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Germination and Seedling Growth of Pearl Millet (*Pennisetum glaucum* L.) Cultivars under Salinity Conditions

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Abstract

The study was conducted to investigate the effect of salinity levels on seed germination and seedling growth of two pearl millet (*Pennisetum glaucum* L.) cultivars. A laboratory experiment was conducted using two pearl millet cultivars locally named *Dimbi* (red seeded color) and *Bauoda* (white seeded color). Fifty seeds of each of the cultivars were germinated in Petri dishes containing filter paper of 9cm diameter. Treatments comprised of control (distilled water), 0.5%, 1.0% and 1.5% Sodium Chloride (NaCl). Treatments were laid in a factorial experiment in completely randomized design (CRD) with 4 replications. Data recorded were subjected to analysis of variance (ANOVA). Least Significant Differences (LSD) method was used to test the differences between treatments means at 5% and 1% probability level. Number of germinated seeds was significantly affected by salinity level, especially by the higher salt concentrations compared with the control. Germination percentage and seedling vigor index (SVI) decreased with increasing salinity level. The differences between treatments were highly significant ($p \leq 0.01$). The highest seed germination percentage (99.3%) and seedling vigor index (18.46) were found with the control (0% NaCl) and the lowest values were found with 1.5% concentration. Plumule length and fresh weight decreased significantly as concentration of NaCl increased. Cultivar had insignificant effect on all parameters measured except for radical fresh weight. *Dimbi* resulted in significantly ($p \leq 0.05$) heavier weight, highest germination percentage and seedling vigor index compared to *Bauoda* and this was the trend for other parameters except plumule fresh weight. An interaction between salinity levels and cultivars exerted non significant effect on all parameters measured.

Keywords

Pearl Millet, Salinity, Germination, Seedling Growth

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1. Introduction

Universally, cereals are important food crops, among which millet is the sixth most important cereal in the world. In Sudan, pearl millet is an important cereal crop, next to sorghum. It constitutes the stable food of the majority of inhabitants of the Western part of Sudan especially Darfur and Kordofan (Abuelgasim and Jain, 1987; FAO, 1999). Based on the time of maturity, plant height and seed color, many cultivars of pearl millet are recognized in Sudan. *Dimbi* is relatively dwarf (1-1.5m), short season (90 days to maturity) and red seeded variety. A taller (2m), longer season (100-120 days to maturity), white seeded type has different names in different places in Darfur viz, *Sharoba*, *Drmsa*, *Bauoda* (Sabil 1991). The crop is well adapted to hot and dry agro-ecologies where salinity and drought are the major environmental hazards affecting the productivity of crops (El-Naim *et al*., 2012). Soil salinity and sodicity problems are

