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Full Length Research Paper

Seed germination and early seedling growth of haricot bean (*Phaseolus vulgaris* L.) cultivars as influenced by salinity stress

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An experiment was conducted to investigate the effect of salinity on germination and seedling growth of haricot bean cultivars. Two haricot bean cultivars (Lehade and Chercher) and five salinity levels (0, 2, 4, 8 and 16 mM) were factorially arranged in complete randomized design with three replications. The result of the study indicated that cultivars × salinity interaction was not significant. However, significant differences were observed between cultivars in germination percentage, root length, shoot and root fresh and dry weights, and seedling dry weight. Lehade cultivar gave the higher germination percentage (100%) compared with Chercher (92.5%), but gave significantly lower value in all other seedling growth traits, except shoot length and root-to-shoot length ratio. Increase in salinity levels decreased germination percentage (2.1-8.3%); shoot (20.6-57.3%) and root (16.4-59.3%) lengths; shoot fresh weight (14.9-41.2%) and root fresh weight (13.1-30.4%); shoot dry weight (11.2-28.5%); root dry weight (8.3-41.2%); seedling dry weight (10.8-57.6%); and root-to-shoot length ratio (0.4-17.1%) of haricot bean. The study confirmed that, cultivars varied genetically for their germination percentage and growth traits. The increase in salinity level substantially decreased germination percentage and seedling growth parameters in haricot bean cultivars.

Key words: Cultivars, Germination percentage, *Phaseolus vulgaris* L., NaCl, Seedling growth, Salinity stress.

INTRODUCTION

Haricot bean is one of the main cash crop and protein sources of farmers in many low lands and mid altitude zones of Ethiopia (EIAR, 2011). The crop is grown by subsistence farmers either as a sole crop and/or intercropped with either cereal or tree crops. Its production is heterogeneous in terms of ecology, cropping system and yield (Belay et al., 1998). It is also one of the most popular and important crops in the Rift Valley parts of the country and the export earnings from haricot bean surpass that of other pulses such as lentils, horse bean and chickpea (Haile, 1990).

According to Munns and Tester (2008) more than 45 million hectares (M ha) of irrigated land (20% of total land) have been damaged by salt worldwide and 1.5 M ha are taken out of production each year due to high soil salinity. Mahajan and Tuteja (2005) also reported that, increased salinity of agricultural land is expected to have destructive global effects, resulting in up to 50% loss of cultivable lands by the middle of the 21st century. In Africa, 1,899 M ha of land is affected by salinity (FAO, 2008). In Ethiopia, salt-affected soils are prevalent in the Rift Valley and the lowlands. The Awash Valley in general and the lower plains in particular, are dominated by salt-affected soils (Gebreselssie, 1993). Many authors (Kinfemichael, 2011; Tsige et al., 2000; Fassil, 2009; Taddese and Bekele, 1996; Haider et al., 1988) reported that salinity problems escalated and spread to many parts of the country including; Melkassa, Melka Sadi, Melka Werer, Abaya State Farm and Dams in Mekelle Plateau. The Ethiopian government has plans to introduce and implement large-scale irrigation agriculture to increase agricultural productivity (Mamo et al., 1996). Unless proper management strategies are designed, the prevailing salinity problem in the country is expected to become severe in the years to come (Kinfemichael, 2011).

Salinity is one of the factors limiting the productivity, be-

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cause most of the crop plants are sensitive to salinity caused by high concentrations of salts in the soil (Hasanuzzaman et al., 2013). According to Brouwer et al., (1985) the highly tolerant crops can withstand a salt concentration of the saturation extract up to 10 g L^{-1}, the moderately tolerant crops up to 5 g L^{-1} and the sensitive group about 2.5 g L^{-1}.

