Effect of Sodium Chloride on Germination and Emergence of Moringa (*Moringa oleifera* L.) Seeds

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Abstract: Two experiments were conducted to evaluate sodium chloride (NaCl) tolerance of moringa tree (*Moringa oleifera* L.) at germination and emergence. The first experiment evaluated germination percentage, mean time of germination and germination uniformity at four NaCl concentrations (0, 40, 80 and 160 mM NaCl/l) on filter paper in Petri dishes in the seed laboratory of Seed Administration, Federal Ministry of Agriculture, Khartoum. The other experiment evaluated emergence percentage, mean emergence time, emergence uniformity and seedling fresh and dry weights at four NaCl concentrations (0.0, 0. 2, 0.4 and 0.8% NaCl w/w of soil, resembling 1.8, 4, 8 and 16 electric conductivity (Ec) of the soil solution) on soil (1.8 Ec and 7.5 pH) in plastic bags in the nursery of the Department of Horticulture, College of Agricultural Studies, Sudan University of Science and Technology at 37^0C and 17^0C mean maximum and minimum temperatures, respectively. Both experiments were laid in completely randomized design with four replications. Germination was only significantly decreased by the highest NaCl concentration (160 mM/l), whereas mean germination time and germination uniformity were significantly retarded by the lowest concentration (40 mM/l). NaCl concentrations higher than 0.2 % (4 dS/m Ec) had significant effects on emergence and its attributes as well as seedlings growth. The reductions of all growth parameters ranged between 30% and 90% at the lowest (0.2% NaCl) and the highest (0.8% NaCl) concentrations, respectively. It could be concluded that moringa may be considered as NaCl sensitive at germination and emergence but to be tolerant at other stages. For utilization of salt affected soils with moringa seedlings which could be raised in the nursery on soils of low or no NaCl.

Key words: NaCl tolerance, Seedling stage, Osmotic potential, Nursery raised.

Introduction

Moringa (*Moringa oleifera* L.) is the most widely cultivated species of Moringace family due to its easy propagation, fast growth and its numerous economic uses (Fahey, 2005). It tolerates drought and salinity but prefers a neutral to slightly acidic (PH 6.3 - 7) well drained sandy or loamy soils. It is sensitive to water logging (Suein, 2008). Salinity impairs agricultural production worldwide, especially in arid and semi arid lands and in coastal deserts, where arable land has been ruined by poor farming practices or rendered unsuitable for farming due to salinity (Hafeez,1993). It also impairs seed germination (Elkeblawy and Alrawi, 2005 and Guma *et al*., 2010), reduces nodule formation, retards plant development and reduces crop yield. However, plants that grow in saline soils show a wide range of salinity tolerance and diverse ionic composition. Salt tolerance of certain crops varies with stage of development. Some crops are salt sensitive during the germination stage but are tolerant after their establishment (Follet *et al*., 1981). Significant effects of salinity on germination speed and germination percen-tage of seeds of five arid zone tree species (*Acacia cyanophylla* L. *Acacia seyal* L., *Acacia tumida* L., *Acacia tortilis* L. *and Parkinsonia aculeate* L.) were found by Shallan (1997), who found that germination of all species decreased rapidly at 10dS/m and no germination was observed at 20dS/m both in laboratory and glasshouse experime-nts. Khan *et al*. (2009) reported significant effects of four salinity levels (3.6, 6.0, 12 and 18 dS/m).on seed germination of four forest tree species (A*cacia ampliceps* L., *Acacia nilotica* L. , *Eucalyptus camaldulensis* L.and *Azadirachta indica* L.). However, the species were significantly different in their salinity tolerance. Similar results were repor-ted by Jamil *et al*., (2006) on seeds of four vegetable species. Farhoudi and Motamedi (2010) used 0, 85, and 170 mM/l NaCl. They found that salinity lowered both germination rate and germination percentage of cowpea.

For utilization of salt affected soils special attention should be given to salinity and drought tolerant trees and shrubs since characters such as rapid growth, drought and salinity tolerance are consider important for utilization of such areas (Fuller, 1979). However, trees may play a major role in desalinization of such soils through their ameliorative effects such as improving soil structure and permeability, adding organic matter through leaf litter and root residues, producing organic acids through root activity, organic matter decomposition by microbial activity and moderating the climatic effects (Gale, 1975). Alatar (2011) stated that seeds of *Moringa peregrina* can be efficient in revegetating salt affected soils. Moringa as economically important and drought (Suein, 2008) and salinity tolerant tree (Elhag, 2010, unpublished data) may play a role in this respect. Moreover, as it is easily propagated by seeds (Jahn *et al*., 1986), its salinity tolerance at seed germination and seedling establishment may help in utilization of salt affected areas. The objective of this study was to evaluate how far moringa is sodium chloride tolerant at germination and emergence.

