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Yield and Yield Components of Pearl Millet as Affected by Various Salinity Levels

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Abstract: In order to study the effect of various salinity levels on the yield and yield components of Pearl millet, a pot experiment was conducted at NWFP Agricultural University Peshawar, Pakistan during 1998. The performance of various millet varieties evaluated was significantly different for germination %age, leaf area, plant height, total biomass and grain yield plant^{-1}. Genotype ICMV-94151 was found to have maximum leaf area, plant height, biomass and grain yield plant^{-1} both at 15 and 30 days after salt application. Three millet varieties ICMV-941 51, ICMV-95490 and Gana white performed better than the others. Increasing salinity levels had significantly reduced germination percentage, leaf area, Plant height, total biomass and grain yield plant^{-1}.

Key words: Yield, salinity, millet, components

Introduction

Due to a number of problems, the production from the total cultivated area of Pakistan does not match with the production of other developing countries. These problems include inadequate drainage, water application, shortage of fertilizer, water logging and salinity. Among these problems salinity plays a very important role in the agricultural system of Pakistan. Salinity have a very bad effect on plant life, residential buildings and general hygienic conditions. Poor physical conditions of soil, death of microbes, restricted root growth and poor decomposition of organic matter, all are caused by salinity. Keeping in view the key role of salinity in the agrarian economy of Pakistan, the present project was designed to screen different millet varieties for their salinity tolerance. Onkware and Ochieng (1993) reported that seed germination, plant height and leaf area decreased with increasing salinity levels. Salinity reduced specific leaf area which indicates alteration in leaf expansion and carbon allocation (Cramer *et al.,* 1994). Yield and yield related traits of different pear millet varieties progressively decreased with increased salinity (Nisha *et al.,* 1993; Guandalia *et al.,* 1992; Kumawat *et al.,* 1991; Alam and Naqvr, 1991).

Materials and Methods

A pot experiment was conducted at NWFP Agricultural University Peshawar Pakistan during 1997 to study the effect of different salinity levels on various varieties of Pear millet. The experiment was laid out in Completely randomized design (CRD) with three replications. Each pot (30 × 35 cm) was filled with 20 kg of soil. The seeds were sown at uniform depth (2 cm) and after completion of emergence, thinning was done and seven plants were maintained in each pot. Recommended dose of commercial fertilizer at the rate of 100-50-0 NPK kg ha^{-1} was applied to each plot. The amount of fertilizer required for each pot was calculated by the following formula Fertilizer required = Nutrient ha^{-1} X weight of soil in pot Soil weight ha^{-1} (20,00,000 kg) Eight varieties of millet (Gick-93771, ICMV-95490, ICMV-9451, Bari-MS-22-95, BS-2, Gana white, Togo and V-94-1 were subjected to different salinity levels (0, 4, 8, 12 and 16 dS m^{-1}) through irrigation water by addition of salt in increments 30 days after emergence. Data regarding leaf area and plant height was recorded at 15 and 30 days after salt application while days to maturity, total biomass and grain yield. plant^{-1} data was collected at maturity. To record data concerning germination percentage, a separate experiment was carried out by exposing the seeds to salinity levels through irrigation water before sowing.

Results and Discussion

Data regarding germination is presented in Table 1. Statistical analysis of the data revealed that various varieties, different salinity levels and their interaction had a significant ($p<0.05$) effect on germination. Mean values of the data showed that maximum germination of 71.80% was recorded for ICMV95490 which was at par with the genotype ICMV-94151 (70.87%). While Gick-93771 recorded minimum germination (61.40%). Data regarding different salinity levels showed that germination was progressively reduced with increasing salinity levels. Maximum reduction was observed when plants were exposed to high salinity levels (i.e. 16 dS m^{-1}). Similarly, data concerning varieties and salinity levels interaction showed that maximum germination was noted for ICMV- 95490 when grown at control while minimum germination was observed for Gick-93771 when exposed to salinity levels of 16 dS m^{-1}. This difference in germination might be due to the physical damage caused by addition of salt on the emerging radicle and plumule and the inherent genetic capabilities of the varieties. Similarly, salinity causes water stress which resulted in low water absorption by seeds required for various enzymatic activities during germination. In addition, ions like Na or Cl are toxic, if absorbed in higher concentration which may reduce germination in moderately salt tolerant crops like millet. Similar results are also reported by Bernal *et al.* (1974), Ahmad *et al.* (1981), Kingsbury and Epstein (1984), Rashid (1986) and Due (1989). Data recording leaf area was recorded at two growth stages. i.e., 15 and 30 days after salt application. Analysis of leaf area showed that varieties and salinity levels had significantly ($p<0.05$) affected leaf area both at 15 and 30 days after salt application, Whereas interaction was non significant (Table 2). Mean values of the data revealed that ICMV-94151 attained maximum leaf area (137 and 199 cm^2) at both growth stages while minimum leaf area was noted for Gick-93771 and Togo at 15 and 30 days after application respectively. Plants subjected to high salinity (i.e. 16 dS m^{-1} attained minimum leaf area while plants grown at control recorded maximum leaf area at both growth period. Similarly, ICMV-94151 when grown at control produced maximum leaf area while Gick-93771 recorded minimum leaf area when exposed to high salinity levels both at 15 and 30 days after salt application.