Various internal (plant) and external (environmental) factors affect seed germination under saline conditions which includes nature of seed coat, seed dormancy, seed age, seed polymorphism, seedling vigor, temperature, light, water and gasses (Wahid et al., 2011). Seed germination is the first step of plant life, which determines when and where seedling growth begins (Jeannette et al., 2002) and is very sensitive to salt stress. Germination percentage of seeds at a particular time varies considerably among species and cultivars (Hasanuzzaman et al., 2013). Seed germination, seedling emergence and early survival are particularly sensitive to substrate salinity (Katembe et al., 1998; Williams et al., 1998). Salt stress affects physiological processes (Noreen and Ashraf, 2008) and exerts undesirable effects through osmotic inhibition and ionic toxicity (Munns et al., 2006). Increased salinity caused a significant reduction in germination percentage, germination rate and root, shoots length and fresh root, and shoots weights (Jamil et al., 2006). Therefore, germination and seedling characteristics are the most viable criteria used for selecting salt tolerance in crop plants; hence, percentage of germination and seedling growth are important growth parameters to be studied for cultivar selection (Mordi and Zavareh, 2013). Hence, the present study was undertaken to investigate the effects of different salt concentrations on the germination and seedling growth of haricot bean cultivars.

MATERIALS AND METHODS

A laboratory experiment was conducted in May, 2013 at the Department of Plant Sciences and Horticulture, Ambo University, to study the effect of salinity on germination and seedling growth of two haricot bean cultivars. The experiment was arranged in factorial and laid out in completely randomized design with three replications. Factors included were two cultivars (Lahede and Chercher) and five levels of salinity (0, 2, 4, 8 and 16 mM) de-ionized water was used for the control treatment. NaCl was used as sources of salinity as described by (Kaymakanova, 2009).

Seeds were surface sterilized with 5% Sodium hypochlorite solution for 5 minute and rinsed with distilled water. Ten uniform seeds of the two haricot bean cultivars, were placed in a Petri plate (9.5 cm diameter) using a forceps.

Filter papers were well soaked by adding 10ml with the respective solutions (4 treatment solutions and the control) at an interval of 48hrs as described by Naveed et al., (2001). All the Petri plates were covered with lids and kept at room temperature (24 ± 2 ^{o}C). Germination was continued for 12 days and germinated seeds were counted daily. The seeds were considered germinated when radicles appeared and are visible when length reached 2 mm. After 12 days, parameters such as percent of germination were calculated according to ISTA (1999); and root and shoot lengths of seedling were measured using a scale. Root and shoot dry weights were measured after oven-drying for 72 h at 60 ^{o}C.

Statistical analysis was performed using one-way ANOVA using SAS statistical software (Version 9). Based on the ANOVA results mean separations were performed by Duncan's multiple range test (DMRT) at 5% level.

RESULTS AND DISCUSSION

Seed Germination and Seedling Growth

Cultivars differed significantly in germination percentage, root length, shoot and root fresh and dry weights, and seedling dry weight. Lehade cultivar gave the higher germination percentage (100%) compared with Chercher (92.5%). The variability of cultivars for germinations and other growth traits could be due to heterogeneity in their genetic makeup. Similar findings were also reported on barley (Nasseer et al., 2001), and on sorghum (Ahmed et al., 2012; Asfaw, 2011). Lehad cultivar though germinated effectively under salt stress; its seedling growth was adversely affected by salt concentrations. This finding is in agreement with earlier reports in sorghum (Ahmed et al., 2012; Geressu and Gezahagne, 2008; Azhar and McNeilly, 1987). This showed that Lehade cultivar is salt tolerant during germination but subsequent seedling growth and biomas production suffered due to salt stress (Table 1).

Seed Germination Versus Salinity

An increase in salinity reduced the germination percentage of haricot bean. The reduction in germination percentage varied from 2.1 - 8.3%. The highest germination percentage (100%) was obtained in control and the lowest with 16 mM (91.7%) (Figure 1). Many authors (Khodarahmpour et al., 2012; Hasanuzzaman et al., 2013; Kinfemichael, 2011; Dantas et al., 2007) also reported that salt stress adversely affected seed germination, either osmotically through reduced water absorption or ionically through the accumulation of Na+ and Cl- and toxicity effect (Kaya and Ozturk, 2003). High salinity due to NaCl was reported to affect germination through altering the imbibition of water by seeds due to lower osmotic potential of germination media (Khan and Weber, 2008), by disturbing hormonal balance (Khan and Rizvi, 1994) and by reducing the utilization of seed reserves (Othman et al., 2006).