Materials and Methods

Two experiments were conducted in 2009 to evaluate sodium chloride (NaCl) effect on moringa germination and emergence. Mori-nga seeds were obtained from Forestry Research Station, Soba, Agricultural Resea-rch Cooperation, Federal Ministry of Agricu-lture, Sudan. In the first experiment three NaCl concentrations (40, 80 120 and 160 mM/l NaCl) and a control of distilled water were prepared for germination test. Moringa seeds were placed on filter paper moistened with the different NaCl concentrations or distilled water in Petri dishes (16 Petri dishes of 15 seeds each) in the germination room (Seed Laboratory, Seed Administration, Federal Ministry of Agriculture, Khartoum, Sudan) at 20 $^{\circ}C \pm 1$ in the dark. In the other experiment the soil used was a heavy clay soil having a pH of 7.5 and 1.8 dS/m Ec. Different quantities of NaCl which comprised the treatments were prepared. The soil field capacity was recorded and soil was packed in 16 plastic bags (12x20 cm) at 4kg each. Three quantities of NaCl were added and thoroughly mixed with soil to provide three concentrations of 0.2, 0.4 and 0.8 % w/w in addition to a control without NaCl (0%). The four NaCl concentrations in the soil solution had 1.8 (control), 4, 8 and 16 dS/m Ec, respectively. The seeds were sown in the plastic bags containing different NaCl conce-ntrations at 50seeds/bag. Equal amou-nts of tap water were added to each bag every other day to keep the soil at the field capacity till the end of the experiment (after one month from emergence) which was carried at the nursery of medicinal and aromatic plants, Department of Horticulture, College of Agricultural Studies, Sudan University of Science and Technology. The mean maxim-um and minimum temper-atures were 36 ^{0}C and $17^{0}C$, respectively. The experimental units were in completely randomized design with four replications. The data were statisti-cally analyzed using the computer package (SAS). The means were compared using the least significant difference test (LSD) at 0.05 (Steel *et al*., 1997).

Germination and emergence uniformity were calculated according to (Nicolos and Heydecker, 1968), germination and emerg-ence rate (Ellis and Roberts, 1980), germination and emergence percentages (ISTA, 1999) and seedlings growth were recorded at the end of germination and emergence periods. The numbers of germin-ated seeds and emerged seedlings were recorded daily and final percentage calcul-ated at the end of germination and emerg-ence. Growth of one month old emerged seedlings was evaluated as seedling shoot and root length and seedling fresh and dry weight.

Results and Discussion

Germination percentage (Table1) was significantly decreased by the highest NaCl concentration, whereas mean germination rate and uniformity were significantly reduced by the lowest concentration (Table1). This finding is in conformity with that of Elkeblawy and Alrawi (2005) and Gama *et al*., (2010) who reported that salinity impairs germination. Shallan (1997) and Alatar (2011) showed that salinity has significant adverse effects on some arid zone tree species.

Table1. Effect of NaCl on germination (germination percentage, rate and uniformity) of Moringa seeds (on petri dishes)

NaCl concentration (mM/l)	Germination (%)	Germination rate (days)	Germination uniformity (Seeds /day)
Control (0)	90.0[a]	4.5[c]	2.9[a]
40	93.6[a]	6.6[b]	1.6[b]
80	91.3[a]	7.9[b]	1.4[b]
160	39.0[b]	12.0[a]	0.6[c]

Means followed by the same letters within the same column are not significantly different using LSD at $P \leq 0.05$

Results of experiment conducted in soil revealed that NaCl concentrations showed significant reductions in emergence perce-ntage , rate and uniformity. Both emer-gence rate and uniformity were mostly affected by NaCl levels above 0.4% compared to emergence percentage (Table2).

Table2. Effect of NaCl on seedling emergence of Moringa

NaCl concentration (% w/w of soil)	Emergence (%)	Emergence rate (days)	Emergence uniformity (seeds/day)
Control	100[a]	2.1[c]	3.3[a]
0.2%	85[a]	2.4[c]	2.8[b]
0.4%	85[a]	4.5[b]	0.9[c]
0.8%	50[b]	6.9[a]	0.5[c]

Means followed by the same letters within the same column are not significantly different using LSD at $P \leq 0.05$

All NaCl concentrations had significant negative effects on seedling growth of moringa (Table3). Seedling shoot and root length and shoot fresh and dry weights were greatly reduced even by the lowest NaCl concentration (0.2%). The reduction of all growth parameters ranged between 30% and 90% at the lowest (0.2%) and the highest (0.8%) concentrations, respectively, show-ing that moringa seedlings were NaCl sensitive. These results are in line with those of Tetwari et al. (2006) and Khan et al. (2009) who found a significant negative effect of salts on emergence and seedling growth and development of

Table3. Effect of NaCl on growth (Seedling shoot and root length and seedling fresh and dry weights) one month after emergence (on soil in plastic bags).

