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Impact of Salinity Stress on Seed Germination Characteristics of Two Medicinal Species *Salvia verticillata* and *S. limbata*

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ABSTRACT: The purpose of this study was to investigate the effects of salt stress on germination characteristics and seedling morphology in two medicinal species of *S. verticillata* and *S. limbata*. A factorial experiment was conducted using completely randomized design with four replications and seven salinity levels. The salinity factor were included of 0, 50, 100 150, 200, 250 and 300 mm NaCl. Data were collected for germination percentage, germination rate, time means of germination, radicle length, plumule length, seed vigor, and allometry ratios. The overall means of germination percentage, germination rate, radicle length, and seed vigor were lower for *T. daenensis* as 41.44, 0.28, 1.15 and 1.87 than those for *S. verticillata* as 54.32, 0.37, 1.81 and 2.8, respectively, indicating more tolerant to salinity for *S. verticillata* than that for *S. limbata*. Results showed that by increasing salinity, the germination percentage, rate of germination, plumule length, radicle length, and seed vigor were reduced in both species. The slop of reduction was higher for *S. limbata* than *S. verticillata*. In other words, *S. verticillata* was more tolerate to salinity than *S. limbata*. It was concluded that this genus could be cultivated in environments, which plants are not in expose to salinity.

Key words: Salinity stress, Germination characteristics, Medicinal plants, *Salvia verticillata, Salvia limbata*.

INTRODUCTION

Medicinal plants play an important role in the provision of health care in many developing countries. They also provide a stable economic return to local communities especially through the sale of wild-harvested material. Most of the genus *Salvia* L. (Labiatae) are medicinal plants that consist of about 215 species of herbaceous perennials and sub shrubs. They originated from Mediterranean region (Jamzad, 2010). Salvia species are commonly used as herbal tea, flavoring agents (condiment and spice) and medicinal plants (Burnett, *et al.*, 2005). Among the species grown in Iran, *Salvia limbata* Celak and *Salvia verticillata* Boiss. are more widely used for these purposes. Infusion and decoction of aerial parts of Salvia species are used as tonic, carminative, digestive, antispasmodic, anti-inflammatory, expectorant and for the treatment of colds in Iranian traditional medicine (Moghimi, 2005). Recent studies have showed that Salvia species have strong antibacterial, antifungal, antiviral, ant parasitic, and antioxidant activities (Omidbayg, 2007). The aromatic and medicinal properties of the genus Salvia have made it one of the most popular plants throughout the world. It is believed that a part of these activities is due to the volatile constituents. Therefore, there is a considerable research interest towards the compositional analysis of *Salvia* essential oils (Sandra and Bicchi, 1987).

Salinity is one of the environmental factors having a critical influence on seed germination, seed physiology and plant establishment. Salinity affects imbibitions, germination and radicle elongation. It reduces substrate water potential, thereby restricting water and nutrient uptake by plants (Safarnezhad and Hamidi, 2008). Salinity may also cause ionic imbalance and toxicity. Because substrate salinity fluctuates through the growing season, a plant may be exposed to different salinity levels, at various stages of development, with potentially significant consequences on population dynamics (Hosseini and Rezvani Moghadam, 2006).

Regarding medicinal importance of Salvia genus, specially *S. verticillata* and *S. limbata*, and high Extension of this genus in saline sodic soil in Iran, the aim of this study was to investigate the effect of salt stress on seed germination characteristics of *S. verticillata* and *S. limbata.*

MATERIALS AND METHODS

Salvia (*S. verticillata* and *S. limbata*) seeds were collected from Ghazvin and Alborz province, Iran in 2013. A Factorial experiment was conducted for species in two levels and salinity in seven levels based on completely randomized design with four replications. The salinity levels were 0, 50, 100 150, 200, 250 and 300 mm NaCl.

Twenty five seeds for each treatment were placed in three petri dishes (25 × 3). The seeds were sterilized using Carboxin Tiram, and then the seeds rinsed with distilled water and transferred to germinator 25±1°C. The germination percentage was recorded every two days. Rate of germination was estimated using modified Timpson's index of germination velocity (Khan and Ungar, 1984). Mean Germination Time (MGT) was calculated in order to assess the rate of germination (Ellis and Roberts, 1981).

$$MGT = \frac{\sum D.N}{n}$$

Where:
N = the number of seeds which in D day grow, n = the total number of seeds grown and
D = is the number of days from the date of germination.
The germination rate index was obtained by reversing MGT at the end of this period.

