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Research Article

EFFECT OF DIFFERENT SALT CONCENTRATION ON SEED GERMINATION AND SEEDLING GROWTH OF DIFFERENT VARIETIES OF OAT (*Avena sativa* L.)

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ABSTRACT

Oats (*Avena sativa* L.) is a winter cereal forage crop. Oat crops are generally less sensitive to soil acidity and salt stress. Salinity is a global problem for limiting plant growth and agriculture productivity in many areas of the world. An experiment was conducted in perti dishes lined with Whatman filter paper at the room temperature. Salinity tolerance of seven oat varieties (JHO-822, Kent, OL-9, OL-125, UPO-212, UPO-94 and NDO-2) were investigated on the basis of seed germination and seedling growth. Different salinity levels (25, 50, 75 and 100 mM NaCl) were used. Distilled water served as control. The rate of seed germination decreased in all cultivars with increasing levels of salinity from 25 to 100 mM. The analyzed data showed that NDO-2 and UPO-212 were found to be highly salt tolerant and moderately salt tolerant respectively in term of germination %, shoot/root length and dry weight of shoot and root with respect to salinity. Conversely, UPO-94 was sensitive to salinity in terms of the above parameters studied.

INTRODUCTION

Oat (*Avena sativa* L.) is popular worldwide cereal crop as a breakfast food and it contains a high percentage of carbohydrate. It is commonly used as feed for livestock (Verma *et al*., 1986) throughout the world. Oat (*Avena sativa* L.) is grown throughout the temperature zone as rabi crop and has a low summer heat requirement and greater tolerance of rain than other cereals, such as wheat, rye or barley, and therefore are particularly important in areas with cool, wet summers (Gray *et al*., 2000). It has rich medicinal value and being used as food by the diabetic patients, since the grain are filled with cholesterol fighting soluble fiber called beta-glucan (Singh *et al*., 2003). Beta-glucan is the main active ingredient responsible for all physiological beneficial effects of Avena sativa (Ahmad *et al*., 2014). Oat grain is a good source of quality protein, unsaturated fatty acids, mineral and vitamins (Drzikova *et al*., 2005; Sun *et al*., 2006). Salinity is one of the brutal environmental factors limiting the productivity of crop plants because most of the crops plants are sensitive to salinity caused by high concentration of salt in the soil (Munns *et al*., 2009).

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Salinization is rapidly increasing on a global scale and effect more than 10% of arable land, which results in a decline of the average yields of major crops greater than 50% (Wang *et al*., 2009). Salinity cause reduction in osmotic potential thereby causing a decrease in plant growth. Salt ions prevent water absorption by roots due to more negative water, potentials of soil solution and plants are subjected to a water deficit. Salinity adversely affects plant growth and development hindering seed germination (Dash and Panda, 2001), seedling growth (Ashraf, 2002). Soil salinity may influence the germination of seeds either by creating an osmotic potential external to the seed preventing water uptake, or the toxic effect of Na^+ and Cl^- ions on germination seed. Salt and osmotic stresses are responsible for both inhibition or delayed seed germination and seedling establishment. Seed germination, seedling emergence and early survival are particularly sensitive to substrate salinity (Nasri *et al*., 2015). Seedling are the most vulnerable stage in the life cycle of plants and germination determines when and where seedling growth begins (Lianes *et al*., 2005). Salinity, in general, has inhibitory effect on germination of seeds (Zhang *et al*., 2010; Abari *et al*., 2011; Kaveh *et al*., 2011). Salinity inhibition of plant growth is the results of osmotic and ionic effects and the different mechanisms to cope with these effects (Munns, 2002).

Sensitive varieties loss vigour quickly by losing water from the stress shocks. But resistant genotypes can tolerate well and survive in severely saline soils (Blaylock, 1994).Germination becomes visible by emergence of the structures surrounding the embryo by the radicle. The shoot and root length are the most important parameters for salt stress because roots are in direct contact with soil and absorb water from soil and shoot supply it to the rest of plant.

For this reason, root and shoot length provides an important clue to the response of plants to salt stress (Jamil and Rha, 2004). High salinity may inhibit root and shoot elongation due to the lower water uptake by the plant (Werner and Finkelstein, 1995). The purpose of this study was to determine the effect of different concentration of NaCl on seed germination and seedling growth of seven varieties of oat (*Avena sativa* L.). Based on these parameters, out of these varieties a most tolerant and a most sensitive were selected for further studies.

MATERIALS AND METHODS

Collection of plant seeds: The seeds of seven varieties of oat (*Avena sativa*) were obtained from different sources as given below.

