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Germination and Growth of *Panicum turgidum* Provenance under Saline Conditions

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Abstract: Salinity tolerance of *Panicum turgidum* Forssk; provenance was studied at various levels of NaCl ranging from 0 to 160 meq l^{-1}. Seed germination studies were carried out both on filter paper and sand while plant growth was studied using sand culture. Salinity has caused a marked reduction in seed germination and plant growth. The greatest decrease in fresh and dry biomass of shoot was observed at the highest salinity level. Na content in plant shoots increased whereas K content decreased in response to increase salinity levels. Cl content along with N and protein (%) increased as salinity concentrations were raised in the rooting medium. The study revealed the potential of the species for salt tolerance.

Key words: NaCl salinity, ion accumulation, proteins, Panicum turgidum

Introduction

Salinity is particularly a problem of arid regions where freshwater drainage is impeded and transpiration exceeds precipitation. The principal effects of salinity are felt via plant's altered osmotic balance which can lead to reduce growth, excessive accumulations of ions, reduced water availability and less uptake of mineral nutrients (Crawley, 1997). Certainly, hydrological approach is successful leaching and drainage of salts with good quality water and addition of various chemicals is a common method for the utilization of saline soils for cultivation. However, such programmes may pose certain limitations regarding climatic and economic constraints. On the other hand, in biological approach, making use of salt tolerant plants in the problem areas appears to be a successful strategy. Consequently, the identification and selection of salt tolerant species become an important aspect (Ashraf *et al.*, 1989).

Early work by Yakir and Yechieli (1995) indicated that perennial plant species could withstand extreme salinity levels. Therefore, a perennial grass, *Panicum turgidum* Forssk; was selected for this study. The species has a great potential for grain, forage and silage. Moreover, quick growth, in addition to good availability of seeds and their resistance to storage, made this study feasible. Responses of the species were assessed for germination, growth, ions accumulation, N content and protein (%) to varying NaCl levels.

The main objective of the present study is to report salt tolerance of the species for its exploitation on saline lands of Pakistan.

Materials and Methods

Seeds and root stocks were collected from a naturally occurring provenance of the species in southern Punjab during October, 2001. A good collection (about 2.5 g seeds and 50 root stocks) was made to represent the provenance. Seeds were sieved (40 mesh) and stored in a paper bag at room temperature. Five salinity levels 0 (control), 20, 40, 80 and 160 meq l^{-1} were prepared by the addition of NaCl using Hoagland nutrient solution (Arnon and Hoagland, 1940). The effects of these salinity levels were assessed on seed germination and growth of the species.

Germination studies: For the first experiment, 0.25 g of seeds were taken then 20 randomly chosen seeds were placed in pertidishes (8 cm internal diameter) containing filter paper. There were made four replicates for each treatment, each containing 20 seeds and 10 ml of respective treatment solution. The germination was conducted in a germination chamber at 25°C, light intensity 36 Wm^{-2} and relative humidity 66-84%. Fresh solution of the same salinity level was added daily to the respective petridish after rinsing out the previous solution. Percentage germination was recorded up to 10 days.

In the second experiment, all twenty petridishes (8 cm internal diameter) were filled with 100 g of thoroughly washed river sand. Randomly selected 20 seeds were placed in each petridish. All dishes were weighed after applying 25 ml of solution of each salinity level (0-160 meq l^{-1}). During the course of experiment, salinity levels were maintained by daily weighing. Water was sprinkled in required amount only to compensate water loss. Seed germination was recorded up to 12 days.

Growth experiment: This experiment was conducted in a wire netting green house at 32±4°C day and 10±2°C night temperature and 14 h day length. For this experiment, salinity levels were 0 (control), 20, 40, 80 and 160 meq l^{-1}. Twenty earthen pots (internal diameter 26 cm) were taken and filled with 3.5 kg of river sand. The sand was thoroughly washed with fresh and distilled water then saturated with nutrient solution. Randomly selected 4 rootstocks were transplanted to each pot. There were four replications for each salinity level. The plants were allowed to establish for 2 weeks and then subjected to salt stress.

Salinity was gradually increased in the rooting medium by the application of salt solution of 20 meq l^{-1} on every alternate day in order to avoid abrupt salt stress. Sand was thoroughly flushed before applying the next salinity level. Hence, desired levels were achieved. After attaining appropriate levels, salt solutions were replaced by fresh solution. Salinity levels were maintained by weighing each pot on every alternate day and water loss was made up. The plants were grown for 8 weeks and then harvested. Fresh and dry biomass of shoot and root was recorded. Shoots were digested in HNO_3 and analyzed for Na and K on a flame photometer (PFP 7 Genway) while Cl contents were determined using Corning 925 chloride analyzer. Nitrogen and protein were estimated following Black (1965).

Statistical analysis: Mean values were calculated for all parameters. For germination (%), data were arcsin transformed for statistical analysis. The effects of various salinity levels on germination and growth were elucidated by carrying out one way analysis of variance (ANOVA) using Excel, 2000. Significant differences between means were determined by Duncan's multiple range test (Duncan, 1955).

Results and Discussion

Data for mean germination % (Table 1) and analysis of variance data (Table 2) showed that increasing salinity levels had significant effects on germination (%) of *P. turgidum* seeds both on filter paper and sand. However, germination (%) was relatively higher in sand than on filter paper. Maximum germination % was recorded in the control and it differed significantly ($P \leq 0.001$) from all salinity levels.

