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Influence of Salt (NaCl, $CaCl_2$, KNO_3) Stress on Germination and Early Seedling Growth Traits of Cumin (*Cuminum cyminum* L.) Seed

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ABSTRACT

Due to increasing salinity problems, in this experiment cumin (*Cuminum cyminum* L.) seeds were treated with different concentrations of salt solutions with different sources of salt to study the effect on germination and early seedling growth traits. Salt treatments included: NaCl, $CaCl_2$ and KNO_3 at 50, 100 and 150 mM. Both salinity-generated factors and concentrations used affected seed germination and cumin seedling characters. All three salts used resulted in a significant decrease in percentage seed germination compared with distilled water (control). The effect of KNO_3 was greater than that of $CaCl_2$ and NaCl treatments. However, a decreasing in seed germination percentage caused by these treatments was also dependent on concentration; at 50 mM NaCl and $CaCl_2$ seed germination did not show any significant difference with the control. Applied salinity treatments resulted in a significant decrease in root and shoot length compared with the control. KNO_3 decreased seedling growth more than the other two salt treatments.

Keywords: abiotic stress, salinity condition, seed germinability, seed priming, seed tolerance
Abbreviations: GP, germination percentage; **MGT**, mean germination time

INTRODUCTION

High salinity in soil or irrigation water is a common environmental problem affecting seed germination and plant growth. Salt stress causes inhibited or delayed germination and seedling establishment (Al-mansouri *et al.* 2001; Ates and Tekeli 2007). Salinity affects almost every aspect of the physiology and biochemistry of plants which in turn significantly reduces yield. Germination and establishment differentially decrease in saline soils depending on the plant and the salinity source (Hampson and Simpson 1990). Salt stress decreased the germination percentage, shoot length and root length of canola and barley but decreased seedling growth of these seedlings under $CaCl_2$ was lower than when other salinity sources like Na_2SO_4 or NaCl were used (Huang and Redman 1995). Ashraf and Naqvi (1992) noted that germination and seedling growth of *Brassica* spp. dereased due to salt stress but the addition of $CaCl_2$ to solution salinized with NaCl improved germination percentage in *Brassica* spp. Shahi-Gharahlar *et al*. (2009) showed that under saline conditions, summer squash (*Cucurbita pepo* L.) seed priming with KNO_3 (-1.27 MPa at Ec = 7 ds/m) was better than with other treatments such as NaCl and PEG. Okcu *et al*. (2005) reported that salt (NaCl) stress decreased seedling growth and increased mean germination time of pea seeds. Kaya and Day (2008) indicated that salt (Nacl) stress decreased seed germination and seedling growth of sunflower (*Helianthus annuus* L.).

Cumin (*Cuminum cyminum* L.) belongs to the Apiaceae family and is an important medicinal plant. In Iranian ancient medicine, it is used for the treatment of diarrhea, toothache and epilepsy (Haghparast *et al*. 2008). Several therapeutic indications involving gastrointestinal, gynecological and respiratory disorders (asthma and dyspnea) have been described for the seeds of *C. cyminum* in ancient Iranian medical books (Boskabady *et al*. 2005). The extracts and essential oil from *C. cyminum* has been reported to possess antimicrobial, antidiabetic, antihyperlipidemic, antiinflammatory and anticarcino-genic properties. In addition, there is evidence of the relaxant effects of the volatile oil from this plant on smooth muscle preparation (Boskabady *et al*. 2005). The present work aimed to investigate the germination and seedling growth of *C. cyminum* under different salt sources and concentrations.

MATERIALS AND METHODS

The experimental design was a two-factorial completely randomized design (CRD) with four replications and 50 *C. cyminum* seeds per replicate. The first factor was salinity source and the second factor was salinity concentration. Treatments were KNO_3 solution (0, 50, 100 and 150 mmol/L), NaCl solution (0, 50, 100 and 150 mmol/L) and $CaCl_2$ solution (0, 50, 100 and 150 mmol/L). Control treatment was distilled water.