S.NO.	Varieties	Sources
1	kent	International Agricultural Research Institutes, New Delhi- (12)
2	OL-9	Punjab Agricultural University, Ludhiana (Pb)
3	OL-125	Punjab Agricultural University, Ludhiana (Pb)
4	NDO-2	Narendra Dev University Of Agricultural and Technology, Faizabad (UP)
5	UPO-212	G.B. Pant University of Agricultural and Technology, Pantnagar (UK)
6	UPO-94	G.B. pant University of Agricultural and Technology, Pantnagar (UK)
7	JHO-822	Indian Grassland and Fodder Research Institutes, Jhansi (UP)

Laboratory studies: Experimental materials (petri dishes, whatman filter paper, forceps etc) sterilized for 24 hours in hot air oven. The plant seeds were placed in 0.01% mercuric chloride solution for five minutes for sterilization and were rinsed four times in distilled water. Twenty seeds were grown in each petri dish in single layers of whatman filter paper. Three replicates were used for each treatment at room temperature.

Finally, a solution of NaCl of different concentration viz. 25, 50, 75 and 100 mM was applied in each petri dish of respective concentration. The respective salt solution of 10 ml was added to each petri dish. 2ml distilled water was added to petri dishes every 3rd and 5th day to prevent drying of filter paper.

Germination and seedling growth: The germination count was taken every alternate day. Final reading of germination were taken after 10 days. The observation on shoot and root lengths, dry weights of shoot and root were recorded at 10 days after germination. Dry weight of shoot and root was measured after keeping fresh plant sample in an oven at 60^0 C for 48 hours. The seed germination was calculated using the formula.

Germination percentage= 100× (number of germinated seeds / number of total seeds)

Data analysis: Statistical analysis and plotting of graphs were done by Excel software. A critical difference (CD) was computed when F-test indicated statistically significant differences between genotypes using the method described by Bruning and Kintz, (1977) at P=0.05.

RESULTS

Seed Germination: The effect of different salt concentration on germination has been shown in (Fig.1). It is evident from the figure that germination percentage gradually declined in all oat cultivars as the concentration of salinity increased from 25 to 100 mM. The results were more pronounced at higher salinity levels (75 to 100 mM). The maximum percentage germination was shown by cv. UPO-212 at all salinity levels including control but minimum reduction was exhibited by cv. NDO-2. It ranges from 10.40 to 34.40 % at 25 to 100 mM. Cv. UPO-94 exhibited maximum reduction (21.74 to 60.87%) followed by Kent, OL-9 and OL-125 (11.22 to 56.15%, 6.9 to 50.48% and 18.89 to 50% respectively) at these salinity levels when compared with control. Analysis of variance revealed that germination was affected non-significantly at 25 mM in cultivar UPO-212. However all cultivars of oat exhibited significant reductions as the level of salinity increased from 25 to 100mM.

Germination is one of the most important phases in the life cycle of plant and is highly responsive to existing environment. the soluble salt in the root, beyond a critical limit, adversely influenced germination. Salinity causes osmotic stress (Nandawal *et al*., 2000; Daniela *et al*., 2004) or specific ion effects, which delay, reduces or completely inhibit seed germination (Munns, 2002; Hanselin *et al*., 2005). Present results indicate that percentage germination in different oat cultivars reduced significantly with increasing the salinity levels from 25 to 100 mM. Cv. UPO-212 showed highest percentage germination while UPO-94 revealed least under different salinity levels. It indicates that it is not essential that the variety that shows maximum percentage germination has to be highly tolerant to salinity. (Tejovathi *et al*., 1988) reported that the ability of seed germination and emergence under salt stress indicates its genetic potential for salt tolerance. (Verma *et al*., 1986) also reported the inhibition of germination in some cultivars of oat. Similar results with different crops were recorded by many workers (Dantas *et al*., 2007; Zhang *et al*., 2010; Akbarimoghaddam *et al*., 2011). Studies on salt stress in germinating seeds showed that during this stage, the seeds are particularly sensitive to the saline environment (Bewley and Black, 1994). Salt induced inhibition in seed germination could be attributed to osmotic stress or ion toxicity (Huang and Remann, 1995). According to (Huang and Redmann, 1995), the salt induced inhibition of seed germination could be attributed to osmotic stress or specific ion toxicity. Seed germination is an essential development event in plant (Kim and Park, 2008). It is an important growth stage often subjected to high mortality rates (Jamil *et al*., 2007; Asaadi, 2009; Begum *et al*., 2010 stated that the germination of seed depends on the utilization of reserved food material of the seed. Salinity interfereas with the process of water absorption by the seeds. This subsequently inhibits the hydrolysis of seed