Table 1. Effect of salinity on germination % and seedling growth parameters of haricot bean cultivars

Cultivars	Germination (%)	Shoot length (cm)	Root length (cm)	Shoot fresh weight (g)	Root fresh weight (g)	Shoot dry weight (g)	Root dry weight (g)	Seedling dry weight (g)	Root/shoot length ratio (cm)
Lehade	100 a	10.9 a	7.1 b	0.709 b	0.325 b	0.372 b	0.155 b	0.527 a	0.662 a
Chercher	92.5 b	11.3 a	8.1 a	0.829 a	0.349 a	0.389 a	0.186 a	0.574 b	0.709 a
SE (m)	1.86	0.66	0.5	0.04	0.02	0.01	0.01	0.02	0.04
CV (%)	3.4	10.3	11.3	8.7	8.8	6.1	9.5	5.3	10.4

Means with similar letters in each column are not significant at 5% level of probability.

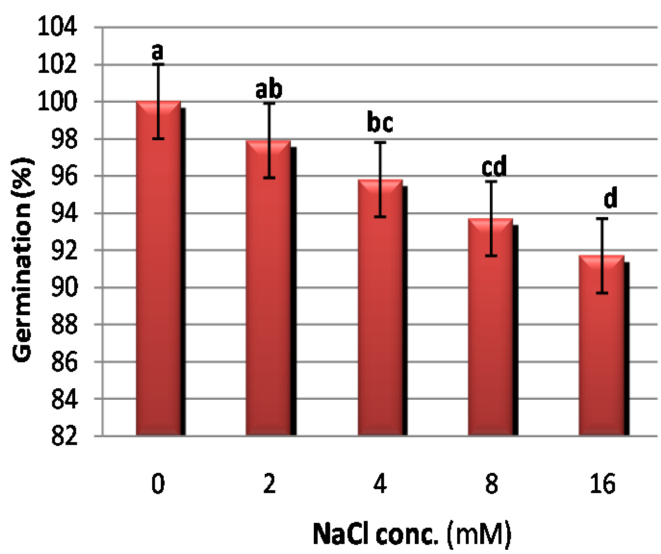

Fig 1. Effect of salinity on germination of haricot bean

Shoot and Root Lengths

The root and shoot elongation of haricot bean decreased significantly with increased salinity (Figure 2). The percent of root and shoot growth decreased due to salinity ranged from 20.6 - 57.3% and 16.4 - 59.3%, respectively. Maximum lengths of the shoot and root were recorded in the control treatment; however, the lowest lengths were recorded with 16 mM NaCl concentrations. Salinity stress had an instant effect on cell division and shoot expansion (Parida and Das, 2005). The results of this study are in conformity with those of other reports (Moradi and Zavareh, 2013; Guan et al., 2011; Kinfemichael, 2010; Asfaw, 2011 ; Ahmed et al., 2012; Naseer et al., 2001), which indicated significant reduction of shoot and root lengths with increase in salinity on different crops.

Shoot and Root Fresh and Dry Weights

Shoot and root fresh weights decreased from 14.9 - 41.2% and 13.1- 30.4%, respectively with increase in salinity. The lowest shoot and root fresh weights were recorded with 16 mM salt concentrations (Figure 3). These results are in conformity with the earlier findings (Asfaw, 2011; Naseer, 2001; Kinfemichael, 2011).

