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Response of Various Sorghum Genotypes to Different Salinity Levels at Early Growth Stage

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Abstract: In order to study the response of various sorghum genotypes to different salinity levels, a pot experiment was carried out at NWFP Agricultural University Peshawar Pakistan during 1997. Analysis of the data revealed that significant differences were observed for shoot fresh weight, shoot dry weight, shoot Na^+ and K^+ concentration both at 15 and 30 days after salt application. Three sorghum genotypes PARC SV-8, PARC SV-1 and PARC SV-2 performed significantly better than the others. Increasing salinity levels had significantly reduced shoot fresh weight, shoot dry weight and shoot K^+ concentration at 15 and 30 days after salt application. Similarly, interaction between various genotypes and salinity levels had significantly affected shoot fresh weight and shoot dry weight at 15 days and shoot Na^+ and K^+ concentration at both 15 and 30 days after salt application.

Key words: Genotypes, salinity, sorghum, response

Introduction

Usually a Wheat-Rice rotation is preferably followed by the farmers of those areas where adequate irrigation water is available for the crop production because these crops are more economical, more valuable and are moderately tolerant to saline soil conditions. On the other hand, in barani area, where soil are well drained, light textured and less water is available for irrigation purpose, the fields are left fellow when wheat is harvested. In these areas, sorghum being moderately salt tolerant and drought resistant, can be successfully adopted as a second crop after Wheat. Different physiological characters are related to salt tolerance in plant (Flowers *et al*., 1977; Yeo and Flowers, 1982; Aslam *at al*., 1993b). Plants exposed to saline environment may overcome excess toxic ions in the root medium through different physiological traits such as compartmentation (pushing the undesirable ions to vacuoles), synthesis and accumulation of compatible solutes in cytoplasm, vigor to provide dilution of salt concentration by growth, efficient exclusion of Na^+ and Cl^- and selective uptake of K^+ (Gorham *et al*., 1985; Aslam *et al*., 1991, 1993b). In general, there is a positive correlation between Na^+ and Cl^- exclusion and relative salt tolerance. The aim of the present project was to study the response of various sorghum genotypes to different salinity levels in order to identify sorghum genotypes which can be grown better and produce more yield under saline conditions.

Materials and Methods

The response of eight sorghum genotypes (PARC SV-10, PARC SV-1, PARC SV-8, A-4009, SS-89, PARC SV-2, PARC S5-2 and IC-1039) to different salinity levels (0, 4, 8, 12 and 16 dS m^{-1} were studied in a pot experiment at NWFP Agricultural University Peshawar, Pakistan during 1997. The experiment was laid out in completely randomized design (CRD) having three replication. Each pot (30 × 45 cm) was filled with 40 kg of soil. The seeds were sown at uniform depth in each pot and after completion of emergence, thinning was done to maintain seven plants in each pot. Recommended dose of NPK (100-50-0 kg ha^{-1}) was applied in the form of urea and diammonium phosphate. Plants were subjected to different salinity levels through irrigation water by addition of salts in increments 30 days after emergence. Data was recorded on shoot fresh weight, shoot dry weight, shoot Na^+ concentration and shoot K^+ concentration at two different growth stages i.e. 15 and 30 days after salt application. Data was subjected to analysis of variance according to CR design and upon obtaining significant differences least significant difference (LSD) test was used for comparison of treatment means.

Results and Discussion

Data regarding shoot fresh weight at 15 and 30 days after salt application is presented in Table 1. Statistical analysis of the data revealed that shoot fresh weight was significantly ($p<0.05$) affected by various genotypes and different salinity levels at 15 and 30 days after salt application. Similarly, interaction between genotypes and salinity levels had a significant effect on shoot fresh weight at 30 days after salt application. It can be inferred from the data that genotypes PARC SV-8 produced maximum shoot fresh weight (11.23 and 20.32 g) and PARC SS-2 produced minimum shoot fresh weight (10.03 and 19.05 g) at 15 and 30 days after salt application. Data in Table 1 also showed that shoot fresh weight has progressively decreased with increasing salinity levels. Mean values of the data showed that maximum shoot fresh weight (13.88 and 24.28 g) was obtained at control and minimum shoot fresh weight was recorded at 16 dS m^{-1}. Genotype PARC SV-8 at control produced maximum shoot fresh weight (15.67 and 26.67 g), While PARC SV-10 at 15 days and PARC SS-2 at 30 days after salt application produced minimum shoot fresh weight at 16 dSm^{-1} This decrease in shoot fresh weight may be due to nutrient stress and toxic effect of Na^+ and hence a decrease in the rate of photosynthesis at higher salinity levels (Carlos and Bingham, 1973; Kawasaki *et al*., 1983). Similar results are also reported by Fernandes *et al*. (1994) who found significant differences in fresh biomass production among various genotypes in salt affected soil. Malibari *et al*. (1993) observed decrease in growth with increase in salinity.

