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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 3 (10): 1577-1579, 2000

Studies of Pearl Millet under Salinity Stress at Early Growth Stage

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Abstract: A pot experiment was conducted at NWFP Agricultural University Peshawar Pakistan during 1998 to study the effect of different salinity levels on pearl millet at early growth stage. The experimental results revealed that the performance of various millet varieties evaluated was significantly different for shoot fresh weight, shoot dry weight, shoot Na^+ content and shoot K^+ concentration at two growth periods i.e., 15 and 30 days after salt application. Millet genotype ICMV-94151 was found to have maximum shoot fresh weight, shoot dry weight, shoot K^+ concentration and lowest shoot Na^+ at 15 and 30 days after salt application. Increasing salinity levels had significantly reduced shoot fresh weight, shoot dry weight and shoot K^+ at both growth stages. Three millet cultivars ICMV-95151, ICMV-95490 and Gana white performed significantly better than the other when exposed to different levels of salinity.

Key words: Salinity, pearl, millet, growth, stage

Introduction

Pearl millet is an important crop of the world. It produces greater quantity of grains than other cereal under conditions of scanty rain fall, infertile soil and intense heat. It requires a short growing season. One of the most important constraint in increasing the production of millet and bringing more area under this crop is soil salinity/sodicity in these areas. Keeping in view the importance of Pearlmillet in our agricultural system, the present experiment was conducted to screen out various varieties of millet under different salinity for different physiological parameters. Various physiological phenomena are related to salt tolerance in plants (Rowers *et al.,* 1977; Yeo and Flowers, 1984; Slam *et al.,* 1993b). Plants can overcome the toxic effect of excessive ions through different physiological traits such as compartmentation, synthesis and accumulation of compatible solutes in cytoplasm, vigor to provide dilution of salt concentration by growth, efficient exclusion of Na^+ (Gorham *et al.,* 1985; Slam *et al.,* 1991, 1993b). Munns *et al.* (1982), Rashid (1986) and Slam *et al.* (1993b) reported a positive correlation between Na^+ exclusion and relative salt tolerance of many crops.

Materials and Methods

In order to study the effect of different salinity levels on pearlmillet at early growth stages, a pot experiment was conducted at NWFP Agricultural University in Randomized Complete Block Design (CRD) with three Replications. Eight Pearlmillet varieties (Gick-93771, ICMV-95490, ICMV-94151, Bari-MS-22-95, 85-2, Ghana white, Togo and V-94-1) were screened at five different salinity levels (0,4,8,12 and 16 dS m^{-1}). Each pot (30×35 cm) was filled with 20 kg of soil. Seeds were sown in each pot at uniform depth (2 cm) and after complete germination emergence, thinning was done and seven plants were maintained in each pot. A recommended fertilizer dose of 100-50-0 NPK kg ha^{-1} was applied to each pot. Plants were subjected to the proposed salinity levels through irrigation water by the addition of salt in increment 30 days after emergence. Data was recorded on shoot fresh weight, shoot dry weight, shoot Na^+ content 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 procedure according to CRD and upon obtaining significant differences least significant difference (LSD) test was applied for the comparison of treatment means.

Results and Discussion

Data recorded on shoot freshweightat15and30 days after salt applicationg is presented inTable 1.Statistical analysis of the data revealed that shoot fresh weight was significantly ($p < 0.05$) affected by various varieties and different salinity

Table 1: Shoot fresh weight (g) of various millet varieties after different days of salt application

Varieties	Salinity levels (dS m^{-1})					
	Control	4	8	12	16	Means
After 15 days of salt application						
GICK-93771	15.03	13.36	10.53	7.70	4.70	10.27cd
ICMV-95490	15.33	13.93	10.66	8.33	6.00	10.85b
ICMV-94151	16.73	15.36	12.20	10.10	7.16	12.31a
BARI-MS-22-95	14.43	13.63	10.20	7.76	4.80	10.17d
BS-2	14.96	14.00	9.70	7.00	4.66	10.11d
Gana White	15.16	14.03	10.66	8.23	5.83	10.75bc
Togo	12.30	10.30	9.23	7.15	4.63	8.63e
V-94-1	14.76	13.33	10.63	8.33	5.16	10.45bcd
Means	14.84e	13.56b	10.48d	8.081	5.37a	
After 20 days of salt application						
GICK-93771	23.87c	21.60fgh	19.77k	14.80o	9.33r	17.87d
ICMV-95490	25.93b	23.57cd	21.03hi	16.43m	13.07pq	19.97b
ICMV-94151	27.70a	25.00b	22.33efg	17.501	13.37p	21.18a
BARI-MS-22-25	25.23b	22.57def	20.03ijk	16.10mn	9.83r	18.75c
BS-2	25.47b	22.33efg	19.50k	15.07no	10.00r	18.47c
Gana White	25.60b	23.43cd	20.97hij	16.07mn	12.23q	19.69b
Togo	22.77de	21.30gh	19.57k	14.43o	9.23r	17.46d
V-94-1	25.00b	21.87e-i	19.93jk	15.20rop	9.93r	18.39c
Means	25.20a	22.71 b	20.39c	15.70d	10.87e	

