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Effect of Salt Stress on Seed Germination, Shoot and Root Length in Basil (*Ocimum basilicum*)

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Abstract: Salinity is one of the most environmental problems in arid and semi-arid region. It is an abiotic stress factor which restricts crop production and affects development of plants. One of the these plants is basil (*Ocimum basilicum*). It is an annual medicinal and aromatic plant from Lamiaceae family. The present study was carried out to determine the response of different salt concentrations from 0 to 240 mM doses which increasing 20 mM. The experiment was conducted with randomized complete block design with 3 replications and placed 20 number from seeds of each plant in petri dishes. 39 petris were used consisting from 1 plant x 13 salt levels x 3 replicats. Germination tests were made at constant temperature (29±1 °C), dark field and drying oven in laboratory conditions. Appropriate test solution was placed at each petri dish being 5 ml and was changed with an interval of two days. According to the study results, germination speed and power of basil seeds completed within 3-15 days. The results noted that root lenght changed between 0.08-5.07 cm, shoot lenght changed between 0.1-5.82 cm in the basil and they changed between 10-100% germination rate between the 0-240 mM salt concentrations. The lowest germination speed and power were seen in 240 mM and the highest germination speed and power were seen in 20 mM except control condition. Germination percentage of basil seeds were decreased from 0 (control) to 240 mM. In addition to this, the highest shoot and root lenght were obtained from 20 mM and the lowest shoot and root lenght were obtained from 240 mM except control condition. Root lenght/shoot lenght was also determined changing between 0.43-1.27. According to results, it was determined that germination number and rate, shoot and root lenght were statistically affected by different salt doses. Considering different salt doses, the highest number of germination was obtained from 20 mM salt dose, the lowest value was determined in 240 mM salt application compared to control application. It is suggested that salt tolerence studies should be preferred under 200 mM salt dose to obtain the germination number and rate over 80% in different salt doses and in order to grow the basil under salted areas.

Keywords: Basil, Salt, Germination, Root and shoot lenght

1. INTRODUCTION

Medicinal and aromatic plants are used for different purposes because of their active components. So, they are cultivated [1]. However, the quality and the quantity of secondary metabolites of medicinal plants strongly depend on environmental conditions. To obtained high yielding genotypes of these plants under different environmental conditions, in many of

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literatures has been given about response of medicinal and aromatic plants againts the salinity stress [2].

Salt stress effects different physiological life of medicinal plants on different stages. One of the most important part of plant life is germination period on salt conditions [3]. For the survival and perpetuation of seeds, they need to germination of seeds under salt concentration in the soil. Seed germination takes place after high downfall in saline habitats as decreased soil saline [4].

Salt stress is becoming a significant global factor as affects nearly 20% of global irrigated land because it limits production in terms of agricultural in the worldwide [5]. Besides many substantial crops are salt-sensitive such as pepper, eggplant, potato, lettuce, and cabbage [6]. Therefore, depending on growing the world population and increasing of soil salinization, crops which are adapt to salt stress, need to develop. Salt stress is also affected essential oil and its component of medicinal and aromatic plants. For this reason, determination of salt tolerance has a great importance in medicinal plants.

It is reported that some plant seeds showed major reduce under salt stress i.e. *Ocimum basilicum* [7], *Petroselinum hortense* [8], sweet marjoram [9] and *Thymus maroccanus* [10]. The other stage is seedling growth which influenced by salinity negatively. It has been reported that, seedling growth of *Thymus maroccanus* [10], basil, chamomile and marjoram [9] were severely decreased depend on salt stress. Some researchers said that morphological characteristics of number of medicinal plants were effected under salt stress conditions such as number of leaves, leaf area and leaf biomas in reduced form as *Majorana hortensis* [11], peppermint [12] , geranium [13], *Thymus vulgaris* [14], sage [15] and *Mentha pulegium* [16].

In this study, sweet basil was used as an experimental material. This plant is commonly used by local people in treatments of various diseases. For example, it is used for treatment of dry mouth and dental complaints, diarrhea and chronic dysentery, respiratory disorders, and effective in the treatment of fungal diseases and stomach discomfort in addition, the influential antitussive, diuretic, anthelminthic, tranquilizer and expectorant roles in medicinal approach [17, 18].

The aim of this study was to investigate the effects of thirteen salt doses (0-240 mM, increasing 20 mM) on basil seed germination, shoot and root length.

