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Effect of salinity on yield, yield attributes and quality of pearl millet (*Pennisetum glaucum* L.) varieties

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Abstract
A pot experiment was conducted at Department of Agricultural Chemistry and Soil Science, College of Agriculture, Junagadh Agricultural University, Junagadh to assess the "Effect of salinity on bio-chemical parameters, nutrient composition and yield of pearl millet (*Pennisetum glaucum* L.) varieties" during the summer season of 2017. The result revealed that the yield and yield attributes, quality parameters, bio-chemical parameters and nutrient uptake were significantly influenced by the different varieties of pearl millet and salinity levels. The variety V_1 (GHB-538) exhibited its superiority in growth, yield and yield attributes like ear head length (20.21 cm), number of total tillers plant^{-1} (3.22), number of effective tillers plant^{-1} (2.56), grain: fodder ratio (0.56), grain yield (4.03 g plant^{-1}) and quality parameters *viz.*100 seeds weight (0.98 g) among different tested varieties of pearl millet at harvest. Significantly the highest plant height (96.67 cm) was observed with variety V_3 (GHB-732). The significant reduction of grain yield was observed mainly at the higher salinity (8 dS m^{-1}) of irrigation water as compared to good quality water. Application of saline irrigation water at S_1 (< 2 dS m^{-1}) was observed superior over rest of the levels in grain yield (4.08g plant^{-1}), plant height (105.83 cm), ear head length (21.22 cm), number of total tillers plant^{-1} (3.49), number of effective tillers plant^{-1} (2.25), grain-fodder ratio (0.50), fodder yield (8.22 g) and quality parameter *viz.*100 seeds weight (1.01 g). The combine effect of variety V_1 (GHB-538) with salinity level S_1 (< 2 dS m^{-1}) gave significantly the highest grain yield, plant height, total tillers per plant, number of effective tillers per plant, test weight, RWC, chlorophyll-a, chlorophyll-b, Na content in leaves at 45 DAS and in grain & fodder at harvest.

Keywords: pearl millet, salinity levels, varieties, growth, yield and yield attributes quality, nutrient content, uptake and available nutrient status

Introduction
Pearl millet (*Pennisetum glaucum* (L) R. Br.) is one of the major coarse grain cereal crop and is considered to be poor people's food. It is widely grown in Africa and Asia since pre-historic times. In Asia, important pearl millet growing countries are India, China, Nigeria, Pakistan, Sudan, Egypt, Arabia and Russia. In India major bajara production state is Rajasthan followed by Maharashtra, Haryana, Gujarat, and Uttar Pradesh. In India, pearl millet is one of the important millet crops. Now a day, water scarcity is one of the most limiting factors in agricultural production. This limitation particularly in arid and semi-arid region because of salt accumulation in this area. Salinization of agricultural areas due to intense practices and irrigation is an important feature for limiting crop yield and production. Soil salinity adversely effects on plant growth and development. Worldwide, about one-third of irrigated arable land is already affected and that level is still rising (Lazof and Bernstein, 1999) [11]. An excess of soluble salts in the soil leads to osmotic stress, which results in specific ion toxicity and ionic imbalances and the consequences of these can be plant demise (Rout and Shaw, 2001) [18]. Increasing crop salt tolerance is a highly attractive approach to overcoming the salinity threat. The need of the hour is to explore and select salt-tolerant genotypes within a species in comparison to relatively salt-sensitive ones through conventional selection and breeding techniques. Keeping this view an attempt has been made to the performance of different pearl millet genotype.

Materials and Methods
A pot experiment was conducted during *summer*- 2017 at the Department of Agricultural Chemistry and Soil Science, College of Agriculture, Junagadh Agricultural University,

Junagadh. The experimental soil was clayey in texture and alkaline in reaction with pH 8.0, EC 0.58 dS m^{-1}, $CaCO_3$ 31.05% and CEC 36.2 cmol (p^+) kg^{-1}.The soil was low in available nitrogen (242 kg ha^{-1}), medium in available phosphorus (39.20 kg ha^{-1}), high in available potassium (298 kg ha^{-1}), high in available sulphur (29.50 kg ha^{-1}), low in available iron (3.25 mg kg^{-1}), high in available zinc (0.55 mg kg^{-1}), medium in available manganese (5.20 mg kg^{-1}) and high in available copper (1.25 mg kg^{-1}). The experiment consists of 20 treatments combinations comprising four levels of salinity water *viz.* < 2, 4, 6 and 8 dS m^{-1} and five levels of varieties *viz.* GHB-538, GHB-744, GHB-732, GHB-905 and GHB-558. Complete Randomized Design with total twenty treatments replicated thrice was employed in this study. Standard agronomic practices were adopted for raising healthy crop. Observations were recorded on five tagged plants in each treatment for growth and yield attributes. The collected data for various parameters were statistically analysed using F' test (Panse and Sukhatme, 1985) [16].