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common in arid and semiarid regions, where rainfall is insufficient to leach salts and excess sodium ions out of the Rhizosphere. Nearly 10% of the total land surface is covered with different types of salt-affected soils. At present, there are nearly 954 million hectares of saline soils on the earth's surface. All these salt affected soils are distributed throughout the world (Alam, 2000). Germination and seedling emergence are the starting point for growth and development process of all annual crop plants, thus good seed germination and emergence are necessary if high yield is to be achieved. Salinity negatively affects many morphological, physiological and biochemical processes including seed germination, growth, yield and nutrient use efficiency of crop plants (Bukhari *et al*, 2012). Salt stress reduces the ability of plants to take up water and this quickly causes reduction in growth rate (Rani, 2011). As reported by (Yakubu *et al.,* 2010) that germination percentage, plant height, shoot and root dry weights of millet were significantly decreased with increasing soil salinity. Soil salinity greatly hampers pearl millet productivity, delaying germination, reducing seed germination percentage, and severely affecting subsequent growth (Ashraf and Idrees 1992). Results of experiment conducted by (Hussein *et al.*, 2010) showed that Plant height, number and surface area of leaves, stem diameter and fresh and dry weight of millet plant were decreased by soil salinity. The depressions were increased with increment of salt concentration. (Nadaf *et al*., 2010) indicated that effects of salinity on pearl millet was significant to highly significant for plant height, number of tillers, leaf length, green matter and dry matter yields. Whereas Redy and Vora (1983) reported that germination of Bajra (*Pennisetum typhoides*) was generally not affected except for that it was delayed, but root and shoot length decreased considerably in addition to plant growth. Rani (2011) reported that salt stress resulted on seeds degrades protein in pearl millet (*Pennisetum glaucum* L.) when subjected to salinity. Kafi *et al*., (2009) concluded that although the yield and other yield related parameters of millets decreased by salinity stress, the reduction was more prominent only at high level of salinity (9.5 dsm^{-1}). Sonam *et al*., (2013) observed that as the salt concentration increased the germination percentage of (*Pennisetum glaucum* L.R.Br) decreased compared to control. Khan *et al*., (2000) concluded that increasing salinity level significantly reduced germination percentage, leaf area, plant height,total biomas and grain yield of pearl millet. Salt stress adversely affects plants and crops at all stages of their life cycle as reported by many researchers (Radhouane, 2013; Dadar, 2014; Kafi *et al*., 2013 and Saddam *et al*., 2013). The objective of this study was to investigate the effect of salinity levels on seed germination and seedling growth characteristics of two pearl millet cultivars.

2. Materials and Methods

In order to evaluate the effect of different salinity levels and two pearl millet cultivars on seed germination and seedling characteristics, a laboratory experiment was conducted in 2014 at Biology laboratory, Faculty of Education, University of Zalingei, Sudan. Red seeded color Pearl millet cultivar locally named (*Dimbi*) was obtained from North Darfur State while white seeded color Pearl millet cultivar locally named (*Bauoda*) was obtained from local farmers of Zalingei, Central Darfur State. Pre-treatment germination test was done for the both cultivar seeds using Petri dishes containing a 9cm diameter filter paper. 50 seeds were placed in every Petri dish after adding 5ml of distilled water. Germination percentage (GP) was calculated according to the International Seed Testing Association (ISTA) method.

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

The treatments comprised of control (distilled water), 0.5%, 1.0% and 1.5% of sodium chloride (NaCl). The treatment solutions were prepared by dissolving NaCl in distilled water. Each experimental unit included a Petri dish contains filter paper of 9 cm diameter with 50 seeds of each cultivar. Treatments were arranged in a factorial experiment in completely randomized design (CRD) with 4 replications. 5 ml solution of each concentration was applied to each Petri dish as treatment. The control plates received the same volume of distilled water devoid of any salt. All Petri dishes were kept at room temperature. The counting of germinated seeds started from the next day of placing seeds. The seeds were considered germinated when radicals appeared and are visible enough to be counted. Germination count was made through the experimental period until all the seeds were either germinated and/or dead.

2.1. Parameters Measured

The parameters measured include number of daily germinated seeds, germination percentage, seedling vigor index (SVI).

SVI calculated by the flowing formula:

SVI = (seedling length (cm) × germination percentage) / 100 (Abdul-Baki and Anderson, 1970)

Plumule and radical length, plumule and radical fresh and dry weights were also calculated (after oven drying for 24 hours at 70 °C.

2.2. Statistical Analysis

The analysis of variance (ANOVA) was carried out for the results and the treatment means were separated using the

Least Significant Differences (LSD) at 5% and 1% probability level according to the procedure described by Gomez and Gomez (1984).