After 15 days of salt application, After 30 days of salt application, $LSD_{(0.05)}$ value for varieties = 0.5777, $LSD_{(0.05)}$ value for varieties = 0.4548 $LSD_{(0.05)}$ value for salinity levels = 0.4567, $LSD_{(0.05)}$ value for salinity levels = 0.3594, $LSD_{(0.05)}$ for interaction = 1.016

Table 2: Shoot dry weight(g) of various millet varieties after different dais of salt application

Varieties	Salinity levels (dS m^{-1})					
	Control	4	8	12	16	Means
After 15 days of salt application						
GICK-93771	4.51	4.24	3.83	3.11	2.48	3.63cd
ICMV-95490	4.69	4.45	3.72	3.85	2.59	3.85ab
ICMV-94151	4.75	4.45	4.17	3.86	3.04	4.00a
BARI-MS-22-95	4.53	4.23	3.67	3.11	2.37	3.58cd
BS-2	4.55	4.31	5.53	3.26	2.82	3.65bc
Gana White	4.66	4.40	3.66	3.52	2.91	3.83ab
Togo	4.31	3.99	3.69	2.95	2.30	3.45d
V-94-1	4.54	4.32	3.80	2.97	2.38	3.80cd
Means	4.57a	4.30b	3.76e	3.30d	2.59e	
After 30 days of salt application						
GICK-93771	7.00a-e	13.53fgh	5.82k	4.48no	3.40rs	5.46cd
ICMV-95490	7.30a	6.78def	6.21hij	5.23m	3.90pq	5.89b
ICMV-94151	7.35a	7.10a-d	6.39ghi	5.42lm	4.46rio	6.14a
BARI-MS-22-95	7.14abc	5.55fgh	5.86k	4.40no	3.57qrs	5.50cd
BS-2	7.13a-d	6.65afg	5.86k	4.40no	3.57qrs	5.50cd
Gana White	7.26ab	8.845-f	5.09ijk	4.43no	4.20op	5.76b
Togo	6.91 b-e	6.35ghi	5.73k1	4.45no	3.27s	5.34d
V-94-1	7.16abc	6.53fgh	5.83k	4.71n	3.73qr	5.59c
Means	7.1$e	8.66b	5.98c	4.71d	3.79c	

After 15 days of salt application, $LSD_{0.05}$ value for varieties = 0.1575
After 30 days of salt application, $LSD_{0.05}$ value for salinity levels = 0.1488
$LSD_{(0.05)}$ for interaction = 0.3523
$LSD_{(0.05)}$ value for varieties = 0.1882
$LSD_{(0.05)}$ value for salinity levels = 0.1245
Means followed by different letter are not significantly different statistically at 0.05 level of probability according to LSD test

Table 3: Shoot Na^+ concentration (rrreg/g dry weight) of various millet varieties at different days after salt application

