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INTER-CULTIVAR VARIATION FOR SALT TOLERANCE IN PROSO MILLET (*PANICUM MILIACEUM* L.) AT THE GERMINATION STAGE

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Abstract

Inter-cultivar variation for salt tolerance in proso millet (*Panicum miliaceum* L.) was assessed by screening 18 diverse accessions originally collected from different areas of Pakistan with varying environmental conditions. The set of accessions examined in this study showed considerable variation in germination percentage and seedling weights under salt stress. Accessions 008208, 008210, 008215 and 008230 had higher germination percentage at higher levels of salt, whereas 008214, 008216 and 008222 had lower germination percentage as compared to the other accessions. In seedling weights, accessions 008216, 008218 and 008225 showed a maximum reduction at higher levels of salt, whereas accessions 008208, 008210, 008215 and 008223 showed less reduction. Of the 18 accessions, 008211 and 008215 showed high tolerance in terms of both germination percentage and seedling weights, but it is not sure whether they would maintain the degree of their tolerance if tested at the later growth stages.

Introduction

Soil salinization is one of the major problems for crop production in arid and semi-arid regions of the world. Salinity whether from soil or water affects plant growth and development due to salt-induced water deficit, low uptake and accumulation of essential nutrients, and high accumulation of toxic ions such as Na^+ and Cl^-. All these factors cause changes in a wide variety of physiological and biochemical processes such as photosynthesis, protein synthesis and nucleic acid metabolism (Zhang & Blumwald, 2001; Ashraf, 2004; Munns, 2005). Reclamative and preventive measures for rendering salt affected soils fit for crop production are usually expensive and generally considered temporary solutions. Alternatively, selection and breeding of cultivars tolerant to salinity is a feasible and economical approach for utilizing salt affected soils (Juan *et al.*, 2005; Munns *et al*., 2006). However, the success of this approach depends on the presence of genetic variation in the gene pool of a species. For example, variability for salt tolerance, within and between species, has been found in cultivated and wild species such as wheat (Kingsbury & Epstein, 1984), sorghum (Azhar & McNeilly, 1988), tomato (Foolad, 1996), *Agrostis stolonifera* and *Festuca rubra* (Ashraf *et al*., 1986). Similarly, while evaluating 25 and 60 strains of *Agropyron desertorum* for salt tolerance, Dewey (1960; 1962) found a few strains tolerant to salt stress. Likewise, Ulfat *et al*., (2007) screened 32 lines of canola and they were able to identify 5 highly tolerant lines.

Since seed germination and seedling growth under saline conditions are critical for establishment of plant population (Ashraf & Khanum, 1997; Noreen *et al*., 2007; Sabir & Ashraf, 2007), screening of different accessions/cultivars of a species at the germination stage may lead to find out salt tolerant individuals at early growth stages.

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Table 1. Numbers and origins of 18 accessions of *Panicum miliaceum*.

Accession No.	Origin
008208	Droshp, Chitral
008210	Parwak, Chitral
008211	Sloaspur, Chitral
008213	Pengal, Gilgit
008214	Damalgand, Gilgit
008215	Drach, Gilgit
008216	Yangal, Gilgit
008217	Sakandar Abad, Gilgit
008218	Murtazabad, Gilgit
008220	Rando Bagicha, Skardu
008221	Karis, Skardu
008222	Goon, Skardu
008223	Kunis, Skardu
008225	Barah, Skardu
008226	Nasir Abad, Gilgit
008230	Quetta, Quetta
008236	Keris, Skardu
008242	Pishin, Pinhin

Proso millet (*Panicum miliaceum* L.) is one of the important species of the largest genus *Panicum*, which includes more than 400 species (Roshevits, 1980). Although in some areas it is cultivated for its food value, this plant naturally grows in hot and dry areas where high salt content is the characteristic of most soils. In view of this information, it was hypothesized that different accessions of *Panicum miliaceum* growing in different areas with different climatic conditions might have evolved some obligatory adaptational characters, including that of salt tolerance. Therefore, the present study was aimed to assess inter-cultivar variation for salt tolerance by screening 18 different accessions of proso-millet at the germination stage. The intra-specific variation so explored for salt tolerance could be exploited in future breeding programs for the improvement of salt tolerance trait in this particular cereal crop.