3. Results and Discussion

3.1. Effect of Salinity on Seed Germination and Seedling Growth

Seed germination: Number of seeds was significantly affected by salinity level, especially by the higher salt concentrations (Table 1). The less number of germinated seeds during the germination period was obtained at 1.5% (18.3-30). For 1.0% and 0.5% NaCl concentrations, (32.1- 44.3) and (40.3-46.3) germinated seeds, respectively, were recorded compared with the control (0% NaCl) which recorded (47 - 49.6). The effect of salinity level appeared in Fig.1. Results in Table (2) indicated that germination percentage and seedling vigor index decreased with increasing salinity level. The differences between treatments were highly significant ($p \leq 0.01$). The highest seed germination percentage (99.3%) and seedling vigor index (18.46) were found with the control (0% NaCl) and the lower seed germination percentage (60%) and seedling vigor index (2.29) were found with 1.5% concentration. Germination percentage and seedling vigor index decreased in 1.5% NaCl concentration by 39.6% and 87.6 from control for Germination percentage and seedling vigor index respectively, while the reduction in the other treatments from control were 10.9% and 3% in 1.0% and 0.5% NaCl for germination percentage and 58.4% and 17% for seedling vigor index respectively. The effect of salinity on seed germination was clearly demonstrated in this study, low level of salinity (control) increased germination percentage and seedling vigor index, these parameters decreased as the level of salinity increased. High salinity levels inhibit the seed germination significantly. This agrees with previous records of Mukhopadhyay (2005). The seed germinates best in non-saline level (control) and then seed germination percentage and seedling vigor index decreased as salinity increased. Similar results were obtained by (Sonam *et al.*, 2013) that germination percentage decreased as the salt concentration increased compared to control and in line with results obtained by (El-Naim *et al.*, 2012).

Table 1. Results of variance analysis of the number of germinated seeds as affect by salinity level and variety.

S.O.V.	Mean square			
	1st count	2nd count	3th count	4th count
Salinity	160.4**	76.95**	25.68**	31.18**
Variety	19.1**	6.59*	0.08ns	0.82ns
Inter action A×B	1.7ns	1.19ns	0.06ns	0.21ns
Error	8.5	14.88	25.31	21.83
C.V%	2.1	9.9	11.7	11.0

Note: * and ** indicate significant difference at 5% and 1% probability level respectively. ns not significant.

Table 2. Effect of salinity level on seed germination parameters

Salinity level	Germination percentage (GP)	Seed vigor index (SVI)
0% NaCl	99.3a	18.46a
0.5% NaCl	96.3a	15.33b
1% NaCl	88.5b	7.68c
1.5 NaCl	60.0c	2.29d
LSD	7.34**	2.23**

Numbers within the column having the same letter are not significantly different. *Significant at 5% level, ** highly significant at 1% level, ns not significant.

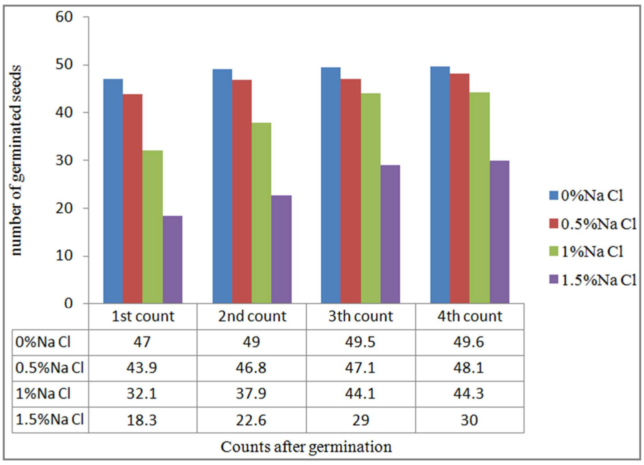

Fig. 1. Effect of salinity level on the number of germinated seeds

Seedling growth: Results in Table (3) indicates that the plumule length and plumule fresh weight decreased significantly ($p \leq 0.01$) as concentration of NaCl increased. The tallest plumule was obtained by the control (0% NaCl) (8.1 cm) flowed by 0.5% (5.8 cm), 1.0% (2.5 cm) and the shortest one in 1.5% NaCl concentrations (1.1 cm). Plumule fresh weight showed the same trend of the plumule length and the difference between treatments was highly significant ($p \leq 0.01$). Plumule length and fresh weight decreased significantly as concentration of NaCl increased. This may be explained by the fact that salt had effect in the root zone of the plant and hence might alter wide changes of physiological process resulting in reduction of plant growth. These results agreed with Reddy and Vora, (1983) findings. The radical length decreased significantly ($p \leq 0.05$) as NaCl increased. Although, the radical fresh weight followed the same trend of the plumule fresh weight but the difference was not significant (Table 3). The light weights were obtained with high NaCl concentration (1.5%). Similar results with different crops were recorded by many workers (Al-Hatlani, 1995; Ali *et al.*, 2014; Tabtabaei and Angholi, 2012).