Table 1: Germination percentage of various millet varieties as affected by different salinity levels

Variety	Salinity levels ($dS\ m^{-1}$) Control	4	8	12	16	Means
GICK-93771	88.00abc	77 .0-0d-g	70.00g	39.331m	32.67m	61.40e
ICMV-95490	92.00a	84.00a-d	83.00bcd	55.33jk	44.671mn	71.80a
ICMV 94151	90.00abo	84.00a-e	81.00d-g	50.6710m	48.67klm	70.87ah
BARI-MS-2295	91.003b	84.00a-e	77.000-1	50.67i-m	33.33o	67.40bc
BS-2	85.00ede	74.00f-i	61.00j	52.00kl	39.33no	62.27de
Gana White	91.00ab	82.00e-g	79. 00e-i	55.33l-n	44.671mn	68.40abc
Togo	90.33ah	81.00d-g	75.00f-i	52.00kl	38.00ijk	67.27bc
V 94-1	84.00a-e	78.00d-i	71.00hi	51.33k1	42.6	65.40cd
Means	89.00a	80.88	74.88c	49.92d	41.17e	

$LSD_{(0.05)}$ values for varieties = 3.602 = $LSD_{(0.05)}$ values for = 2.848 =$LSD_{(0.05)}$ values for 8.035

Table 2: Leaf area {cm)^2 of various millet varieties at different days after salt application

Variety	Salinity levels ($dS\ m^{-1}$) Control	4	8	12	16	Means
After 15 days of salt application						
GICK 93771	166.08	152.10	117.74	86.73	57.26	115.0c
ICMV-95490	183.17	151.01	124.62	97.09	63.61	124.4h
ICMV-94151	184.95	167.25	140.36	113.17	79.41	137.0a
BARI-MS-22-95	175.59	149.01	116.25	89.62	60.95	118.3bc
85-2	171.35	151.81	119.34	86.30	58.75	117.7bc
Gana White	180.66	158.10	126.63	92.16	64.00	123.4hc
togo	173.60	142.93	118.89	94.41	66.37	117.7bc
V-94-1	173.69	148.83	124.02	94.84	62.33	121.thc
Means	175.41a	152.8h	123.5e	94.29d	64.11e	
After 30 days at salt application						
GICK-93771	264.53	246.44	186.42	126.97	92.40	183.2b
ICMV-95490	270.66	253.79	199.59	142.24	106.94	194.6ab
ICMV-941 51	279.37	258.92	203.59	146.48	110.45	199.8a
BART-MS-22-95	268.78	242.12	181.77	123.57	101.63	183.60
65-2	265.15	244.23	193.64	135.32	98.58	188.6ab
Gana White	270.06	247.43	196.07	141.85	112.86	192.6ab
Togo	259.20	167.17	180.19	122.46	91.09	164.0c
V-94-1	267.51	243.07	191.70	132.06	102.00	187.3ab
Means	268.3a	237.9b	191.5c	133.9d	101.9e	

After 15 days of salt application:		After 30 days of salt application:	
$LSD_{(0.05)}$ value for varieties	= 7.184	$LSD_{(0.05)}$ values for varieties	= 15.92
$LSD_{(0.05)}$ value for salinity levels	= 5.679	$LSD_{(0.05)}$ values for salinity levels	= 12.59
$LSD_{(0.05)}$ values for salinity levels	= 12.59		

Means followed by atleast one common letter are not significantly different statistically at 0.05 level of probability to LSD test

Table 3: Plant height (cm)^2 of various millet varieties at different days after salt application