Result and Discussion

Yield parameters

The grain yield was significantly influenced by different varieties of pearl millet (Table 1). Significantly, the higher grain yield (4.03 g $plant^{-1}$) was registered with variety V_1 (GHB-538). The grain yield of pearl millet observed in descending order of GHB-538> GHB-732> GHB-744> GHB-558> GHB-905. The effect of variety did not produced significant effect on fodder yield at harvest. The value of grain yield and fodder yield decreased with increasing levels of salinity. Significantly higher grain yield (4.08 g $plant^{-1}$) and fodder yield (8.22 g $plant^{-1}$) were recorded under an application of 2.0 dS m^{-1} (S_1) saline irrigation water. The fodder yield was significantly affected by increasing salinity levels. Reduce fodder yield per plant under salinity condition might be due to inhibited photosynthesis under a salinity stress that causes low amount of nutrient uptake by the plant (Babu and Thirmurugan, 2001) [3]. The interaction effect of variety and salinity levels in relation to grain yield was recorded statistically significant (Table 2). The highest grain yield (4.60 g $plant^{-1}$) was observed in V_1 (GHB-538) with S_1 (2.0 dS m^{-1}) which was statistically at par to that of V_1 (GHB-538) X S_2 (4.0 dS m^{-1}) and V_3 (GHB-732) X S_1 (2.0 dS m^{-1}). The lowest grain yield (1.90 g $plant^{-1}$) was observed in V_4-GHB-905 under 8.0 dS m^{-1} (S_4) which indicated that variety GHB-905 is more sensitive to salinity level as compared to other varieties. Decreasing grain yield by increasing salinity of irrigation water may be due to more negative water potential of soil solution causing reduced water and nutrient uptake which consequently lowers leaf area development in turn reduced net assimilates. Shani and Dudley (2001) also reported the yield loss due to reduced photosynthesis, high energy and carbohydrate expenses in osmoregulation, and interference with cell function under saline conditions. Ghadiri *et al.* (2002) [7] also observed restricted water uptake by salinity due to the high osmatic potential in the soil and high concentration of specific ions that may cause physiological disorders in the plant tissues and reduce yields. Salinity stress delays the onset, reduces the rate and increases the dispersion of germination event which results in reduce the plant growth and finally crop yield (Ashraf and Foolad, 2005) [1]. Saqib *et al*. (2005) [20] found that salt stress caused excessive accumulation of Na^+ and Cl^- in tissue and ultimately reduction in crop yield of wheat. These results are in concordance with those of Khan *et al*. (2000) [10], Munns (2002) [14] and Makarana *et al.* (2017) [12] in pearl millet. The interaction effect of variety and salinity was found non-significant with respect to fodder yield at harvest.

Growth and yield attributes parameters

The different varietal effect was found significantly on growth and yield attributing characters *viz.,* plant height, ear head length, no. of total tillers $plant^{-1}$, no. of effective tillers $plant^{-1}$ and grain fodder ratio (Table 3). The highest plant height (96.67 cm) was observed with variety GHB-732 (V_3). The ear head length, no. of total tillers $plant^{-1}$, no. of effective tillers $plant^{-1}$ and grain fodder ratio were significantly the highest (20.21 cm, 3.22, 2.36 and 0.56) with variety GHB-538 (V_1), respectively. The effect of salt concentration was found on growth and yield attributing characters *viz*., plant height, ear head length, no. of total tillers $plant^{-1}$, no. of effective tillers $plant^{-1}$ and grain fodder ratio. The plant height (105.83 cm), ear head length (21.22 cm), no. of total tillers $plant^{-1}$ (3.49), no. of effective tillers $plant^{-1}$ (2.25) and grain fodder ratio (0.50) were significantly recorded the highest with salinity level S_1 (< 2 dS m^{-1}). The combine effect of variety and saline irrigation water found significant in the parameters like ear head length, no. of total tillers $plant^{-1}$, No. of effective tillers $plant^{-1}$ and grain fodder ratio were the highest (20.21 cm, 3.22, 2.36 and 0.56) observed with variety GHB-538 (V_1) at salinity level S_1 (< 2 dSm^{-1}). The interaction effect in grain fodder ratio was found non-significant. The concentration of soluble salts through their high osmotic pressure which might have an effect on plant growth by restricting the uptake of water by roots. Salinity can affect plant growth, because of high concentration of salts in the soil solution which interferes with the absorption of essential nutritional ions by plant. Russel (1973) [19] reported that high salt concentration resulted in stunted plant and yield can be reduced by over 20%, the leaves of the crop become dull colored. High salinity concentration which hampered the growth of ear head length and hindered the photosynthetic activity of plant as a result of plant exposed to deficiency of important minerals and food to survive. Singh *et al.* (1988) [21] noted that high exchangeable sodium percentage decreases dry matter yield, number of pods per plant, grain and fodder production and protein and oil content of soybean. Elfouly *et al.* (2002b) found that NaCl treatment in irrigation water had negative effect on dry weight of both shoot and roots. These growth attributes are also in accordance with the finding of Ashraf & Neilly (1987) [2], Nadaf *et al*. (2010) [15], Yakubu *et al*. (2010) [22] in pearl millet and Makarana *et al.* (2017) [12] in pearl millet.