2. MATERIAL and METHODS

Seed of *Ocimum basilicum* was obtained from field experiment in 2016. The present study was carried out to determine the response of different salt concentrations from 0 to 240 mM which increasing 20 mM. The experiment was conducted with randomized complete block design with 3 replications and placed 20 number from seeds of each plant in petri dishes. 39 petris were used consisting from 1 plant x 13 salt levels x 3 replicats. Germination tests were made at constant temperature (29±1 °C), dark field and drying oven in laboratory conditions. Appropriate test solution was placed at each petri dish being 5 ml and was changed with an interval of two days. Germination trials were conducted in 9 cm sterile petri dishes lined with Whatman No.1 filter papers and moistened with distilled water to ensure adequate moisture for the seeds. The seed was examined daily and considered germinated when the radicle was visible. The germination percentage, like shoot length and root length were measured at the end of the germination periods.

Statistical analysis of the experimental data was conducted with the SPSS statistical program. Differences between the average values were compared by Duncan at a 5% probability level (Table 1).

Table 1. Analysis of variance table

Treatment		SS	df	MS	F	Sig.
Number of germinating seeds	Between groups	878.308	12	5.524	22.657	0.000
	Within Groups	40.667	26	0.224		
	Total	918.974	38			
Germination ratio	Between Groups	21957.7	12	73.192	46.795	0.000
	Within Groups	1016.67	26	1.564		
	Total	22974.4	38			
Shoot lenght	Between Groups	103.513	12	1829.808	46.795	0.000
	Within Groups	7.922	26	39.103		
	Total	111.435	38			
Root Lenght	Between Groups	66.288	12	8.626	28.312	0.000
	Within Groups	6,339	26	0.305		
	Total	72.627	38			
Root/Shoot Lenght	Between Groups	0,859	12	0.072	1.948	0.075
	Within Groups	0.955	26	0.037		
	Total	1.813	38			

SS: sums of squares; df: degrees of freedom, MS: mean squares, F: test statistic, Sig.: significance

3. RESULTS and DISCUSSIONS

3.1. Germination Dates and Number of Germinating Seeds

The results indicated that salinity doses had a significant effect on the measured traits (Table 1). According to the data obtained from the petri trials, generally, salt stress caused significant decrease in shoot lenght, root length, germination of basil. Increasing salinity doses led to decrease in germination of this plant. This decrease started after 40 mM salinity dose. The germination stopped at 240 mM salinity dose. The germination varied from 3 to 14 days and the highest germination obtained from the control applications followed by the others. In sweet basil, average 19.66 seeds germinated in control application and 3.33 seed germinated in 240 mM. The highest germination was seen in 20-120 mM salt doses.

Table 2. Number of germinating seeds in basil

Doses (mM)	Number of Germinating seed	Doses (mM)	Number of Germinating seed
0	19.67^{a}	140	17.00^{bc}
20	19.33^{ab}	160	16.67^{c}
40	19.00^{abc}	180	16.67^{c}
60	18.33^{abc}	200	13.00^{d}
80	18.33^{abc}	220	7.33^{e}
100	17.33^{abc}	240	3.33^{f}
120	17.33^{abc}		

Different letters at each column indicate significant differences at 5% probability level.

3.2. Germination Percentage

According to results of variance analysis, effect of salinity stress dose on germination percentage was statistically significant (Table 3). The results showed that the germinations decreased sharply with increasing salinity doses. While the lowest germination was obtained from 240 mM NaCl dose application in basil, the highest germination was obtained from control

concentration application. Comparing control, germination reductions were 1.68, 6.77, 15.25 and 83.05% in 20, 80,160 and 240 NaCl doses, respectively.

Table 3. Effect of different doses (mM) of NaCl on the germination percentage for evaluated plant (%)

Doses (mM)	Germination Percentage (%)	Doses (mM)	Germination Percentage (%)
0	98.33^{a}	140	85.00^{bc}
20	96.68^{ab}	160	83.33^{c}
40	95.00^{abc}	180	83.33^{c}
60	91.67^{abc}	200	65.00^{d}
80	91.67^{abc}	220	36.67^{e}
100	86.67^{abc}	240	16.67^{f}
120	86.67^{abc}		

Different letters at each column indicate significant differences at 5% probability level.

3.3. Shoot Lenght

The effect of salinity stress on shoot lenght has been showed in Table 4. Comparison of shoot length mean in salinity different dose showed that when salinity dose increase, shoot length decrease. The most reduction in shoot length obtained from 240 mM salt dose with 0.12 cm and the highest rate was seen 20 mM with 4.72 cm. On control conditions, shoot lenght found 4.67 cm after 20 mM salt application. Comparing control, while shoot lenght increased with 1.08% in 20 mM salt dose, reductions were found 25.27, 79.01 and 97.43% in 80, 160 and 240 NaCl doses, respectively.

