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Effect of Brine (NaCl) on Germination of Sorghum and Pearl millet Seeds

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Abstract

This study was conducted to investigate the effect of salinity levels on seed germination of sorghum (*Sorghum bicolor* L.) and pearl millet (*Pennisetum glaucum* L. R. Br.) in a Laboratory. The experiment was conducted using one improved sorghum variety *Kaura* and one pearl millet variety SOSAT-C88. Fifty seeds of each of the treatment were germinated in Petri dishes containing filter paper of 9cm diameter. Treatments comprised of control (distilled water), 1.0M, 1.5M and 2.0M NaCl concentrations. Treatments were arranged in completely randomized design (CRD) with 5 replications. Data recorded for both experiment were subjected to analysis of variance (ANOVA). Least Significant Differences (LSD) was used to test differences between treatments means at 5% level of probability. Results of the analysis revealed that all brine concentrations reduced significantly the germination of sorghum and millet seeds compared with the control treatment by 90.56% and 84.24%, respectively. However, there was no significant difference in sorghum and millet seeds germination between the brine concentrations. The germination percentage of the sorghum seeds with brine treatments keeps decreasing with increasing brine concentration and reaches a peak at 1.5M NaCl concentration (62.36%) and then sharply decreased (44.36%) with increase concentration. In millet, the lowest seed germination percentage was obtained from 1.5M NaCl and 2.0M NaCl concentrations (both at 32.52 %). In conclusion, irrespective of NaCl concentrations, the germination of sorghum and millet seeds were significantly reduced, but optimum germination was obtained at 1.M and 1.5M for sorghum and millet seeds, respectively.

Keywords: Sorghum, Pearl Millet, NaCl, Germination

Introduction

Soil salinity is a major factor limiting plant productivity, affecting about 95 million hectares worldwide (Akram *et al.*, 2011). Soil salinity is a global problem that limits crop production especially on irrigated area of the world. Salinity is a limitation where plant growth is reduced to presence of the soluble salts in the soil, which are high enough to affect plant growth and development, as they are unproductive, and unmanageable (Nyagah and Musyimi, 2009).

Modern agriculture management practices also worsen the extent of salinity by remobilizing salts from deep soil layer. Salinity also occurs in non-irrigated environment (Musyimi, 2005). Soil salinity problem can be combated through two approaches: one is to make the available technology for reclaiming these soils, while the other is based on biological exploitation of such soils through cultivation of salt tolerant plant species (Guasmi *et al.*, 2007).

Saboora *et al.* (2006) warned that there was dangerous trend of a 10% per year increase in saline areas throughout the world. Salinity imposes serious environmental problems that affect grassland cover and the availability of animal feed in arid and semi arid regions (El-Kharbotly *et al.*, 2003). Salt stress undesirably affects plant growth and productivity during all developmental stages (Akram *et al.*, 2011). Plants exposed to salt undergo changes in their metabolism in order to cope with changes taking place in their environment. This makes water unavailable to plant which results in reduced water uptake (Mwai, 2001).

The stresses imposed by salinity are mainly due to ion compositions and concentrations in rhizosphere and in plant tissue (Hossein and Thengene, 2007). Saline solutions (salinity stress), affect plant growth by water deficits (osmotic stress), ion toxicity and ion imbalance (ion stress) or a combination of these factors (Musyimi, 2005, Aliakbar and Kobra, 2008). Irrigation systems are particularly prone to salinization, and about half of the existing irrigation system of the world is under influence of salinization (Munns, 2002). In general plants, glycophytic (salt sensitive) plants suffer a decline in growth and productivity when exposed to saline conditions (Nyagah and Musyimi, 2009).

Plants exhibit great variability in their capacity to tolerate salinity, they evolve adaptive mechanisms, which enable them to continue the various metabolic and physiological growth process. The germination process comprises of two distinct phases the first is imbibitions, mainly dependant on the physical characteristics of the seeds (Araya, 2005), and the second is s heterotrophic growth phase between imbibitions and emergence (Almodares *et al.*, 2007).

Imbibition is a process of diffusion of water in plants where the net movement of water is along a diffusion gradient. High salt concentration causes a more negative water potential, and this brings about a decrease in the rate at which water is imbibed and thus the amount of water taken up (Devlin and Witham, 1983).

The rate of salinity on plant growth and development are increasingly problematic worldwide (Musyimi *et al.*, 2007). The mechanisms for salt damage during germination are not fully understood (Almodares *et al.*, 2007). However, the effect of the salinity on plant growth is a complex syndrome that involves osmotic stress, ion toxicity and mineral deficiencies (Musyimi *et al.*, 2007).