The normality of data was checked and non-normal data transformed by ArcSin to verification of this hypothesis. ArcSin transformation was used for germination percentage before analysis (Khan *et al.*, 2006). Experimental data was analyzed by MSTATC software. The comparisons among treats were made using Duncan's Multiple Range Tests (DMRT) at 5% level of probability.

RESULTS

The results of analysis of variance showed significant effects of salinity for all of traits (P≤0.01). The species effect was also significant for all of traits except plumule length and the time of germination (P≤0.01). The species x salinity interaction effect was significant for only radicle length, germination percent, and seed vigor (Table 1).

Table 1: The Results of analysis of variance for seed characteristics of *S. verticillata* and *S. limbata.*

S.O.V	DF	Mean of squares						
		Radicle Length	Plumule Length	Germination Rate	Time Means Germination	Germination Percentage	Seed Vigor	Allometry Ratios
Species	1	1.48**	0.01	0.14**	0.200	3020**	2.9.0**	0.042**
Salinity	6	8.03**	3.59**	0.21**	1.38**	6383**	20.6**	0.36**
Salinity*Species	6	0.39**	0.200	0.700	0.35	328.1*	0.56**	0.006
Error	28	0.30	0.02	0.004	0.25	128.7	0.06	0.004
CV%		20.3	21.9	24.8	25.8	29.8	17.9	5.2

*, ** Significant at 5% and 1% level respectively.

Table 2: Mean of interaction effects of species and salinity treatments for the seed characteristic.

Species	Germination Percentage	Time Means Germination	Germination Rate	Plumule Length	Radicle Length	Seed Vigor	Allometry Ratios
S. limbata	41.44 b	4.49 a	0.28 b	1.08 a	1.15 b	1.87b	1.19 a
S. verticillata	54.32 a	3.60 b	0.37 a	1.14 a	1.81 a	2.8 a	0.87 b

Means with different superscript letters in a row are significantly (P<0.05) different

Table 3: Mean of interaction effects of species and salinity treatments for germination percentage, time means of germination and germination rate.

Treat	Germination Percentage		Time Means Germination		Germination Rate	
	S. limbata	***S. verticillata***	***S. limbata***	***S. verticillata***	***S. limbata***	***S. verticillata***
0	83.9 a	83.9 a	2.34 d	1.91 b	0.43 a	0.55 a
50	53.8 b	79.4 a	3.09 d	1.79 b	0.34 ab	0.56 a
100	42.0 b	69.1 a	3.58 cd	2.25 b	0.29 b	0.45 ab
150	22.7 c	61.2 a	4.62 c	3.21 b	0.22 bc	0.31 b
200	5.7 cd	23.6 b	8.25 b	5.63 a	0.12 c	0.18 c
250	2.9 d	8.7 b	10.00 a	6.80 a	0.10 c	0.16 c
300	0.0 e	0.0 c	-	-	0.0 d	0.0 d
Means	41.44	54.32	4.49	3.60	0.28	0.37

Means with different superscript letters in a row are significantly (P<0.05) different

Table 4: Mean of interaction effects of species and salinity treatments for plumule length, radicle length, seed vigor and allometry ratios.

Treat	Plumule Length		Radicle Length		Seed vigor		Allometry Ratios	
	S. limbata	*S. verticillata*	*S. limbata*	*S. verticillata*	*S. limbata*	*S. verticillata*	*S. limbata*	*S. verticillata*
0	1.88 a	1.94 a	2.28 a	3.60 a	4.08 a	5.44 a	0.83 b	0.54 b
50	1.36 b	1.46 b	1.50 b	2.23 b	2.27 b	3.51 b	0.91 b	0.66 b
100	0.78 c	0.85 c	0.67 c	1.20 c	0.97 c	1.85 c	1.20 ab	0.72 b
150	0.27 d	0.29 d	0.14 d	0.19 d	0.17 d	0.40 d	1.80 a	1.57 a
200	0.0 e	0.00 e	0.00 e	0.00 e	0.00 e	0.00 e	-	-
Means	1.08	1.14	1.15	1.81	1.87	2.81	1.19	0.87

Means with different superscript letters in a row are significantly ($P<0.05$) different

The overall means of germination percentage, germination rate, radicle length, and seed vigor were lower for *S. limbata* as 41.44, 0.28, 1.15 and 1.87 than those for *S. verticillata* as 54.32, 0.37, 1.81 and 2.8, respectively, indicating more tolerant to salinity for *S. verticillata* than that for *S. limbata*. The results showed that by increasing salinity, the germination percentage, rate of germination, plumule length, radicle length, and seed vigor were reduced in both species (Tables 3 and 4).