Quality parameters

The test weight was significantly affected by various varieties of pearl millet (Table 8). The higher (0.98 g) test weight was observed with variety GHB-538. The protein content was not significantly affected by different varieties of pearl millet. The test weight was significantly affected by various salinity levels. The higher (1.01 g) test weight observed at salinity level S_1 (< 2 dS m^{-1}). The protein content was not significantly affected by different levels of salinity. The test weight was significantly affected by various variety and various salinity levels. The interaction of variety GHB-538 (V_1) with salinity level S_1 (< 2 dS m^{-1}) gave significantly higher (1.20 g) test weight (Table 9). The protein content was not significantly affected by different variety and different levels of salinity. This salt stress at grain filling stage can cause a decrease in the photosynthates mobilization to grains and thereby decreasing grain mass. The lowest test weight-

100 grain was observed in V_4-GHB-905 under 8.0 dS m^{-1} (S_4). These results are agreement with research work reported by Chopra and chopra (1993) [5], Ragab *et al.*, (2008) [17] and Makarana *et al.*, (2017) [12] in pearl millet.

Table 1: Effect of varieties and salinity on grain yield and fodder yield of pearl millet

Treatments	Grain yield (g plant^{-1})	Fodder yield (g plant^{-1})
Variety (V)		
V_1-GHB-538	4.03	7.21
V_2-GHB-744	3.26	7.19
V_3-GHB-732	3.68	7.14
V_4-GHB-905	2.81	7.30
V_5-GHB-558	3.24	6.91
S.Em.$\pm$	0.06	0.18
C.D. (P=0.05)	0.17	NS
Salinity (S) dS m^{-1}		
S_1:< 2.0 (tap water)	4.08	8.22
S_2: 4.0	3.73	7.58
S_3: 6.0	3.49	6.95
S_4: 8.0	2.33	5.85
S.Em.$\pm$	0.05	0.16
C.D. (P=0.05)	0.15	0.47
Vx S Interaction		
S.Em.$\pm$	0.12	0.37
C.D. (P=0.05)	0.35	NS
C.V.%	6.14	8.89

Table 2: Interaction effect of varieties and salinity on grain yield (g plant^{-1}) of pearl millet

	S_1 - < 2.0 dS m^{-1} (tap water)	S_2 - 4.0 dS m^{-1}	S_3 - 6.0 dS m^{-1}	S_4 - 8.0 dS m^{-1}	Mean
V_1-GHB-538	4.60	4.43	3.93	3.17	4.03
V_2-GHB-744	3.88	3.47	3.60	2.10	3.26
V_3-GHB-732	4.30	4.20	3.87	2.37	3.68
V_4-GHB-905	3.60	2.93	2.80	1.90	2.81
V_5-GHB-558	4.10	3.50	3.27	2.10	3.24
Mean	4.08	3.73	3.49	2.33	
S. Em. $\pm$	0.12		C.D. (P=0.05)	0.35	

Table 3: Effect of varieties and salinity on growth and yield attributing characters at harvest of pearl millet