Table 3. Effect of salinity level on seedling growth parameters

Salinity level	Plumule length (cm)	Radical length (cm)	Plumule fresh weight (g)	Radical fresh weight (g)
0% NaCl	8.1a	10.6a	0.05a	0.016a
0.5% NaCl	5.8b	10.7a	0.046a	0.018a
1% NaCl	2.5c	6.1b	0.02b	0.0094a
1.5 NaCl	1.1d	2.6c	0.001c	0.001a
LSD	0.65**	2.04**	0.0081**	0.00902ns

Numbers within the column having the same letter are not significantly different. *Significant at 5% level, ** highly significant at 1% level.

3.2. Effect of Cultivar on Seed Germination and Seedling Growth

Fig.2 and results in (tables 4&5) showed the effect of cultivar on seed germination and seedling growth under different salinity level. Results indicated that cultivar had insignificant effect on all parameters measured except for radical fresh weight that *Dimbi* resulted in significantly ($p \leq 0.05$) heavier weight than *Bauoda*. *Dimbi* resulted in highest germination percentage and seedling vigor index compared with *Bauoda* and this was the trend for other parameters except plumule fresh weight. This indicated that *Bauoda* was found to be sensitive to salinity than *Dimbi*. Kafi *et al*., (2009) observed remarkable difference among some species of millet. Yakubu *et al*., (2010) reported that the variety could possess superior inherent genetic characteristics that could assist in identification of superior genes for salt tolerance in pearl millet for improving its productivity.

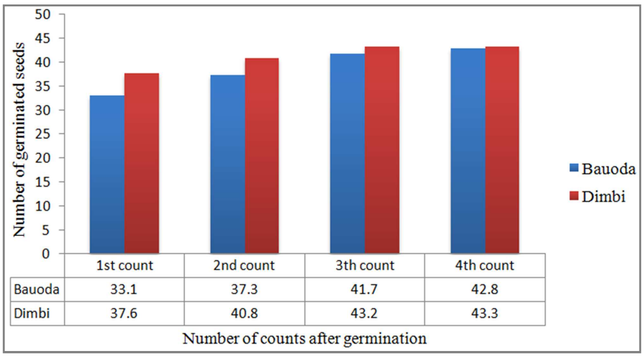

Fig. 2. Effect of variety on the number of germinated seeds

Table 4. Effect of variety on seedling growth parameters

Variety	Plumule length(cm)	Plumule fresh weight(g)	Radical length(cm)	Radical fresh weight(g)
Bauoda	5.7a	0.041b	6.59c	0.021a
Dimbi	6.0a	0.037b	8.41c	0.008b
LSD	0.65ns	0.0081ns	2.04ns	0.00902*

Numbers within the column having the same letter are not significantly different. *Significant at 5% level, ** highly significant at 1% level, ns = not significant.

Table 5. Effect of variety on seed germination parameters

Variety	Germination percentage (GP)	Seed vigor index (SVI)
Bauoda	85.5b	13.54a
Dimbi	86.5b	15.66a
LSD	7.34ns	2.23ns

Numbers within the column having the same letter are not significantly different. *Significant at 5% level, ** highly significant at 1% level.

3.3. Treatments Interaction

The interaction of salinity level × cultivar exerted non significant effect on all parameters measured.

4. Conclusion

The current study indicate that increasing NaCl concentration effected seed germination, germination percentage, plumule length, radical length, fresh weights of plumule and radical of both pearl millet cultivars. 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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