C. cyminum seeds were superficially sterilized with 0.1% $HgCl_2$ solution for 5 min, and then thoroughly washed for 5 min. Four replicates of 50 seeds were germinated between two rolled sheets of filter paper with 10 ml of each test solution. The filter paper was replaced every day to prevent accumulation of salts. Seeds were allowed to germinate at 22 ± 1°C in the dark for 9 days. A seed was considered germinated when the emerging radicle elongated to 2 mm. Seed germination was recorded every 24 h for 24 days. Radicle length, shoot length and seedling fresh weights were measured on the 9th day of the experiment.

Germination percentage was calculated using the formula:

$$\text{Germination percentage (GP)} = \frac{\text{Number of germinated seeds}}{\text{Total of number seeds}} \times 100$$

Mean germination time (MGT) was calculated using the method of Schelin *et al*. (2003):

$$\text{Mean germination time (MGT)} = \frac{\sum f_i x_i}{N}$$

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Original Research Paper

Table 1 Analysis of variance of the effect of salinity source on *Cuminum cyminum* L. seed germination under study.

	Germination percentage (%)	Mean germination time (day)	Shoot length (mm)	Root length (mm)	Seedling fresh weight (g)
Salt solution	2800.3**	2.13**	106.9**	203.0**	0.96*
Salt source	2178.5**	1.67**	119.8**	237.1**	0.92**
Salt solution × salt source	1876.8*	1.9**	98.6**	128.1**	0.038**
Error	109.2	0.09	3.7	9.30	0.005
CV (%)	14.7	11.2	5.2	8.1	9.3

*: Significant at $P = 0.05$; **: Significant at $P = 0.01$.

fi: Day number during germination period

xi: Number of germinated seeds per day

N: Sum of germinated seeds

Data was analyzed using MSTATC software. Mean comparison was performed with Duncan's multiple range test, and graphs were drawn using Excel 2000 software.

RESULTS AND DISCUSSION

Germination percentage and mean germination time

GP and MGT of *C. cyminum* were influenced by salinity source, salinity concentration and interaction of these factors (**Table 1**). Increased salinity concentration decreased GP, independent of the salinity source (**Fig. 1**). The control (83%), 50 mmol/L NaCl solution (78%) and 50 mmol/L $CaCl_2$ solution (77%) showed highest GP among the treatments. At 50 mmol/L NaCl, highest GP was obtained (66%). *C. cyminum* germination percentage was not significantly different in all salinity sources at 150 mmol/L (**Fig. 1**). Farhoudi *et al.* (2007) reported that salt stress decreased canola seed germination. Similar results were reported in several crops as wheat (Hampson and Simpson 1990), watermelon (Demir and Oztokat 2003) and soybean (Khajeh-Hosseini *et al*. 2003) in which seed germination and seedling growth were reduced under saline conditions.

Salt stress increased MGT of *C. cyminum* seeds (**Fig. 2**). Indeed, increased salinity levels elongated MGT. At 50 mmol/L KNO_3 *C. cyminum* seeds had the lowest MGT value compared to other salinity sources but seeds treated with 150 mmol/L KNO_3 showed a remarkable increase in MGT compared other salinity sources (**Fig. 2**). Okcu *et al.* (2005) reported that salt stress increased MGT of pea seeds. Abd El-Samad and Shaddad (1997) stress that decreased seedling growth but increased MGT of soybean seeds occurred under salinity stress. Ashraf and Naqvi (1992) showed that germination and seedling growth of *Brassica* spp. decreased due to salt stress but addition of $CaCl_2$ to solution salinized with NaCl improved germination percentage but had no effect on germination speed.

Shoot and root length

C. cyminum shoot and root length were significantly influenced by salinity source, salinity concentration and the interaction of these factors (**Table 1**). Salt stress decreased shoot length of *C. cyminum* (**Figs. 3, 4**). Control and 50 mmol/L NaCl resulted in the highest values of shoot and root length of *C. cyminum* seedling. **Figs. 3** and **4** showed the lowest shoot lengths at 100 and 150 mmol/L KNO_3 (7 and 5 mm) and 150 mmol/L NaCl (6 mm). Under high salinity, $CaCl_2$ treatment resulted in highest shoot and root length compared to other treatments (**Figs. 3, 4**).