The slop of reduction was higher for *S. limbata* than that of *S. verticillata*. In other words, *S. verticillata* was more tolerate to salinity than *S. limbata*. For speed of germination the average values of *S. verticillata* was significantly higher than *S. limbata*, while for algometric index the higher values were obtained for *S. limbata* (Figs. 1 and 2 and Table 1). For plumule length, there was no difference between two species (Table 1). By increasing the salinity levels, the means time of germination and Allometry ratios were increased in both of species (Tables 3 and 4).

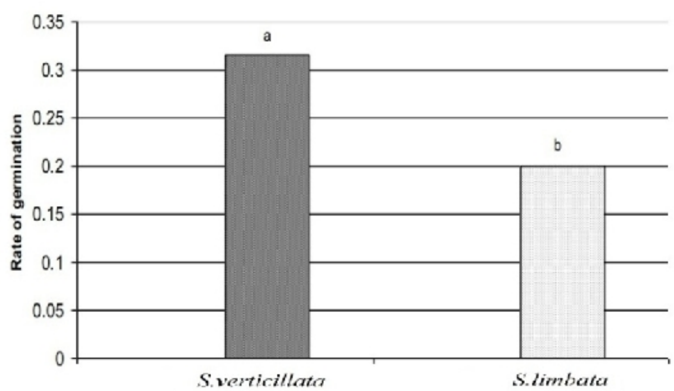

Fig. 1. Mean effects of species on the rate of germination.

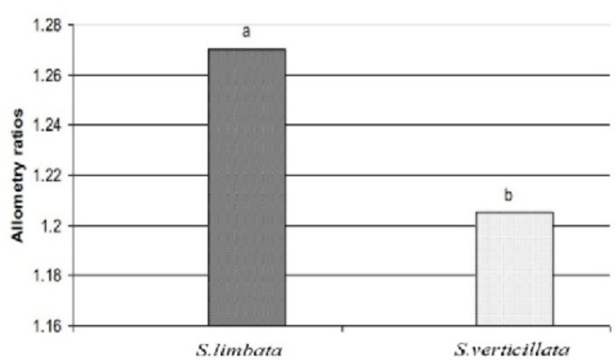

Fig. 2. Mean effects of species on the allometry ratios.

The results showed that critical point of salinity was 150 mil/molar/lit. Therefore, by increasing to this point, the plumule length and radicle length were less than 1 mm. However, for germination percentage, the seeds of both species were germinated up to 250 mil/molar/lit and for 300 mil/molar/lit concentration, no seeds was germinated.

DISCUSSION

In both species of Salvia, by increasing of salinity, germination percentage, rate of germination, plumule length and radicle length had decreased. Increasing salinity caused the reduction in water, nutrient uptake and osmotic imbalance in the environment of plumule radicles, ion toxicity and ultimately reduction in germination percentage and rate of germination, and finally led to decrease plant establishment. Our results were in agreement with some publications (Stephanie *et al.,* 2005; Burnett *et al.,* 2005; Boromanerezazade and Kocheki, 2005 and Fallahi *et al.,* 2008).

High concentration of salinity caused the impairment in seedling growth and its physiological processes. Hosseini *et al.* (2006) in the study of the effects of drought and salinity stress on seeds characteristics of Isabgol (*Plantago ovata*), and Safarnezhad *et al.,* (2007) in study of salinity stress of *Nigella sativa* found that by increasing in salinity stress, germination percentage and speed of germination were decreased and the salinity stress led to reduction of plant growth. Our study indicates that when salinity levels increased, the plumule length and radicle length of both species decreased.

This increasing in morphology and physiological processes of plant may be due to decreasing plants access to water and nutrient due to the osmotic imbalance and impairment of biological activity and metabolic of plant. Tarzi (1995) investigated the effect of salinity on builder compound *Cuminum cyminum* in cultivation tissue and mature plant and showed that by increasing salinity effect, the plumule length had decreased. This was due to due impairment of ion toxicity and biological metabolic processes. Our results are in agreement with Fallahi *et al.,* (2008) in which they showed that with increasing in salinity levels, the seedling length had decreased and minimum and maximum length of seedling were observed for control and 300 Mm NaCl treatments, respectively. The results of the present study were in agreement with those of Salami *et al.,* (2006) in study of the effect of salinity stress on *Cuminum cyminum* and *Valeriana officinalis* and Safarnejad and Hamidi (2008) in study of the morphological characters of *Foeniculum vulgare* under salt stress in which they showed that with increasing in salinity levels, seed vigor, the ability of plant for survival and normal living were decreased. Consequently, based on the results, the published studies and regarding high medicinal values of this genus and their sensitivity to salinity stress, we recommend that the genus is cultivated in environments that plants are not in expose to salinity.

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