200 mM NaCl	81.6 ^c	100	100	32.14	100	-	16.9
300 mM NaCl	66.6 ^b	100	100	24.5	100	-	32.24
400 mM NaCl	63.3 ^b	100	100	21.42	100	-	35.6
500 mM NaCl	46.6 ^b	93.75	96.6	15.57	96.6	3.4	52.5
600 mM NaCl	33.3 ^b	100	100	9.64	100	-	66.12
800 mM NaCl	11.6 ^a	94.3	95	3.85	95	5	88.19

*1 seed was removed from the trial because of molding.

All the seeds except for 1, germinated in distilled water, the ungerminated seed could not be included in recovery or viability tests because of molding. For the salinity trials other than 500 mM and 800 mM NaCl, germination percentages were found as 100% after recovery. For 500 mM and 800 mM NaCl trials 2 and 3 seeds respectively were found as non-viable and the viability was 94%.

As in most of the halophytes the highest germination ratio is observed in distilled water and decreases with increasing salinity [1, 16, 19, 20, 21, 22, 23, 24, 25].

Germination rate was calculated by modified Timson index which showed decrease with increase in salinity. Germination rates at different salinities can be seen from Table 1.

Increase in NaCl concentration decreases the germination percentage, whether this is caused by high salinity or not, recovery tests were applied to the ungerminated seeds. Removal of salts (NaCl) from growing media increase germination of seeds treated with salinity. The results can be seen from Table 1.

Although salinity cause stress over *S. grandis* seeds, germination continues after the conditions become optimum, so it can be concluded that *S. grandis* seeds are salt tolerant. However their recovery abilities are different most of the halophytes seeds are salt tolerant [10, 20].

The highest the decreasing germination percentage means the lowest the salt tolerance. According to the Table 1 it can be seen that over 500 mM NaCl the germination percentage decreases below the 50 %. But, *S. grandis* seeds still have germination capability which helps the species to survive in saline areas.

According to recovery tests, it can be said that viability is very high in *S. grandis* seeds. TTC test results in only 5 non-viable seeds which may already non-viable at the beginning. Although salinity is a stress factor for germination, if the conditions recovered, seeds can germinate. It can be concluded that *S. grandis* individuals produce highly viable seeds.

According to the statistical analysis, there was a statistically important difference between germinabilities of seeds at different salinities ($F=40.81$,

df=7.24, $p<0.01$) (One way ANOVA, SPSS 13). Between 300 mM and 600 mM NaCl concentrations, there is not any statistically important difference between germination of seeds. For distilled water, 100 mM, 200 mM and 800 mM NaCl solutions there was a distinctive difference between germination behaviour of seeds (Duncan pos-hoc, SPSS 13.0) (Table 1).

In general, it was concluded that inhibition of germination of halophyte seeds can be occur in 2 ways; complete inhibition at salinities over tolerance threshold of a species or retardation of the germination as a result of some stress but eventually germination occurs [9].

It was found that light has not any peculiar influence on germination of *S. grandis* seeds. As in many other halophyte species, the best germination occurred in distilled water. Having spiral embryo results in rapid germination even in hours.

Although increase in salinity decreases the germination, even at 800 mM NaCl, *S. grandis* seeds have 11.6% germination percentage and then recovered after taken into distilled water. So it can be concluded that *S. grandis* seeds are highly salt tolerant. Because it is a local endemic with category of CR (Critically endangered), it is not possible to investigate the influence of other environmental factors or salts other than NaCl on germination. Also *S. grandis* seeds have high viability ratio. Even though seeds are salt tolerant and highly viable the species has a very narrow distribution area which maybe the results of very specialized environmental conditions and the seedling death [26].

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