Shoot dry weight was also recorded at two growth stages i.e., 15 and 30 days after salt application (Table 2). Statistical analysis of the data revealed that genotypes and different salinity levels had a significant ($p<0.05$) effect on shoot dry weight at 15 and 30 days after salt application whereas interaction was significant at 30 days after salt application. It is clear from the data presented in Table 2 that PARC SV-8

Table 1: Shoot fresh weight of various Sorghum varieties after salt application

Varieties	Salinity levels (dS m^{-1})											
	15 days after salt application						30 days after salt application					
	Control	4.0	8.0	12.0	16.0	Mean	Control	4.0	8.0	12.0	16.0	Mean
PARC SV-10	14.00	12.33	9.50	6.67	8.67	9.23c	23.00d	20.87gh	18.90kl	13.90ra	8.10wx	16.95e
PARC SV-1	14.50	13.00	9.83	7.33	5.50	10.038	25.238	22.63de	19.93ij	15.30o	12.17uv	19.05h
PARC SV-8	15.67	14.17	11.50	8.67	6.17	11.23a	26.67a	24.37bc	21.43th	16.47n	12.67tu	20.32a
A-4009	18.67	12.67	9.00	6.67	4.00	9.20c	24.37bc	21.50fh	19.17jkl	14.90orm	8.70wx	17.72dY
55-89	14.17	12.83	8.83	6.33	3.83	9.20c	24.23c	21.13fg	19.03kl	14.37pqr	8.80wx	17.518
PARC SV-2	13.83	12.83	9.67	7.17	4.83	9.67bc	24.678c	22.50de	19.73ijk	15.00op	11.37v	18.65c
PARC SS-2	11.67	9.83	8.17	6.17	3.67	7.80d	21.93ef	20.17hi	17.93m	13.30st	7.93x	16.251
IC-1039	14.00	12.67	9.67	7.17	4.17	9.53bc	24.17c	21.03gh	18.80lm	14.03qrs	8.93w	17.39d
Mean	13.88a	12.54b	9.52c	7.02d	4.48d		24.28a	21.778	19.37c	14.65d	9.83c	

Mean followed by at least one common letter are not significantly different statistically at 0.05 level of probability according to LSD test
LSD after 15 days of salt application
LSD after 30 days of salt application. $LSD_{(0.05)}$ value for varieties = 0.564
$LSD_{(0.05)}$ values for varieties = 0.389, $LSD_{(0.05)}$ value for salinity levels = 0.446. $LSD_{(0.05)}$ value for salinity levels = 0.307. $LSD_{(0.05)}$ value for interaction =0.869

Table 2: Shoot dry weight of various Sorghum varieties after salt application

Varieties	Salinity levels (dS m^{-1})											
	15 days after salt application						30 days after salt application					
	Control	4.0	8.0	12.0	16.0	Mean	Control	4.0	8.0	12.0	16.0	Mean
PARC SV-10	3.47	3.19	2.78	2.39	1.44	2.65b	6.01cf	5.53ij	4.82n	3.56q	2.49uv	4.488d
PARC SV-1	3.64	3.40	3.01	2.47	1.87	2.92a	6.30ah	5.88eh	5.22kl	4.27o	3.24rs	4.98b
PARC SV-8	3.70	3.19	3.12	2.57	2.47	2.92a	6.38a	6.10be	5.39jk	4.42o	3.46qr	5.15o
A 4009	3.48	3.18	2.76	2.20	1.46	2.61b	6.148cd	5.66hi	4.88mn	3.84p	2.701u	4.64c
Y SS-89	3.50	3.23	2.78	2.18	1.54	2.65b	6.14bcd	5.66hi	4.88mn	3.84p	2.70tu	4.64c
PARC SV-2	3,62	3.35	2.94	2.45	1.90	2.85a	6.26ab	5.84fgh	5.10lm	4.20o	3.21s	4.92b
PARC 55-2	3.26	2.94	2.65	1.91	1.25	2.40c	5.92dg	5.35jk	4.72n	4.45gr	2.27v	4.34e
IC-1039	3.50	3.28	2.75	2.21	1.55	2.66b	6.17abc	5.73ghi	4.84n	3.89p	2.74t	4.67b
Mean	3.52a	3.22b	2.85c	2.30d	1.63e		6.16a	5.71b	4.98c	3.94d	2.84e	