Shoot and root dry weights also decreased significantly with increase in salinity with maximum being in the control treatment, while the lowest with high NaCl concentrations (16 mM) (Figure 4). The percent reduction of shoot and root dry weights were 11.2 - 28.5% and 8.3 - 41.2%, respectively. The reduction in dry weight with increased salinity could be due to limited supply of metabolites to young growing tissue, because metabolite production is significantly affected at high salt stress, and low water up- take or toxicity effect of NaCl (Hasanuzzaman

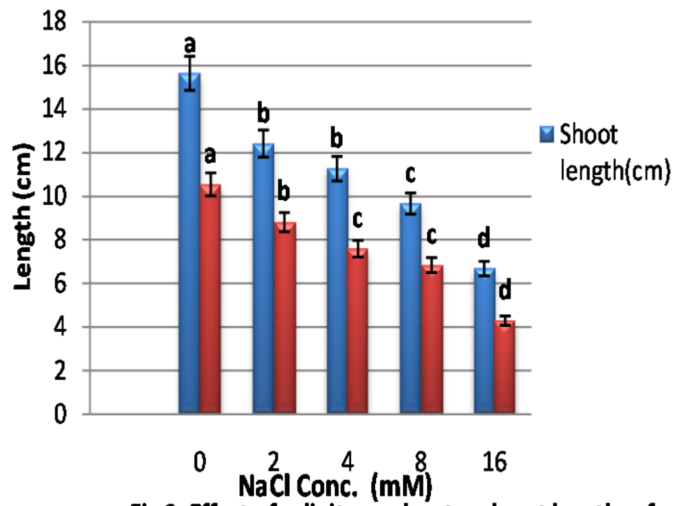

Fig 2. Effect of salinity on shoot and root lengths of haricot bean

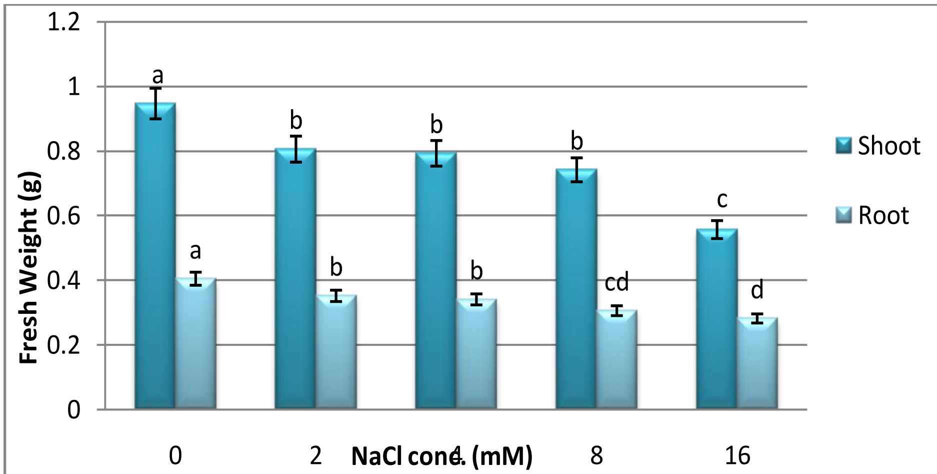

Figure 3. Effect of salinity on shoot and root fresh weights of haricot bean

et al., 2013). Similar findings were reported in sorghum (Geressu and Gezahagne, 2008; Asfaw, 2011), canola (Seyed and Morteza, 2013), sugar beet (Ghoulam and Fores, 2001), chickpea (Moradi and Zavareh, 2013) and safflower (Kaya and Ozturk, 2003).

Seedling Dry Weight and Root–to-Shoot Length Ratio

Increase in salt concentration decreased seedling dry weight significantly. The regression analysis showed that there was a strong negative relationship (Y=-0.011x + 0.622; R^2 = 0.933) between seedling dry weight and salinity concentrations (Figure 5). Seyed and Morteza, (2013) showed that seedling dry weight had strong negative relation with salinity levels in canola.

Strong relation was observed between root-to-shoot lengths ratio with salinity (y = -0.003x + 0.706; R^2 = 0.849). The root-to-shoot length ratio of haricot bean showed a decreasing trend with increasing in NaCl concentrations (Figure 6). With increased salinity, root-to-shoot length ratio decreased to 0.4 - 17.1%. The highest value of root–to-shoot length ratio was observed with the control, while the lowest with 16 mM salt concentration.