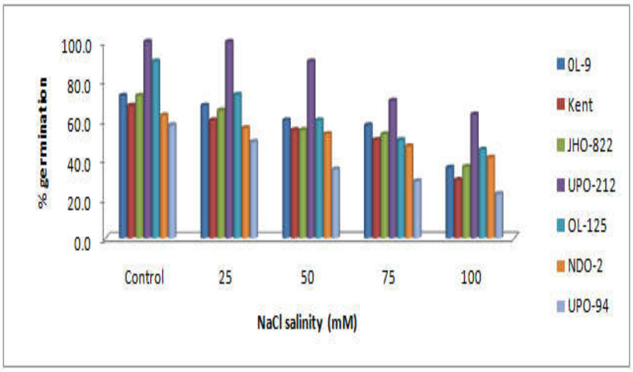

Fig. 1. Effect of NaCl concentration on % germination

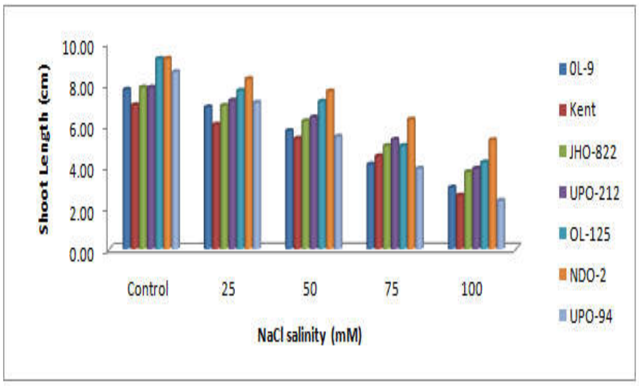

Fig. 2. Effect of NaCl concentration on shoot length (cm)

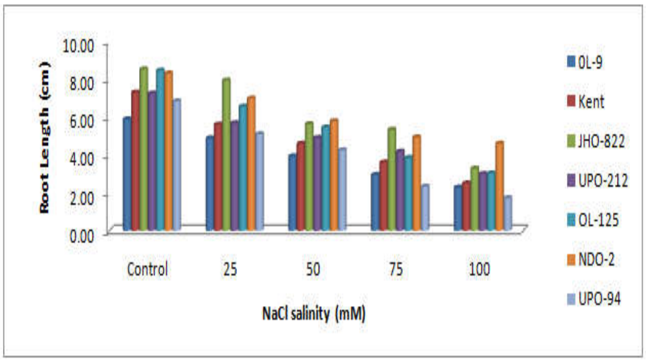

Fig. 3. Effect of NaCl concentration on root length (cm)

researves which ultimately delays and decreases seed germination. Many scientists had reported the inhibitory effect of salinity on seed germination of various crops like *Glycine max* (Essa, 2002), *Vigna* spp. (Ibrar *et al*., 2003), *Brassica* spp. (Ulfat *et al*., 2007), *Zea mays* (Khodarahmpour *et al*., 2012), *Pisum sativum* (Tsegay and Gebreslassie, 2014).