Variety	Salinity levels ($dS\ m^{-1}$) Control	4	8	12	16	Means
After 15 days of salt application:						
GICK-93771	74.13	71.73	65.00	48.66	40.73	60.05d
ICMV-95490	77.26	72.30	66.43	54.96	48.80	63.950
ICMV-94151	79.20	75.80	68.10	59.30	50.70	66.62a
BARI-MS-22-95	72.66	71.26	64.36	50.50	41.46	60.05d
BS-2	72.80	72.26	62.20	48.23	41.4	59.39d
Gana White	75.70	72.16	64.23	51.63	45.73	61.89c
Togo	68.80	66.70	59.40	48.00	39.53	56.68d
V-94 1	72.06	69.70	61.73	48.56	41.16	58.640
Means	74.20a	71.49b	63.93c	51.234	43.70c	
After 30 days of salt application						
GICK-93771	114.30	109.00	97.56	79.06	61.50	92.28e
ICMV-95490	115.56	112.43	101.10	83.40	65.56	95.61h
ICMV-94151	117.30	115.46	105.70	89.16	70.30	99.58a
BARI MS-22.95	114.30	110.46	97.26	79.66	61.06	92.50c
135-2	113.33	109.23	96.03	78.90	60.60	91.62cd
Gana White	116.53	107.30	99.86	82.86	64.50	94.19b
Togo	110.90	103.90	98.80	78.13	59.40	90.220
V-94-1	115.60	108.13	97.20	78.20	60.70	91.96c
Means	114.69a	109.47b	99.19e	81.17d	62.95e	

After 15 days of salt application:		After 30 days of salt application:	
$LSD_{(0.05)}$ value for varieties	= 1.471	$LSD_{(0.05)}$ values for varieties	= 1.623
$LSD_{(0.05)}$ value for salinity levels	= 1.153	$LSD_{(0.05)}$ values for salinity levels	= 1.283

Means followed by atleast one common letter are not significantly different statistically at 0.05 level of probability to LSD test

The difference in leaf size might be due to higher salt concentration added to the soil and the inborn genetic capabilities of different varieties. Increase in salt concentration in the soil had an adverse effect on the osmotic exchange between root hairs and soil solution and the plants were unable to absorb water from the soil, thus making the soil physiologically dry. Increased salt accumulation had a negative effect on the availability of certain nutrients particularly nitrogen to the plants (Bernal *et al.*, 1974; Kawasaki *et al.,* 1983). The plants are thus unable to develop maximum leaf area due to water and nutrient stress caused by salinity. The toxic effect of Na^+ at higher salinity levels might also be responsible for decrease in leaf area production. Kumawat *et al.* (1991) reported a decrease in leaf area with an increase in

Table 4: Days to maturity of various millet varieties as affected by different salinity levels

Variety	Salinity levels (dS m^{-1})					
	Control	4	8	12	16	Means
GICK-93/71	129.00	132.66	130.66	131.00	131.33	130.93
ICMV-95490	130.00	132.66	130.66	130.66	128.66	130.53
ICMV-94151	130.66	131.00	129.33	130.66	130.33	130.40
BART MS-22-95	132.66	132.33	132.00	132.33	132.00	132.26
BS 2	131.66	132.00	132.66	129.66	130.33	131.26
Gana White	131.00	129.00	132.65	130.33	131.33	130.66
Togo	127.00	129.33	134.33	135.66	131.00	131.46
V-94-1	131.00	135.00	132.66	132.33	132.66	132.86
Means	130.45	131.62	131.45	131.58	130.95	

Table 5: Total biomass (g/plant) of various millet varieties as affected by different salinity levels

Variety	Salinity levels (dS m^{-1})					
	Control	4	8	12	16	Means
GICK-93771	48.23cd	45.070	39.300	28.101m	20.900	36.320
ICMV 95490	52.43ab	49.07	43.905	35.73k	28.031m	41.765
ICMV 941 51	52.63a	50.37bc	45.37e-h	37.70jk	29.471	43.13a
BARI MS 2295	48.60cci	45.33fg5	39. 27ij	29.811	19.63n	36.546
CS 2	48.270	45.43e-1i	40.001	29.801	19.73n	36.656
Gana White	52.07abc	47.37dcf	43.53h	25.53k	25.97m	40.57c
Togo	47.56de	44.37h	39.071i	29.831	19.57n	36.08e
V-94 1	46.906-g	44.8035	39.77ij	39.431	20.53n	36.296
Means	49.34a	46.474	41 . 2 9e	32.00d	22.98	

LSD$_{(0.05)}$ values for varieties = 0.9949 = LSD$_{(0.05)}$ values for = 0.7865 =LSD$_{(0.05)}$ values for 2.225

Table 6: Grain yield (g/plant) of various millet varieties as affected by different salinity levels