Materials and Methods

Eighteen accessions used in the study were obtained from the National Agricultural Research Center, Islamabad. Their numbers and origins are given the Table 1.

Before sowing, seeds were surface sterilized in 5% Sodium hypochlorite solution for 5 minutes. Four different concentrations of NaCl (0, 60, 120 and 180 m*M*) in Hoagland's nutrient solution were used. The experiment was setup in a completely randomized (CRD) factorial design with four replicates in a growth room of the Department of Botany, University of Agriculture, Faisalabad. Fifteen seeds of each accession were allowed to germinate in a Petri plate double lined with filter paper moistened with 10 mL of NaCl solution. Salt levels were maintained daily by dripping out and applying fresh salt solution twice. Germination was recorded daily and a seed was considered germinated when the radicle attained length ≥5 mm.

After 7 days of sowing, germinated seeds were collected, their plumules and roots carefully separated and fresh and dry weights recorded. The data obtained from the experimentation were subjected to a two-way analysis of variance using the CoStat computer package (CoHort Software, Berkeley, USA).

Results

Imposition of salt stress reduced seed germination of all accessions of *P. miliaceum*. However, salt induced reduction in seed germination was considerably variable among different accessions. Furthermore, accessions 008208, 008210, 008215, and 008230 were found to be highest in seed germination percentage at the highest level of NaCl. Moreover, accessions 008216, 008214 and 008222 were found to be highly sensitive to salt stress with respect to this attribute.

Data for fresh and dry weights of plumules and roots of 18 accessions of *Panicum miliaceum* showed that salt stress caused a significant reduction in these growth attributes. However, accessions differed significantly in their fresh and dry weights of both plumules and roots at different levels of salt stress. Some accessions showed greater reduction in their seedling weight while others exhibited less reduction under saline conditions. For example, accessions 008218, 008216 and 008225 showed a maximum reduction in their seedling weight. Likewise, accessions 008208, 008223, 008210 and 008215 produced greater plumule weights at the highest level of salt. In contrast, root fresh and dry weights of the germinated seeds were maximally reduced in accessions 008218, 008222, 008242 and 008230 at the highest level of salt. In addition, accessions 008211, 008213 and 008215 produced maximum root fresh and dry weights at the highest level of NaCl. Thus, accessions 008211 and 008215 were superior in terms of plumule and root weights under saline conditions.

Discussion

As is well evident from the literature, the existence of genetic variability for salt tolerance is a pre-requisite for improving salt tolerance in a plant species through selection or breeding. If sufficient magnitude of genetic variation for salt tolerance exists in a species, then considerable improvement in tolerance could be expected from selection. Of a number of grasses, *Panicum* is the most intensively studied for interspecific and intraspecific variation for salinity tolerance (Ashraf, 2004). Although ecophenic variation for salt tolerance has also been reported in other grass species such as *Sporoblous alterniflora* (Nestler, 1977) and *Spartina foliosa* (Cain & Harvey, 1983), there is no published information available in the literature regarding intraspecific variation for salt tolerance in *Panicum miliaceum* (Sabir & Ashraf, 2007). In the present study, the primary objective was to assess whether accessions of *Panicum miliaceum* collected from different regions display a significant intra-specific variation. This information will be beneficial for understanding how different accessions of *Panicum miliaceum* from different climatic conditions or geographical regions respond to salinity. Furthermore, identifying genotypes with varying degree of salt tolerance may be of value to economically utilize salt affected areas as well as to uncover underlying biochemical and physiological mechanisms of salt tolerance in this economically important species.