Table 1: Mean values for germination (%) and biomass (g) of *Panicum turgidum* at varying levels of NaCl

	Salinity levels (meq l^{-1})				
	0 (Control)	20	40	80	160
Germination					
Filter paper	43.0a	29.25ab	24.50bc	13.50c	11.75c
Sand	51.25a	40.0ab	37.50ab	25.0b	22.50b
Growth					
Shoot fresh weight	27.03a	19.10b	14.28c	13.37c	9.31d
Shoot dry weight	9.31a	7.87b	4.50cd	4.72c	3.29d
Shoot dry/fresh	0.34	0.41	0.31	0.35	0.35
Weight ratio					
Root dry weight	6.15a	5.20a	3.60b	3.32b	3.05b

Therefore, salinity has posed adverse effects on germination of the species. These results are consistent with other studies (Ashraf and McNeilly, 1986; Ashraf *et al*., 1989) where germination inhibition under saline conditions has been reported for grass species. Salt tolerance of species varies with stages of plant growth. Accordingly, higher germination rates may not guaranteed a successful later growth of the plant. Thus, it becomes necessary to assess later growth responses so that the overall salt tolerance of a species can be determined. Varying salinity levels had significantly adverse effects on biomass production (Table 2). A significant decrease ($P \leq 0.001$) in fresh and dry matter of *P. turgidum* shoots was observed at all salinity levels (Table 1). However, the lowest biomass was obtained at the highest salt concentration (160 meq l^{-1}). These results agree with the finding of Ashraf *et al.* (1989) who also reported reduction in biomass in response to salinity stress.

Osmotic imbalance as well as ions toxicity are considered to inhibit plant growth in saline media (Cheeseman, 1988). High salt concentration results in decrease water uptake which may cause physiological desiccation. At this point, dry/fresh weight ratio can be used as a predictor of water uptake by plants, the ratio being inversely related to water content (Naidoo, 1985). The dry/fresh biomass ratios of *Panicum* plants grown under various salinity levels were slightly affected (Table 1) indicating that the species has the ability for water uptake and thus osmotic adjustment to avoid physiological drought.

Table 2: Analysis of variance summaries (mean squares) for germination (%) (arcsin transformed) and biomass (g) of *Panicum turgidum* at varying levels of NaCl

		Germination		Biomass yield		
S.O.V	df	Filter paper	Sand	Shoot fresh wt.	Shoot dry wt.	Root dry wt.
Salinity levels	4	550.48*	590.95*	158*	38.25*	6.96*
Residual	15	1.99	1.57	1.15	0.15	0.35

* = Significant at 0.001 level of probability

Table 3: Ionic composition (meq/100g dry wt) nitrogen and protein (%) in shoots of *Panicum turgidum* when grown for 8 weeks at varying levels of NaCl

	Salinity levels (meq l^{-1})				
	0 (Control)	20	40	80	160
Na	19.00a	56.00b	67.10c	72.00c	89.70d
K	24.50	25.00	26.60	24.80	24.00
K/Na	1.28	0.44	0.39	0.34	0.26
Cl	36.40a	48.70b	60.90c	72.00d	90.50e
Nitrogen (%)	1.25a	1.55b	1.98c	2.51d	2.58d
Protein (%)	7.81a	9.68b	12.37c	15.68d	16.12d

Each mean value is from 4 replicates. Means sharing same letters in each row are not significantly different by Duncan's multiple range test at 5% level

Table 4: Analysis of variance summaries (mean squares) for ionic composition (meq/100g dry weight) nitrogen and protein (%) in shoots of *Panicum turgidum* when grown for 8 weeks at varying levels of NaCl

		Ionic concentration (meq/100 g dry weight) nitrogen and protein %					
Sources of variation	df	Na	K	K/Na	Cl	Nitrogen %	Protein %
Treatments	4	2701*	5.38NS	2.46NS	1704*	1.33*	54.51*
Residual	15	12.8	2.26	2.85	3.04	0.05	0.07

* = Significant at 0.001 level of probability, NS= Non significant

Na and Cl concentrations in plant shoots were significantly ($P\leq 0.001$) greater at higher salinity regimes (Table 3). The augmented Na and Cl content in plant parts can be related with high salinity levels in the root zone. However, K uptake was not significantly influenced by salinity (Table 4). Nevertheless, these results are consistent with other studies (Shannon, 1997). Despite enhanced Na uptake in response to salinity, K/Na ratios in plant shoots were found higher as compared to their respective roots. The selectivity for K absorption by shoots seems to be an important feature that contributes and facilitates high salinity tolerance in plants (Khan *et al.*, 1995).

Nitrogen contents are the markers of protein (%), an important trait of forage crops. Nitrogen and protein (%) increased in *P. turgidum* at higher salt concentrations (Table 3). Differences between treatments were also found to be significant ($P\leq 0.001$) for both of these attributes (Table 4). The greater N content in response to hyper-salinity may signify the accumulation of proteins. It has indicated that salt stress can promote protein synthesis in plants possibly due to the transformation of free amino acids into proteins (Zidan and Elewa, 1995). The accumulation of proteins in *P. turgidum* in response to prevailing stress could be a phenomenon of adjustment as suggested by Naidu (1998) for plants growing under stress environments.

This study indicated that *P. turgidum* has a fair potential for salt tolerance. It is highly liked that species has ability to maintain K, water uptake and prevention of Na accumulation to a toxic level. These attributes might have provided the species some means of coping with saline conditions. On the basis of results presented here for *P. turgidum*, it can be concluded that the species had considerable salinity tolerance besides maintaining reasonably high protein content. Therefore, the species can be used as a substantial forage and silage crop for saline areas.

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