NaCl concentration (% w/w of soil)	Seedling shoot length (cm)	Root length (cm)	Seedling fresh weight (g)	Seedling dry weight (g)
Control (0%)	37.0[a]	5.7[a]	28.20[a]	5.9[a]
0.2%	24.7[b]	4.6[b]	18.50[b]	4.1[b]
0.4%	11.6[c]	2.4[c]	9.20[c]	1.6[c]
0.8%	4.9[d]	0.8[d]	3.75[d]	0.5[d]

Means followed by the same letters within the same column are not significantly different using LSD at $P \leq 0.05$).

several forest trees. Jamil *et al.* (2006) indicated that seed emergence of four vegetables species was strongly affected by increased growth medium salinity. Salinity showed significant inhibitory effect on seed germination and seedling growth of *Achilllea fragrantissima* L. *and Moringa peregrine* L. (Alatar, 2011). Gulzar *et al.,* (2001) found that increased NaCl of the growth medium delayed emergence and educed emergence percentage of seeds. Strong reduction was observed mainly at the higher concentrations compared to control They concluded that increasing NaCl adversely affected seed germination and emergence as a result of reducing cell division and plant growth metabolism. The adverse effects of growth medium salinity at germination and emergence may be due to the reduced water potential of the medium which may hinder water absorption of germinating seeds or emergent seedlings (Huang and Reddman, 1995 and Mauromicale and Licandro , 2002) or it may be attributed to toxic effects of certain ions ($Na^+$and Cl^-) as stated by Munns (2002).

Conclusion

Sodiun chloride at various concentrations impaired moringa germination (germination percentage, rate and uniformity). It also impaired emergence, delayed emergence rate, decreased emergence uniformity and reduced seedling growth.

Moringa could be considered NaCl sensitive at germination and emergence.

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تاثير كلوريد الصوديوم على انبات وانبثاق بذور المورينقا

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المستخلص

اجريت تجربتين لتقييم تحمل شجرة المورينقا لكلوريد الصوديوم عند الانبات والانبثاق. اجريت التجربة الاولى لتقييم نسبة الانبات، متوسط زمن الانبات و تجانس الانبات عند اربعة تراكيز من كلوريد الصوديوم (صفر، 40، 80 و 160 ملمول/ل) على ورق ترشيح فى اطباق بترى بمعمل التقاوى (ادارة التقاوى ، وزارة الزراعة الاتحادية ، الخرطوم). اجريت التجربة الاخرى لتقييم انسبة الانبثاق ، متوسط زمن الانبثاق و تجانس الانبثاق وطول ساق وجذر البادرة ووزنها الرطب والجاف عند اربعة تراكيز لكلوريد الصوديوم(صفر، 0.2، 0.4 و 0.8 % من وزن التربة ، تعادل 1.8 ، 4 ، 8 و 16 ديسى زيمن/م توصيل كهربائى لمحلول التربة) فى اصص بلاستيكية (20x12 سم) فى المشتل، قسم الساتين ، كلية الدراسات الزراعية، جامعة السودان للعلوم والتكنلوجيا) فى تربة (1.8 ديسى زيمن/م توصيل كهربائى و 7.5 pH). هذا وقد كانت درجة الحرارة 37°م و17°م قصوى ودنيا، على التوالى. وضعت المعملات فى كل من التجربتين فى تصميم احصائى كامل العشوائية باربع تكرارات. تاثرت نسبة الانبات سلبيا بدرجة معنوية فقط عند اعلى تركيز لكلوريد الصوديوم (160 ملمول/ل) فى حين تاثر متوسط زمن الانبات وتجانس الانبات معنويا عند اقل تركيز لكلوريد الصوديوم (40 ملمول/ل) . وبالنسبة للانبثاق فقد و ضح ان اقل تركيز لكلوريد الصوديوم (0.2%) كان له تاثيرا معنويا على الانبثاق زمنه وتجانسه. تروواح الانخفاض فى كل خواص النمو بين 30% و90% عند اقل تركيز (0.2%) واعلى تركيز (0.8%)، على التوالى. هذا ويمكن ان يخلص الى ان المورينقا تعتبر حساسة لكلوريد الصوديوم عند الانبات او الانبثاق رغم انها متحملة فى الاطوار الاخرى. وللاستفادة من الاراضى المتاثرة بالملوحة بالموررينقا يمكن انتاج بادرات المورينقا فى المشتل او فى اراضى خالية من كلوريد الصوديوم اوتحتوى نسبة منخفضة منه ونقلها لتلك الاراضى.