Varieties	Salinity levels (dS m^{-1})					
	Control	4	8	12	16	Means
After 15 days of salt application						
DICK-93771	0.0431	0.286jk	0.530hi	0.806ef	1.11ob	0.55b
ICMV-95490	0.0401	0.243k	0.490hi	0.716g	0.986cd	0.495c
ICMV-94151	0.0401	0.336j	0.466i	0.890g	0.916d	0.490e
BARI-MS-22.95	0.0431	0.270jk	0.520hi	0.796ef	1.110h	0.548b
BS-2	0.0461	0.283jk	0.530hi	0.803ef	1.077b	0.522b
Gana White 0.0401	0.256k	0.493hi	0.740fg	1.007c	0.522b	
Togo	0.0501	0.2136jk	0.546h	0.826e	1.210a	0.586a
V-94-1	0.0401	0.2801k	0.523hi	0.800ef	1.100b	0.548b
Means	0.042e	0.281d	0.512e	0.772h	1.067a	
After 30 days of salt application						
GICK-93771	0.046r	0.300op	0.546k	0.850fg	1.16 3b	0.581b
ICMV-95490	0.040r	0.250pq	0.423n	0.713i	0.983de	0.482d
ICMV-94151	0.040r	0.236q	0.4861m	0.716i	0.933e	0.482d
BARI-M5-22-95	0.043r	0.280opq	0.523k1	0.786h	1.120bc	0.550c
BS-2	0.043r	0.270opq	0.520k1m	0.790h	1.103c	0.545c
Gana White	0.040r	0.250pq	0.470mn	0.7231	0.986d	0.494d
Togo	0.050r	0.320o	0.603j	0.863f	1.237a	0.814a
V-94-1	0.043r	0.283opq	0.523k1	0.810gh	1.103c	0.552c
Means	0.043e	0.273d	0.512e	0.781b	1.079a	

After 15 days of salt application
$LSD_{(0.05)}$ value for varieties = 0.02298
$LSD_{(0.05)}$ value for interaction = 0.07267
After 30 days of salt application
$LSD_{(0.05)}$ value for salinity levels =0.05569
$LSD_{(0.05)}$ value for interaction =0.05138
$LSD_{(0.05)}$ value for varieties = 0.03250
$LSD_{(0.05)}$ value for salinity levels = 0.01817
Means followed by different letter are not significantly different statistically at 0.05 level of probability according to LSD test

Table 4: Shoot K* concentration(mag/g dry weight) of various millet varieties at different days after salt application

Varieties	Salinity levels (dS m^{-1})					
	Control	4	8	12	16	Means
After 15 days of salt application						
GICK-93771	1.460d	1.360ef	1.210h	0.906k1	0.894no	1.126d
ICMV-95490	1.570ab	1.483d	1.313fg	1.080j	0.9001m	1.2736
ICMV-94151	1.610a	1.510cd	1.377ef	1.143i	0.930k1	1.314a
BARI-M S-22-95	1.467d	1.403e	1.203h	0.856k	0.713n	1.149d
BS-2	1.467d	1.390e	1.200h	0.953k	0.726n	1.147d
Gana White	1 .537bc	1.477d	1.303g	1.0701	0.853m	1.24Bc
Togo	1.357ef	1.247h	1.733g	0.853m	0.646o	1.047e
V-94-1	1.483d	1.377ef	1.197h	0.946k1	0.728n	1.146d
Means	1.494a	1.406b	1.245c	0.988d	0.773e	
After 30 days of salt application						
GICK-93771	1.523fg	1.437hi	1.210no	0.916ors	0.680vw	1.153d
ICMV-95490	1.463ab	1.5130cde	1.3130jk	1.073p	0.900rs	1.311b
ICMV-94151	1.683a	1.610bed	*1* .4074	1.173o	0.940qr	1.363a
BARI-MS-22-95	1.537fg	1.487gh	1.237mn	0.966q	0.720uv	1.189c
BS-2	1.537efg	1.470h	1.223no	0.846qr	0.706uv	1.177c
Gana White	1.623bc	1 .560def	1.330k1	1.073p	0.886st	1.295b
Togo	1.3901j	1.2871m	1.113p	0.838t	0.630	1.049e
V-94-1	1.540ef	1.467h	1.237mn	0.956q	0.736v	1.187c
Means	1.560a	1.487b	1.263c	0.992d	0.775e	

After 15 days of salt application
$LSD_{(0.05)}$ value for varieties = 0.02299
$LSD_{(0.05)}$ value for interaction = 0.05140
After 30 days of salt application
$LSD_{(0.05)}$ value for salinity levels =0.01817
$LSD_{(0.05)}$ value for interaction =0.05140
$LSD_{(0.05)}$ value for varieties = 0.02299
$LSD_{(0.05)}$ value for salinity levels = 0.01817
Means followed by different letter are not significantly different statistically at 0.05 level of probability according to LSD test