Mean followed by at least one common letter are not significantly different statistically at 0.05 level of probability according to LSD test
LSD values after 15 days of salt application. LSD values after 30 days of salt application
$LSD_{(0.05)}$ value for varieties = 0.178. $LSD_{(0.05)}$ value for varieties = 0.1028
$LSD_{(0.05)}$ value for salinity levels = 0.1407. $LSD_{(0.05)}$ value for salinity levels = 0.0812. $LSD_{(0.05)}$ value for interaction = 0.2298

Table 3: Shoot Na^{+} concentration of various Sorghum varieties after salt application

Varieties	Salinity levels (ds m^{-1})											
	15 days after salt application						30 days after salt application Control					
	Control	4.0	8.0	12.0	16.0	Mean	Control	4.0	8.0	12.0	16.0	Mean
PARC SV-10	0.033n	0.277kl	0.520hi	0.797e	1.103b	0.546b	0.037s	0.287op	0.537jk	0.833ef	1.143b	0.567b
PARC 5V-1	0.030n	0.233lm	0.480ij	0.707fh	0.977c	0.485c	0.030s	0.227qr	0.467mn	0.707h	0.967cd	0.479d
PARC SV-8	0.030n	0.207m	0.4571	0.670g	0.917b	0.456d	0.030s	0.203r	0.447n	0.637l	0.923d	0.448e
A-4009	0.030n	0.260kl	0. 510hi	0.787e	1.100b	0.538b	0.033s	0.267opq	0.507klm	0.7779	1.110b	0.539c
Y 55.89	0.033n	0.273kl	0.520hi	0.793c	1.090b	0.542b	0.037s	0.2630opq	0.480jkl	0.710g	1.097b	0.539c
PARC SV-2	0.030n	0.247klm	0.483ij	0.730f	1.003c	0.499c	0.030s	0.237pqr	0.480lma	0.71 oh	0.980c	0.487d
PARC SS-2	0.040n	0.287k	0.537h	0.817e	1.200a	0.576a	0.040s	0.310o	0.573k	0.860e	1.220a	0.601a
IC-1039	0.030n	0.270kl	0.513hi	0.790c	1.097b	0.540b	0.033s	0.267opq	0.523jkl	0.800fg	1.093b	0.543c
Mean	0.032e	0.257d	0.502c	0.761b	1.061a		0.034e	0.257d	0.507c	0.763b	1.067a	

Mean followed by at least one common letter are not significantly different statistically at 0.05 level of probability according to LSD test
LSD values after 15 days of salt application. LSD values after 30 days of salt application
$LSD_{(0.05)}$ value for varieties = 0.0230. $LSD_{(0.05)}$ value for varieties = 0.0230
$LSD_{(0.05)}$ value for salinity levels = 0.0182. $LSD_{(0.05)}$ value for salinity levels = 0.0182. $LSD_{(0.05)}$ value for interaction = 0.0514
$LSD_{(0.05)}$ value for interaction = 0.0514

Table 4: Shoot K^{+} concentration of various Sorghum varieties after salt application

Varieties	Salinity levels (ds m^{-1})											
	15 days after salt application						30 days after salt application Control					
	Control	4.0	8.0	12.0	16.0	Mean	Control	4.0	8.0	12.0	16.0	Mean
PARC SV-10	1.427ef	1.340gh	1.157kl	0.893no	0.673qr	1.098d	1.503	1.420	1.190	0.897	0.660	1.134a
PARC SV-1	1.550ab	1.457de	1.307hi	1.060m	0.880op	1.251b	1.623	1.560	1.340	1.053	0.880	1.291h
PARC SV-8	1.590a	1.490cd	1.357gh	1.1231	0.910no	1.294n	1.663	1.590	1.387	1.153	0.920	1.343a
A 4009	1.427ef	1.383fg	1.187jk	0.937n	0.693q	1.125c	1.513	1.467	1.217	0.948	0.700	1.169c
Y SS-89	1.447de	1.370g	1.180jk	0.933n	0.707q	1.27c	1.517	1.450	1.203	0.928	0.687	1.157d
PARC SV-2	1.517bc	1.457de	1.283l	1.050m	0.833p	1.228b	1.603	1.540	1.310	1.053	0.867	1.275l
PARC 55-2	1,337gh	1.227j	1.113l	0.833p	0.627r	1.027e	1.370	1.267	1.117	0.817	0.603	1.035e
IC-1039	1.463de	1.357gh	1.177jk	0.927no	0.707q	1.126c	1.520	1.447	1.217	0.937	0.717	1.167c
Mean	1.470a	1.385h	1.220c	0.970d	0.754d		1.539a	1.467b	1.247c	0.973d	0.754e	