Table 4. Effect of different doses (mM) of NaCl on shoot lenght for evaluated plant (cm)

Doses (mM)	Shoot Lenght (cm)	Doses (mM)	Shoot Lenght (cm)
0	4.67^{a}	140	1.30^{de}
20	4.72^{a}	160	0.98^{efg}
40	3.62^{b}	180	0.44^{fg}
60	3.10^{bc}	200	0.31^{fg}
80	3.49^{b}	220	0.17^{g}
100	1.67^{de}	240	0.12^{g}
120	2.33^{cd}		

Different letters at each column indicate significant differences at 5% probability level.

3.4. Root Lenght

Root lenght is one the most important features for salt stress because of contacting with soil directly. Impact of salinity on root lenght has been showed Table 5. As you see by increasing salinity doses, rate of root lenght decreased extremely. In this case, on control conditions we had the tallest root lenght with 3.82 cm and the smallest shoot length was seen 0.10 cm in 240 mM. Comparing control, root lenght reductions were determined as 12.40, 22.33, 69.50 and 96.86% in 20, 80, 160 and 240 NaCl doses, respectively.

Table 5. Effect of different doses (mM) of NaCl on the root lenght for basil (%)

Doses (mM)	Root Lenght (cm)	Doses (mM)	Root Lenght (cm)
0	3.18[a]	140	0.89[d]
20	3.63[ab]	160	0.97[d]
40	2.93[bc]	180	0.35[d]
60	2.58[c]	200	0.19[d]
80	2.47[c]	220	0.13[d]
100	0.91[d]	240	0.10[d]
120	1.04[d]		

Different letters at each column indicate significant differences at 5% probability level.

3.5. Root/Shoot Lenght

Basil showed different responses to the salinity doses applied in terms of root/shoot lenght ratio in Table 6. Generally, the root/shoot lenght ratio decreased with increasing salinity doses, which showed that a more reduction in root lenght than shoot lenght. In other words, the root lenght was more negatively affected than shoot lenght by increasing salinity doses. Among the salinity doses, 160 mM salt dose gave a higher root/shoot lenght ratio at all salinity doses with 1.069 cm. It was also observed that 160 mM had higher values than control condition. The lowest root/shoot lenght was seen in 120 mM salt concentration with 0.445 cm. Comparing control, root lenght reductions were determined as 2.57, 12.24 in 20 and 80 mM NaCI concentrations and they were found increasing 160 and 240 mM NaCl concentrations with 30.84 and 5.26%, respectively.

Table 6. Effect of different doses (mM) of NaCl on the root/shoot lenght for basil (%)

Doses (mM)	Root/Shoot Lenght (cm)	Doses (mM)	Root/Shoot Lenght (cm)
0	0.817[abc]	140	0.687[bc]
20	0.796[abc]	160	1.069[a]
40	0.798[abc]	180	0.785[abc]
60	0.824[ab]	200	0.672[bc]
80	0.717[abc]	220	0.889[ab]
100	0.561[bc]	240	0.860[ab]
120	0.445[c]		

Different letters at each column indicate significant differences at 5% probability level.

In the earlier studies in the literature, harmful effects of high salinity effects on crops are multidirectional and effect plants in several ways as drought stress, ion toxicity, nutritional disorders, oxidative stress, alteration of metabolic processes, membrane disorganization and reduction of cell division and expansion [19-24]. Therefore, it is reported that plant growth, development and survival are reduced [25, 26]. Salinity effects seedling growth slowly or less mobilization of food which is reserved, deferring the cell division, growing and injuring hypocotyls [27]. Reduced seedling growth has been reported on basil, chamomile and marjoram by increasing salt doses [8, 9, 28]. Salinity stress is an important distinctive when a variety is selected for tolerance of salinity [29]. It is reported that number of germination, germination percentage, shoot and root lenght of sage (*Salvia officinalis* L.), black cumin (*Nigella sativa* L.) and flaxseed (*Linum usitatissimum* L.) were effected by different salt concentrations [30]. The results of present investigation are in agreement with the findings of many workers in different plant species [8, 9, 28,30].

4. CONCLUSION

The results in this study showed that the application of NaCl from 0-240 mM had significantly effect on basil seed germination, shoot and root length. Highest germination percentage was seen under control condition, and followed by 20 mM salt dose. While the highest root lenghts were found under control condition and followed by 20-80 mM salt doses. The highest shoot lenght were seen under 20 mM salinity level and it was higher than control condition. Depending on the increased salt levels, germination, shoot and root lenght were decreased. In conclusion, 200 mM salt dose should be preferred to grow basil in salt area.

Conflict of Interests

Authors declare that there is no conflict of interests.

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