Bhattacharjee and Mukherjee (2002) and Farooq and Azam (2006) reported that salt stress decreased the growth of rice and wheat seedlings. They suggested that increased cell membrane leakage decreased seedling growth under salt stress. Huang and Redman (1995) reported that NaCl, Na_2SO_4 and $CaCl_2$ as sources of salt stress decreased root and shoot length of canola and barley but least negative impact on seedling growth was with $CaCl_2$. Bandeoglu *et al.* (2004) and Khajeh-hosseni *et al.* (2003) noted that under salinity (32.2 to 421.1 mmolal NaCl and 5-30% w/v PEG),

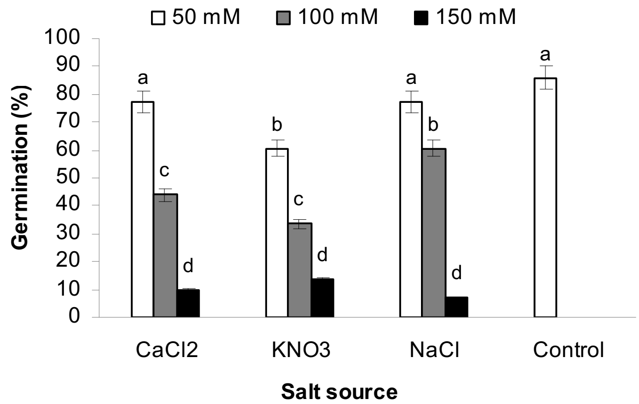

Fig. 1 Effect of salinity source on seed germination percentage of *Cuminum cyminum* L.

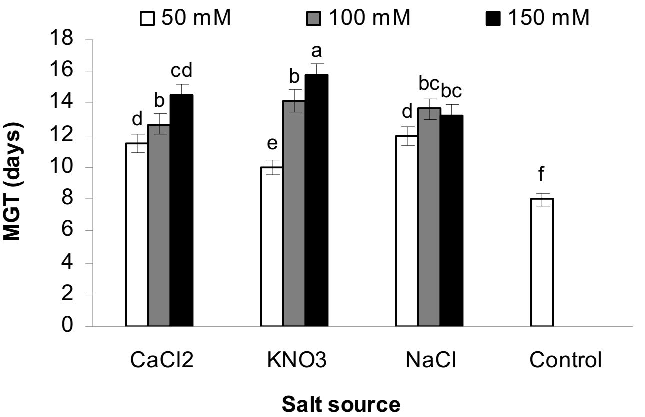

Fig. 2 Effect of salinity source on mean germination time (MGT) of *Cuminum cyminum* L.

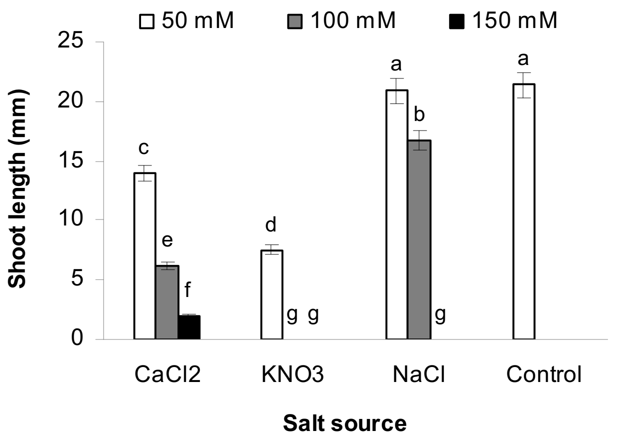

Fig. 3 Effect of salinity source on shoot length of *Cuminum cyminum* L.

negative osmotic potential prevented water uptake and inhibited soybean seedlings root and shoot growth.