Germination refers to emergence of the radical through the seed coat (Araya, 2005). Salinity affects germination by creating an osmotic potential to prevent water uptake or by providing conditions for the entry of the ions that may be toxic to embryo or developing seedlings (Almodares *et al.*, 2007; Nazanin and Mani, 2014). Most of salt normally accumulate at upper soil layer due to evaporation of water from soil surface and this is where seeds are placed. Thus, most of germination takes place at a higher salt concentration than in the whole soil profile, and plants with long taproot or fast growing root system will emerge. However, plants are most sensitive to salinity during germination and seedling growth (Reinhardt and Rost, 1995; Aliakbar and Kobra, 2008; Ali *et al.*, 2014; Siddig and Abdellatif, 2015).

Salinity effects in plants have been with increasingly salinity. These effects on plant include dwarf, stunted plants with colored leaves, coated with wax deposits. High salt concentrations in the rooting media results to loss of turgor, growth stops, and stress is severe enough, killing of tissues in form of falling leaves, or death of whole plant (Mwai, 2001).

Many arid and semi-arid regions of the world contain soil and water resources that are too saline for germination and growth of most important crops. Low germination rates of various crops occur due to high salinity of the irrigation water, thus, poor crop establishment and reduced yield potential (Nyagah and Musyimi, 2001). To produce satisfactorily under saline conditions, seeds must germinate, and seedlings must vigorously pass through the salty layer of the soil and survive (Aliakbar and Kobra, 2008). Under such conditions vigorous seedling is very important for crop establishment. Germination is an important stage in the life cycle of crop plants particularly in saline soils as it determines the degree of crop establishment. Rapid and uniform seed germination under saline condition not only increases early seedling establishment but also has the advantage of higher drought tolerance (Bradford, 1995).

It has been reported by Gworgwor *et al.* (2002) that brine concentration had significant effect on the stand count of sorghum. These decrease significantly with an increasing concentration of brine to a maximum concentration of 1.5M and then decline sharply at rates above the maximum. NaCl has also been used to control *Striga* in sorghum and millet by soaking the seeds of these crops over night before sowing. Gworgwor *et al.* (2002) reported that the brine treatment in all cases significantly resulted in lower *Striga* shoot count on sorghum for example, compared with the non-brine treatment. However, it would be appropriate to observe the reaction of sorghum and millet seeds germination as influenced by brine concentration. Therefore, the objective of this research was to evaluate the effect of different concentration of NaCl solutions on the germination of sorghum and millet seeds under laboratory conditions.

Materials and Methods / Methodology

This experimental study was carried out under laboratory conditions in November, 2006. Sorghum (Kaura variety) and pearl millet (SOSAT-C88) seeds were obtained from the Department of Crop Production, University of Maiduguri, Nigeria and washed before soaking it in the NaCl solution. The seeds were soaked separately in different brine concentrations (i.e. 1.0M, 1.5M, and 2.0M NaCl solution) and left overnight. The treatment solutions were prepared by dissolving proportionate quantity NaCl in distilled water. The seeds were drained off the solution of NaCl and placed on cotton wool to soak away excess water. Forty Petri dishes (9 cm) were arranged, 20 for millet and 20 for sorghum seeds. The treatments comprised of control (distilled water), 1.0Ml, 1.5M, and 2.0M NaCl solution for each of the crop, replicated five times in completely randomized design (CRD). Whatman Filter paper No. 1 was placed inside each set of Petri dish and soaked with 5ml of the NaCl concentration and 5ml of distilled water for the control. Ten seeds of millet and sorghum seeds were arranged in each of the Petri dishes. The treatments were covered and kept in the laboratory and the germination percentage was calculated according to International Seed Testing Association method (ISTA) by counting the germinated seeds per Petri dish on daily basis for 5 days and seeds were considered germinated when the radicals emerged as follows:

% Germination = Number of normally germinated seeds / number of total seeds sown × 100 (Ilori *et al*., 2012).

Data analysis

The data on percent germination count was analyzed by Analysis of Variance (ANOVA) in accordance with Completely Randomized Design (CRD) and the treatment means compared by using LSD at 5% level of probability (Gomez and Gomez, 1984).