Shoot and Root Length (cm): Root and shoot length of all the oat varieties decreased with. According to Fig.2 and 3, the cultivars UPO-94 showed maximum reduction range from 17.25 to 72.61% and 25.33 to 74.67% followed by Kent and OL-9 (13.61 to 62.75% and 23.29 to 65.75%) and (11.06 to 61.45% and 17.09 to 61.22%). Cv. NDO-2 showed minimum reduction range 10.62 to 42.80% and 15.96 to 44.58% in shoot and root length respectively at all levels of salinity. Length of UPO-212 cultivar showed maximum reduction at 25 mM level but lesser than NDO-2. In the present study shoot and root lengths showed almost similar pattern reduction under salinity level. At higher levels of salinity (75 to 100 mM) the length of shoot and root in all cultivars was more affected as compared to lower levels of salinity. Statistical data revealed that shoot length of NDO-2, JHO-822 and Kent and root length of JHO-822, NDO-2, UPO-212 and OL-9 were non-significantly affected at 25 Mm level of salinity. Length of shoot and root was significantly affected at highest levels of salinity (75 to 100mM), but shoot length of UPO-94, OL-125 and OL-9 and root length of UPO-94, Kent and OL-125 were significantly affected at all levels of salinity (25 to 100mM). Our results indicate that under salt stress, shoot and root lengths were decreased. This reduction with increasing salinity may be due to limited supply of metabolites to young growing tissues because metabolic production is significantly perturbed at high salt stress, probably due to the toxic effects of salt (Yousofinia *et al*., 2012). The present findings indicate that length and dry weight of shoot and root significantly reduced at higher salinity levels. Cv. NDO-2 showed lowest reduction while cultivar UPO-94 greatest reduction by salinity. This indicates that shoot length was more affected than root length at higher salinity level. Our results are not in conformily with the other worker. It was observed by (Gupta and Srivastava, 1989) that roots were less affected than shoots in wheat as salinity of the medium increased. Similar observation have been reported by (Mauro-micale and Licandro, 2002), in globe artichoke (El Goumi *et al*., 2014), in barley (Turan *et al*., 2010), in maize (Ratanakar and Rai, 2013) in *Trigonella foenum-graecum*. Radicle length was more suppressed than plumule by salinity at all salt concentration levels. The gradual decrease in root length with increase in salinity might be due to more inhibitory effect of salt to root growth compared with shoot growth (Anbumalarmathi and Mehta, 2013), in rice. Salinity leads to disturbances in plant metabolism, which consequently led to reduction of plant growth and productivity (Shafi *et al*., 2009; Jaleel *et al*., 2008) also reported a decrease in root length in *Catharanthus roseus* under salinity. Such a decrease in root length and shoot length may be due to salt toxicity and disproportion in nutrient absorption by the seedling as suggested by (Bybordi and Tabatabaei, 2009).

Dry Weight of Shoot and Root (mg): Dry weight of shoot and root showed a remarkable decline at all salinity levels. Percentage reduction in dry weight was lower in the shoot than root (Fig.4 and 5). The cultivars UPO-94 showed maximum reduction (24.35 to 73.91% and 27.14 to 78.57%) while NDO-2 and UPO-212 minimum reduction (7.14 to 42.86% and 10.00 to 45.00%) and (11.76 to 46.47 and 13.14 to 48.86%) in dry weight of shoot and root respectively at all salinity level. It is the interesting to note that cv. NDO-2, UPO-212 and OL-9 showed significant reduction in dry weight of shoot respectively at higher level of salinity (100 mM) while non-significant reduction noted at 25 to 75 mM. Reduction in dry weight of root in cultivar UPO-212 at all levels of salinity are statistically non-significant. The different varieties showed a declining trend in dry weight of shoot and root as concentration under varying salt stress. Dry weights of shoot and root were strongly inhibited at all salinity treatments. At higher level of salinity (75 to 100 mM) cv. UPO-94 and Kent up to (65.22-73.91 % and 62.50-7.50%) and (50.44-64.44% and 40.60-68.12%) respectively.

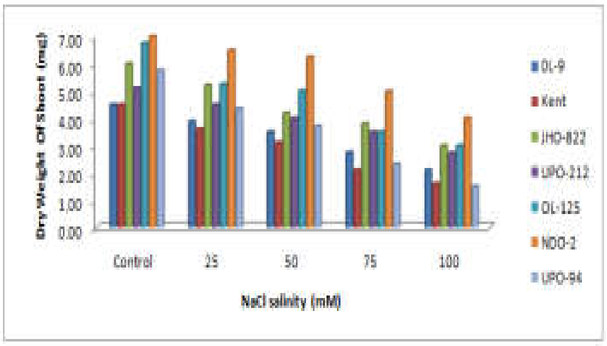

Fig. 4. Effect of NaCl concentration on dry weight of shoot (mg)

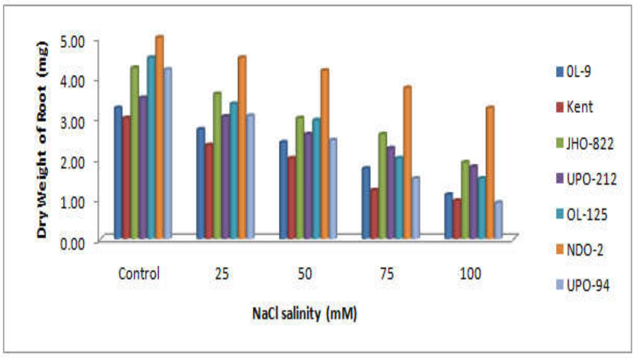

Fig. 5. Effect of NaCl cconcentration on dry weight of root (mg)