Mean followed by at least one common letter are not significantly different statistically at 0.05 level of probability according to LSD test
$LSD_{(0.05)}$ values after 15 days of salt application. LSD values after 30 days of salt application
$LSD_{(0.05)}$ value for varieties = 0.2298. $LSD_{(0.05)}$ value for varieties = 0.0230
$LSD_{(0.05)}$ value for salinity levels = 0.0182. $LSD_{(0.05)}$ value for salinity levels = 0.0182. $LSD_{(0.05)}$ value for interaction = 0.0514

produced maximum shoot dry weight (2.92 and 5.15 g) and PARC 5S-2 reccrrdecfminimurn shoot dry weight at both 15 and 30 days after salt application . Plants exposed to higher salinity levels (i.e. 16 dS m^{-1}) produced minimum shoot dry weight while plants grown at control produced maximum shoot dry weight at both growth stages. Similarly, PARC SV-8 recorded maximum shoot dry weight at control while PARC S5-2 at 16 dSm^{-1} produced minimum shoot dry weight at 15 and 30 days after salt application. Increase in salinity levels resulted in the development of water and nutrient stress (Carlos and Bingham, 1973; Kawasaki *et al*., 1983). The toxic effect of Na^+ at high salt concentration might have caused physical damage to roots, thereby decreasing their ability to absorb water and nutrient, which might have resulted in poor growth. These results agree with those reported by Khan *et al*. (1990) and Yang *et al*. (1990), who observed a decrease in shoot dry weight in response to salinity. Increase in soil salinity levels significantly decreased shoot dry weight and the most salt tolerant genotype had the highest shoot dry weight at maturing under field condition (Hassanein and Ajab, 1993). Data concerning shoot Na^+ concentration at 15 and 30 days after salt application is presented in Table 3. Statistical analysis of the data showed that shoot Na^+ concentration was significantly affected by various genotypes and different salinity levels as well as their interaction at both 15 and 30 days after salt application. Mean values of the data revealed that PARC SS-2 had maximum of 0.576 and 0.601 meq g^{-1} dry weight of shoot Na^+ while PARC SV-8 had minimum shoot Na^+ concentration (0.456 and 0.448 meq g^{-1}) at 15 and 30 days after salt application. Shoot Na^+ progressively increased with increasing salinity levels. Shoot Na^+ concentration was minimum (0.32 and 0.34 meq g^{-1} dry weight) at control and maximum (1.04 and 1.061 meq g^{-1} dry weight) at 16 dS m^{-1} at both growth stages. Similarly, data recorded for genotypes and salinity levels showed that PARC SV-8, PARC SV-1, PARC SV-2 and IC-1039 at control had minimum shoot Na^+ concentration (0.03 meq g^{-1}) at 15 days after salt application while PARC SV-8, PARC SV-1 and PARC SV-2 at control had minimum shoot Na^+ concentration (0.03 meq g^{-1}) at 30 days after salt application. Increase in salt concentration in the soil profile due to increasing salinity levels had resulted in increase in Na^+ concentration in the plants. Different varieties also, due to their inborn genetic abilities to exclude Na^+ from their cells had different concentration of Na^+ in their shoot. Similar results were also reported by Khan *et al*. (1992) who found that Na^+ concentration in roots and shoot of various sorghum genotypes increased with increasing salinity levels. Many researchers agreed that salt exclusion is an important salinity tolerance mechanism (Yeo and Flowers, 1984; Akita and Cabuslay, 1990; Yeo, 1992; Aslam *et al*., 1993a).

Shoot K^+ was also recorded twice i.e., 15 and 30 days after salt application (Table 4). Statistical analysis of the data revealed that shoot K^+ concentration was significantly ($p<0.05$) affected by various genotypes, different salinity levels and their interaction at both growth stages. Mean values of the data showed that PARC SV-8 had maximum of 1.294 and 1.343 meq g^{-1} dry weight of shoot K^+ both at 15 and 30 days after salt application. Shoot K^+ progressively decreased with increasing salinity level, maximum shoot K^+ was found at control and minimum at 16 dS m^{-1} at both growth stages. Similarly, data regarding genotypes and salinity levels interaction showed that PARC SS-2 at control had minimum shoot K^+ whereas PARC SV-8 at control had maximum shoot K^+ concentration at both growth stages. There are numerous biochemical reasons as to why tolerant sorghum genotype maintained better K^+ in their tissues under adverse conditions. Sharma (1986) reported that salt tolerant rice had their tissue relatively free from the toxic ions besides maintaining assured supply of K^+. Similarly, Aslam *et al.* (1993b) observed that IC concentration had a pivotal role in the induction of salt tolerance. Khan *et al*. (1992) reported that shoot K^+ in sorghum decreased with increasing salinity levels.

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