Results

Effect of brine (NaCl) on percent germination of sorghum

The result revealed that all brine concentrations reduced significantly the germination of sorghum seeds compared with the control treatment at all the days of assessment (Table 1), while, there was no significant difference in sorghum seed germination between the brine concentrations, but there was a gradual decrease in percentage seed germination of sorghum from the lowest concentration to the highest concentration (Table 1). The 1.5M treatment significantly had the highest germination of the sorghum seeds compared with the 2.0M treatment (Table 1).

Effect of brine (NaCl) on percent germination of pearl millet

The results revealed that all the concentrations of brine significantly reduced the germination of millet seed ($p \geq 0.05$) compared with the control treatment (Table 2). The 1.0M brine treatment had the highest germination of millet seeds compared with the 1.5 and 2.0M brine concentrations.

Discussion

The influence of salinity on germination of sorghum and pearl millet seeds was clearly demonstrated in this study. The effect of brine (NaCl) on sorghum and millet seeds was similar where all the three brine concentration treatments significantly reduced both sorghum and millet seed germination compared with the control treatment. NaCl may be inhibitory to the activities of some enzymes that may play critical roles in seed germination as well as might have damaged the embryo while left overnight. This is in line with the findings of Ali *et al.* (2014) and Siddig and Abdellatif (2015) which also demonstrated that high level of salinity decreased germination percentage due to inhibition of the seed germination. Furthermore, reduction in germination of plants by increasing salinity levels has been reported by numerous authors (Breen *et al.*, 1997; El-Tayeb, 2005; Abdul karim *et al.*, 1992; Abbad *et al.*, 2004; Akram et al., 2011; Sonam *et al.*, 2013).

Flowers (1972) experimenting with species in the genera Beta, Salicornia and Sueda and Cavalieri and Huang (1977) investigating species in the genera Borrichia, Distichlis, Juncus, Salicornia and Spartina reported that malate and glucose-6-phosphate dehydrogenase were among the enzymes affected and their mean inhibition by 0.33m NaCl (-1.5Mpa NaCl) was 66 and 60% respectively. Strognov (1974) reported that growth of alfalfa (*Medicago sativa*) dropped by 42.9% during 7d in the presence of manitol (osmotic effect) and by 89.3% in the presence of NaCl, indicating both a toxic and osmotic effect.

Gworgwor et al. (2002) reported that sorghum establishment in the field was significantly affected by brine treatments where a significantly lower stand count was recorded with 2.0M brine treatment compared with lower rates brine treatments results in low grain yield. This suggests that brine concentration was damaging to sorghum as earlier reported by Ogunremi and Olaniyan (1994) on maize.

Although treating sorghum and millet seeds with any levels of brine affect the germination/establishment of sorghum and pearl millet seeds, it has been reported that such seed treatment with brine significantly reduced *Striga hermonthica* infestation in the field. Gworgwor *et al.* (2002) reported that grain yield of sorghum increased with brine treatment concentration up to a maximum with 1.5M brine treatment and declined at 2.0M brine thus, confirming that 1.5M brine treatment was promising in protecting sorghum from *Striga* attack.

CONCLUSION

This study indicated that increasing NaCl concentration in both sorghum and pearl millet affected seed germination and germination percentage of both the two crops. For higher germination of sorghum and millet the 1.5M and 1.0M brine solution are better than the higher rates of brine. The study was conducted under controlled environment, the result of which may need to be taken with caution when dealing with field conditions, so field experiment should be conducted to confirm the results.

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Table 1. Effect of brine (NaCl) on the percent germination of sorghum

Treatment	Days after first germination					Mean
	1	2	3	4	5	
Control	90.0	90.6	90.6	90.8	90.8	90.56
1.0M	50.4	60.0	60.0	60.4	60.4	58.24
1.5M	50.6	60.4	60.4	70.0	70.4	62.36
2.0M	40.4	40.6	40.8	50.0	50.0	44.36
S.E(±)	9.165	6.633	6.164	5.916	6.164	3.360
$LSD_{0.05}$	19.43	14.06	13.07	12.54	13.07	7.13

Table 2. Effect of brine (NaCl) on the percent germination of pearl millet

Treatment	Days after first germination					Mean
	1	2	3	4	5	
Control	80.0	80.4	80.4	90.2	90.2	84.24
1.0M	50.0	40.2	40.2	40.4	60.2	46.24
1.5M	40.2	30.4	30.4	30.8	30.8	32.52
2.0M	20.6	30.6	30.6	40.2	40.6	32.52
S.E(±)	10.583	11.747	11.662	12.207	13.964	3.400
$LSD_{0.05}$	22.44	24.90	24.72	25.88	29.60	7.22