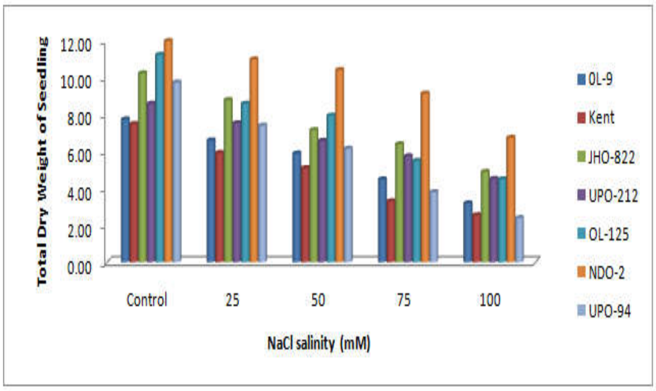

Fig. 6. Effect of NaCl concentration on total dry weight of seedling

These results are similar to those reported by researchers (Shannon and Grieve, 1999; Akbarimoghaddam *et al*., 2011; Zhani *et al*., 2012; Agarwal *et al*., 2015; Kirnak *et al*., 2001) have also reported that the increasing salt concentration declined the dry matter yield at high NaCl concentration. Present study indicates that dry weight of root and shoot were significantly reduced at higher salinity levels (100 mM). Present results are also similar to the findings of (Jamil and Rha, 2007; Bakht *et al*., 2007) who had reported that the dry weight of shoot and root were decreased with increasing salt stress. The decrease of shoot and root dry weight probably may be due to some reasons such as (i) salt stress reduced photosynthesis per unit leaf area which turned into limited supply of carbohydrate needed for shoot length, (ii) reduced turgor resulting in lower water potential. In addition, salinity affected final cell size as well as rate of cell production and thereby resulting in reduced shoot and root dry weight. The results are in agreement with the findings of (Alam *et al*., 2004; Mahmood *et al*., 2009).

Total dry weight of seedling (mg): Total dry weight of seedling in all cultivars of oat was decreased with increasing salinity levels. The maximum reduction was noted in the UPO-94 (24.00 to 75.38%) and minimum in NDO-2 (8.33 to 43.75%) and UPO-212 (12.33 to 47.44%) respectively at all salinity levels (Fig.6). Data revealed that dry weight of seedling in all cultivars were reduced significantly, however cv. NDO-2 and UPO-212 recorded non-significant reductions at 25 to 50 mM and significant reduction at 75 to 100 mM. Cv. UPO-94, OL-125 and OL-9 was significantly affected at all salinity levels (25 to 100 mM). It is evident that cv**.** UPO-94 proved most sensitive and while NDO-2 proved highly tolerant and UPO-212 proved moderately tolerant to salinity in the term of total seedling dry matter. Similar observation have been reported by (Rastegar and Kandi, 2011) in soybean and (Hoque *et al*., 2014) in maize. (Ashraf *et al*., 2002) reported that the reduction in seedling fresh and dry weight is due to decreasing water uptake by seedling in salt stress presence. (Mohamedin *et al*., 2006) have also been reported that salinity induced weter deficit hence the reduced plant growth. (Cha-Um and Kirdmane, 2009) reported that a decrease in fresh weight as well as dry weight in maize seedling under NaCl salinity. According to them, salinity leads to water deficit in plants thereby causing a decrease in fresh and dry weight (Ratanakar and Rai, 2013; Dadkhah and Grrifiths, 2006). (Dadkhah and Grrifiths, 2006) attributed such a decrease in dry weight to greater reduction in uptake and utilization of mineral nutrients by plants under salt stress. In general, there is a decrease in dry weight of plants under saline conditions which can be attributed to reduced rate of photosynthesis, as suggested by (Jafari *et al*., 2009).

DISCUSSION

Seed germination: It seems that decreased in per cent germination may be due to decrease of water movement in to the seeds which can be called water deficit effects of salinity. Different cultivars reveal their varying ability of seed germination towards salinity.

Shoot and root length (cm): The reduction in shoot and root lengths is due to decreased physiological activities resulting from water and nutrients stress occurring under high salinity stress. Salinity may lead to disturbances in plant metabolism that leads to reduction of plant growth.

Dry weight of shoot and Root (mg): The accumulation of more dry matter in shoots than roots indicated the partitioning of more photo-assimilates in roots. It may be due to greater ability of shoot osmotic adjustment under salt stress.

Total dry weight of seedling (mg): The decline in total dry weight of seedling under different salinity levels correspond to dry weight of shoot and root taken together. Total dry weight is reduced due to water deficit that impaired metabolism and other biochemical changes.

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