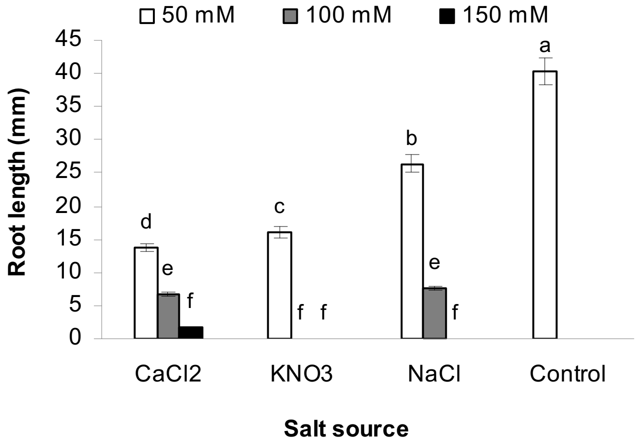

Fig. 4 Effect of salinity source on root length of *Cuminum cyminum* L.

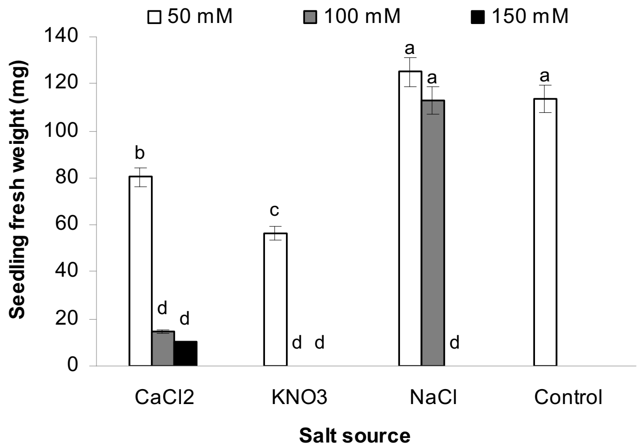

Fig. 5 Effect of salinity source on seedling fresh weight of *Cuminum cyminum* L.

Seedling fresh weight

C. cyminum seedling fresh weight was significantly influenced by salinity source, salinity concentration and the interaction of these factors (**Table 1**). Increasing salinity concentration resulted in a decrease in seedling fresh weight (**Fig. 5**). There was no significant difference in seedling fresh weight between control and 50 and 100 mmol/L NaCl (**Fig. 5**). The lowest seedling fresh weight (3-5 mg) was obtained at 100 and 150 mmol/L KNO_3 and 150 mmol/L NaCl (**Fig. 5**). At 150 mmol/L $CaCl_2$, highest seedling fresh weight was observed (**Fig. 5**). Salt stress decreased seedling weight in many plants (Bhattacharjee and Mukherjee 2002; Okcu *et al.* 2005; Farhoudi *et al.* 2007). Kaya and Day (2008) reported that salt stress decreased seed germination and seedling growth of sunflower (*Helianthus annuus* L.) under salinity stress and similar responses were been reported for *Phaseolus* spp. seeds (Bayuelo-Jiménez *et al*. 2002). Salinity source can influence seedling growth (Huang and Redman 1995). Suhayda *et al*. (1992) found that the addition of calcium had no effect of germination but improved seedling growth of cotton (*Gossypium hirsutum* L.) seedlings.

CONCLUSION

Earlier growth stages are more sensitive to salinity than subsequent ones (Boem and Lavado 1996). Our study showed that increased salinity concentration decreased seed germination and seedling growth of *C. cyminum*. The source of salinity significantly influenced the response of *C. cyminum* to salt stress. After seeds were treated with 100 and 150 mmol/L $CaCl_2$, *C. cyminum* seedlings had highest fresh weight, shoot and root length compared to other (NaCl and KNO_3) sources of salinity. Salinity may also affect the germination of seeds and seedling growth by creating an external osmotic potential that prevents water uptake or due to the toxic effects of Na^+ and Cl^- ions on the germinating seed (Khajeh-Hosseini *et al*. 2003). Supplemental calcium had no effect on final germination in some plants like cotton (Suhayda *et al*. 1992) and barley (Huang and Redman 1995), rather, it improved seedling growth of these plants. Our study showed that under high salinity stress (100 and 150 mmol/L), *C. cyminum* seeds treated with $CaCl_2$ had higher seedling fresh weight and seedling growth compared to other sources of salinity (NaCl and KNO_3) but we did not observe any significant different between seed germination under high salinity level of various salinity sources.

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