levels at 15 and 30 days after salt application. It can be evident from the data presented in Table 1 that ICMV-94151 produced maximum shoot fresh weight (12.31 and 21.18 g) while Togo produced minimum shoot fresh weight (8.83 and 17.48 g) at both growth stages. Mean values of the data also showed that shoot fresh weight was progressively decreased with increasing salinity, maximum decreased being noticed at high salinity level (i. e., 16 dS m^{-1}). Similarly ICMV-94151 at control produced maximum shoot fresh weight, while Togo when exposed to high salinity levels produced minimum shoot fresh weight. This decrease in shoot fresh weight by high salinity may be due to water and nutrient stress and toxic effect of high concentration of Na^+ in the soil medium which in turn reduced photosynthesis (Carlos and Bingham, 1973; Kawasaki *et al.,* 1983). Similar results are also supported by Chhlppa *et al.* (1992) who found that fresh shoot decreased with increasing salinity. Similarly, Malibari *et al.* (1993) reported decrease in growth with an increase in salinity. Shoot dry weight data was also recorded at two growth stages i.e. 15 and 30 days after salt application (Table 2). Analysis of the data revealed that varieties and salinity levels had significantly ($p<0.05$) affected shoot dry weight at 15 and 30 days after salt application whereas the effect of interaction was significant at 30 days after salt application. The data manifested that ICMV-94151 recorded maximum shoot dry weight (4 and 6.14 g), while minimum shoot dry weight (3.45 and 5.34 g) was noted from Togo. Mean values of the data also showed that plants exposed to higher salinity levels (i.e., 18 dS m^{-1}) produced minimum shoot dry weight at both growth stages as compared with other treatments. Similarly, 1CMV-9415 produced more shoot dry weight at control while Toga when exposed to 18 dS m^{-1} produced minimum shoot dry weight at both growth stages i.e. 15 days and 30 days salt application. This decrease in shoot dry weight may be due to the fact that Na^+ concentration may have caused physical damage to the root system and have decreased their ability to absorb water and nutrient which has resulted in stunted growth.

These results are supported by Ashraf and McNeilly (1992) and Onkware and Ochieng (1993) who reported significant decrease in shoot dry weight when exposed to salinity.

Table 3 presents data regarding shoot Na^+ concentration recorded at 15 and 30 days after salt application. Statistical analysis of the data showed that shoot Na^+ concentration was significantly ($p<0.05$) affected various varieties, different salinity levels and their interactions at both growth stages. Mean values of the data revealed that Togo had Maximum dry weight shoot Na^+ (0.586 and 0.614 meq g^{-1}), while ICMV-94151 recorded minimum dry weight shoot Na^+ (0.490 and 0.482 meq g^{-1}) at both 15 and 30 days after salt application. It can be inferred from the data that shoot Na^+ content progressively increased with increasing salinity levels. Minimum Na^+ concentration was obtained at control, while maximum at high salinity level (i.e., 16 dS m^{-1}) at both growth stages. Similarly, data concerning varieties and salinity Interaction showed that ICMV-94151 accumulated less Na^+ in their shoot when compared with other varieties exposed to different salinity levels. it has been observed by many researchers that salt exclusion is an important salinity tolerance mechanism. (Yeo and Flowers, 1984; Akita and Cabuaaly, 1990; Yeo, 1992; Slam *et al.,* 1993a; Onkware, 1993). Table 4 shows data regarding shoot K^+ concentration at 15 and 30 days after salt application respectively. Statistical application analysis of the data indicated that K^+ was significantly ($p<0.05$) effected by various varieties and different salinity levels as well as their interaction. Mean values of the data exhibited that ICMV-94151 had maximum shoot K^+ (1.314 and 1.363 meq g^{-1} dry weight) concentration while Togo accumulated minimum K^+ in their shoot at both growth stages i.e., 15 and 30 days after salt application. It can also be seen from the data that plants exposed to high salinity levels accumulated less K^+ in their shoot when compared with other treatments at 15 and 30 days after salt application. Similarly, mean values of the data presented in Table 4 also indicated that ICMV-94151 accumulated more IC in their shoot when exposed to different levels of salinity as compared to other varieties. Many researchers agreed that tolerant varieties maintained better K^+ and K: Na in their tissue under saline conditions. Salt tolerant crops had their tissue relatively free from the toxic ion besides maintaining assured supply of K^+ (Sharma, 1986). Maintenance of high K^+ concentration and especially K: Na ratio are the major physiological character of salt tolerant plants (Slam *et al.,* 1993b).

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