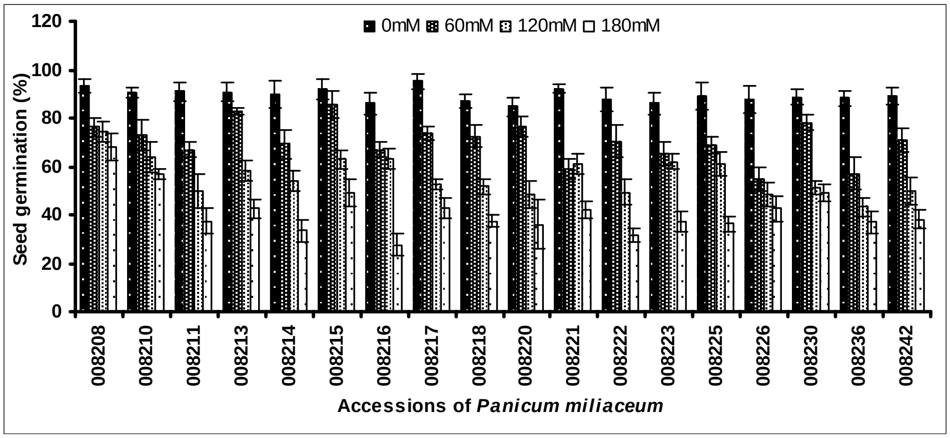

Fig. 1. Germination percenrage (± SE) of 18 accessions of *Panicum miliaceum* when grown at different concentrations of NaCl (0, 60, 120 and 180 m*M*) in Hoagland's nutrient solution (*n* =4).

It is well evident that a genotype selected for salt tolerance at one growth stage may not produce tolerant plants as adult (Kingsbury & Epstein, 1984; Shannon, 1997). Thus, it is necessary to assess salt tolerance at different growth stages. In the present study, 18 accessions of *Panicum miliaceum* were screened at the germination stage. It is obvious from the data that salt stress caused a significant decrease in the weights of germinated seeds in all accessions. However, salt-induced reduction in plumule or root weight was different in different accessions of *P. miliaceum*. On the basis of plumule weight, accessions 008208, 008223, 008210 and 008215 were ranked as tolerant and 008218, 008216 and 008225 as salt sensitive. The remaining accessions were considered as moderatly salt tolerant. However, pattern of root weight at varying levels of NaCl was different from that of plumule weight.

Germination percentage of all accessions of *P. miliaceum* was decreased due to salt stress. However, germination percentage of all accessions varied significantly at different levels of salt. Of all accessions, 008208, 008210, 008215 and 008230 had higher germination percentage and can be categorized as salt tolerant. In contrast, accessions 008216, 008214 and 008222 were found to be highly sensitive to salt stress with respect to germination percentage. From these results, it is clear that accessions 008208, 008210 and 008215 were tolerant in terms of their ability to germinate as well as in plumule weight while accession 008230 was tolerant in germination ability but intermediate in plumule weights. Likewise, accession 008216 remained salt sensitive to salt stress in terms of germination ability and seedling weight. The results from the present study were similar to those reported for turnip and radish (Noreen *et al.*, 2007) and *Panicum miliaceum* (Sabir & Ashraf, 2007) showing that the degree of salt tolerance varied with different variables of measurement.

From these results, it can be concluded that only two out of 18 accessions were tolerant in terms of their ability to germinate under saline conditions. However, it is not sure whether the variation for salt tolerance observed at the germination stage in the set of 18 accessions of proso millet would be maintained at the later growth stages.