Variety	Salinity levels (dS m^{-1})					
	Control	4	8	12	16	Means
GICK-93771	11.29c	10.52de	8.225i	6.31m	3.45m	7.95e
ICMV 95490	12.31 ab	11.51e	8.763	7.341	4.690	8.89b
ICMV-94151	12.35a	11.56e	9.27f	7.60k1	5.21 n	9.21a
BARI MS-22-95	11.755c	10.66d	7.69jkl	6.14m	3.47p	7.94c
CS-2	12.16a5	10.62d	8.181ij	6.12m	3.37p	8.09c
Gana White	12.17a	11.50c,	8.5095	7.50k1	4.570	8.85b
Togo	11.48c	10.06e	7.61k1	6.10in	3.25p	7.70d
V-94-1	11.44o	10.25de	7.97ijk	6.18m	3.66p	7.90cd
Means	11.87a	10.844	8.27c	6.67d	3.96e	

LSD$_{(0.05)}$ values for varieties = 0.2229 = LSD$_{(0.05)}$ values for = 0.1762 =LSD$_{(0.05)}$ values for 0.4984

Means followed by atleast one common letter are !rut significantly different statistically at 0.05 level of probability to LSD test

salt application. Table 3 indicates data regarding plant height recorded at 15 and 30 days after salt application. Statistical analysis of the data revealed that varieties and salinity levels had a significant ($p<0.05$) effect on plant height at both growth periods. Mean values of the data showed that ICMV-94151 attained maximum plant height 166.62 and 99.59 cm) while dwarf plants (56.68 and 90.22 cm) were noted from Togo at both growth periods. i.e. 15 and 30 days after salt application. It can be also inferred from the data that plants exposed to high salinity level (16 dS m^{-1}) produced dwarf plants while taller plants were noted at control at both 15 and 30 days after salt application. Similarly, ICMV-94151 when grown at control produced taller plants whereas Togo when subjected to high salinity level recorded dwarf plants. It was noticed that increasing salinity levels had progressively decreased plant height which may be due to decrease in leaf area because of Na toxicity. Water and nutrient stress (Bernal *et al*., 1974; Kawasaki *et al.* (1983). The decrease in leaf area might have resulted in decrease in photosynthates production which in turn reduced plant height. Increasing salinity levels had significantly decreased plant height. Alam and Naqvr (1991), Kingsbury and Epstein (1984), Zahid *et al.* (1986), Singh and Rana (1987), Sharma and Swarup, (1988) Data recording days to maturity is presented in Table 4. Analysis of the data revealed that days to maturity were non significantly affected by varieties, salinity and their interaction. However, mean values of the data indicated that V-94-1 took more days to maturity whereas ICMV-94151 took minimum days to maturity. Similarly, Togo when exposed to 12 dS m^{-1} matured later whereas the same variety at control took minimum days to maturity.

Table 5 presents data regarding total biomass. plant^{-1} at harvest. Statistical analysis of the data indicated that biomass was significantly ($p<0.051$ affected by varieties, salinity levels and their interaction. It can be seen from the data that ICMV-94151 produced maximum biomass. plant^{-1} (43.13 g) while minimum biomass plant^{-1} (36.08 g) was recorded from Togo. Mean values of the data regarding salinity levels showed that biornass was minimum (22.98 g Plant^{-1}) when plants were exposed to high salinity level (16 dS m^{-1}) while plants grown at control recorded maximum biomass (49.34 g plant^{-1}) . Similarly, it is also clear from the data that ICMV-94151 when grown at control produced maximum biomass. plant^{-1} while Togo when exposed to high salinity (16 dS m^{-1}) recorded minimum biomass plant^{-1}. Improper development of leaves due to salt stress might be responsible for decrease in biomass production. Similar results are also reported by Guandalia *et al*. (1992).

Data recording grain yield plant^{-1} is shown in Table 6. Statistical analysis of the data revealed that varieties, salinity levels and their interaction had a significant ($p<0.051$ effect on grain yield. plant^{-1}. Mean values of the data indicated that ICMV-94151 produced maximum grain yield of 9.21 g plant^{-1} while Togo recorded grain yield of 8.89 g plant^{-1}. It can be also seen from the data shown in Table 6, that grain yield. plant^{-1} progressively decreased with increase in salinity level, maximum reduction in yield was observed at 16 dS m^{-1} while plants grown at control produced maximum grain yield plant^{-1}

(11.87 g). Mean values also indicated that ICMV-94151 when grown at control produced maximum grain yield plant^{-1} whereas Togo when subjected to high salinity level recorded minimum grain yield plant^{-1}. This decrease in grain yield by salinity may be due to lower leaf area development as result of sodium toxicity, water and nutrient stress which in turn reduced net assimilates. These results are substantiated by Nisha *et al.* (1993), Kumawat *et al.* (1991), Zahid *et al.* (1986), Francois *et al.* (1998) and Verma and Neue (1984), who reported a decrease *in* grain yield due to addition of salts.

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