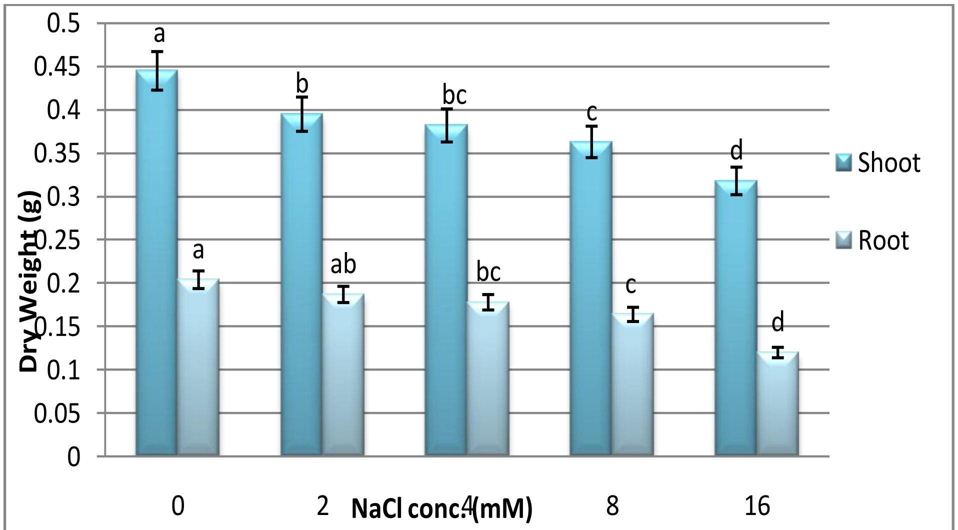

Figure 4. Effect of salinity on shoot and root dry weights of haricot bean

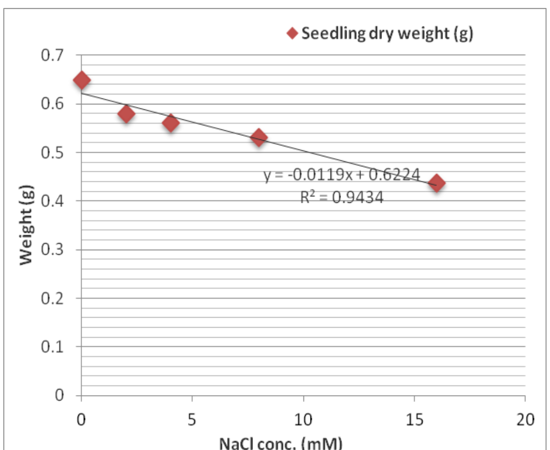

Fig 5. Relation between seedling dry weight to NaCl concentrations

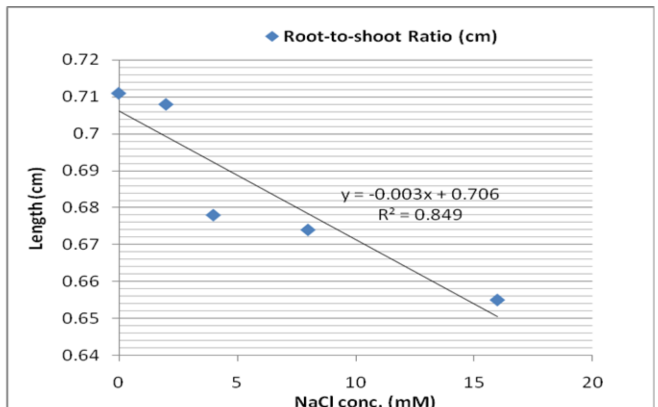

Fig 6. Relation between Root-to-shoot Ratio to NaCl concentrations

CONCLUSION

The results of this study confirmed that cultivars vary in their germination percentage. High germination percentage might not necessarily mean higher seedling growth traits under salinity stress. Lehade cultivar showed high germination percentage but performed poorly in other growth parameters compared with Chercher cultivar. An increase in salinity concentration decreased germination percentage, shoot and root lengths, shoot and root fresh and dry weights, seedling dry weight and root-to-shoot length ratio in haricot bean. Hence, further evaluation of different cultivars of haricot bean for salinity tolerance both in laboratory and field conditions should be encouraged in the future under Ethiopian condition.

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