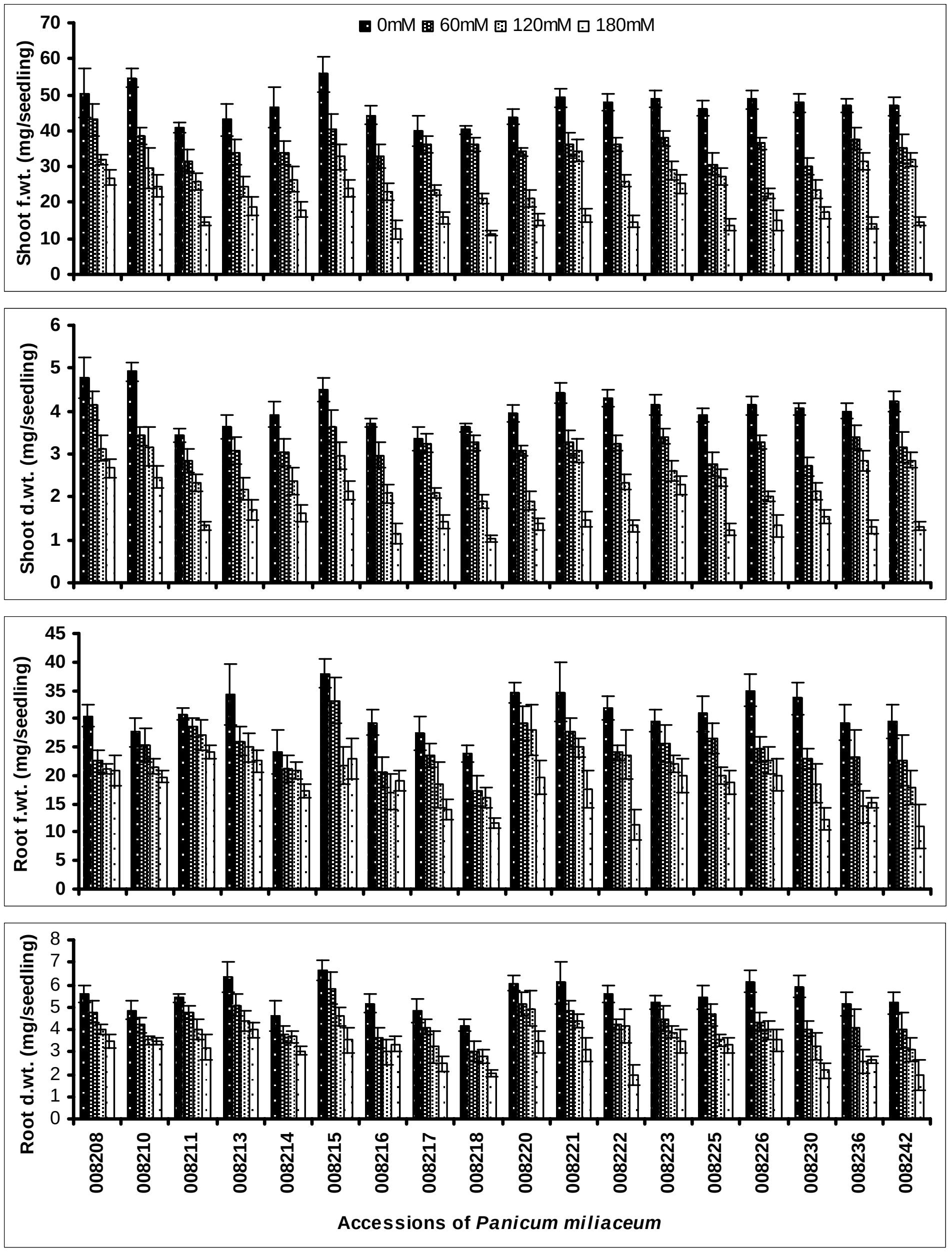

Fig. 2. Fresh and dry weights (mg/plant ± SE) of shoots (plumules) and roots of seven day-old seedlings of 18 accessions of *Panicum miliaceum* when grown at different concentrations of NaCl (0, 60, 120 and 180 m*M)* in Hoagland's nutrient solution (*n* = 4).

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