Treatments	Yield Attributing characters				
	Plant height (cm)	Ear head length (cm)	No. of total tillers per plant	No. of effective tillers per plant	Grain: fodder ratio
Variety (V)					
V_1-GHB-538	94.38	20.21	3.22	2.36	0.56
V_2-GHB-744	76.83	15.84	2.50	1.55	0.45
V_3-GHB-732	96.67	17.54	2.60	1.65	0.51
V_4-GHB-905	81.50	14.83	2.45	1.32	0.38
V_5-GHB-558	88.25	14.88	2.49	1.45	0.47
S.Em. +	1.45	0.41	0.08	0.05	0.01
C.D. (P=0.05)	4.15	1.18	0.22	0.15	0.04
Salinity level (S) dS m^{-1}					
S_1 - < 2.0 (tap water)	105.83	21.22	3.49	2.25	0.50
S_2 - 4.0	94.33	17.42	2.96	1.83	0.49
S_3 - 6.0	82.67	14.62	2.36	1.45	0.51
S_4 - 8.0	67.27	13.38	1.79	1.14	0.41
S.Em. +	1.30	0.37	0.07	0.05	0.01
C.D. (P=0.05)	3.72	1.06	0.19	0.13	0.04
Vx S Interaction					
S.Em. +	2.91	0.83	0.15	0.10	0.03
C.D. (P=0.05)	8.31	2.36	0.44	0.30	NS
C.V.%	5.75	8.59	9.97	10.76	10.56

Table 4: Interaction effect of varieties and salinity on plant height (cm) of pearl millet

	S_1 - < 2.0 dS m^{-1} (tap water)	S_2 - 4.0 dS m^{-1}	S_3 - 6.0 dS m^{-1}	S_4 - 8.0 dS m^{-1}	Mean
V_1-GHB-538	112.83	106.33	91.00	67.33	94.38
V_2-GHB-744	96.67	81.67	71.00	58.00	76.83
V_3-GHB-732	109.00	100.67	93.00	84.00	96.67
V_4-GHB-905	105.67	90.00	74.33	56.00	81.50
V_5-GHB-558	105.00	93.00	84.00	71.00	88.25
Mean	105.83	94.33	82.67	67.27	
S.Em.$\pm$	2.91		C.D. (P=0.05)	8.31	

Table 5: Interaction effect of varieties and salinity on ear head length (cm) of pearl millet

	S_1 - < 2.0 dS m^{-1}(tap water)	S_2 - 4.0 dS m^{-1}	S_3 - 6.0 dS m^{-1}	S_4 - 8.0 dS m^{-1}	Mean
V_1-GHB-538	22.33	20.27	19.73	18.50	20.21
V_2-GHB-744	21.13	15.57	13.50	13.17	15.84
V_3-GHB-732	22.40	20.27	15.07	12.43	17.54
V_4-GHB-905	21.67	16.33	11.33	10.00	14.83
V_5-GHB-558	18.57	14.67	13.47	12.80	14.88
Mean	21.22	17.42	14.62	13.38	
S.Em.±	0.83		C.D. (P=0.05)	2.36	

Table 6: Interaction effect of varieties and salinity on total tillers per plant of pearl millet

	S_1 - < 2.0 dS m^{-1} (tap water)	S_2 - 4.0 dS m^{-1}	S_3 - 6.0 dS m^{-1}	S_4 - 8.0 dS m^{-1}	Mean
V_1-GHB-538	3.60	3.40	3.07	2.80	3.22
V_2-GHB-744	3.33	2.98	2.43	1.23	2.50
V_3-GHB-732	3.70	2.60	2.03	2.07	2.60
V_4-GHB-905	3.53	2.90	2.03	1.33	2.45
V_5-GHB-558	3.30	2.92	2.23	1.50	2.49
Mean	3.49	2.96	2.36	1.79	
S.Em.±	0.15		C.D. (P=0.05)	0.44	

Table 7: Interaction effect of varieties and salinity on number of effective tillers per plant of pearl millet

	S_1 - < 2.0 dS m^{-1} (tap water)	S_2 - 4.0 dS m^{-1}	S_3 - 6.0 dS m^{-1}	S_4 - 8.0 dS m^{-1}	Mean
V_1-GHB-538	2.90	2.77	1.97	1.80	2.36
V_2-GHB-744	2.33	1.62	1.27	1.00	1.55
V_3-GHB-732	2.27	1.83	1.32	1.20	1.65
V_4-GHB-905	1.87	1.30	1.33	0.77	1.32
V_5-GHB-558	1.87	1.65	1.35	0.93	1.45
Mean	2.25	1.83	1.45	1.14	
S.Em.±	0.10		C.D. (P=0.05)	0.30	

Table 8: Effect of varieties and salinity on quality parameters of pearl millet

Treatments	Quality parameters	
	Test weight-100 grain (g)	Protein content (%)
Variety (V)		
V_1-GHB-538	0.98	10.10
V_2-GHB-744	0.95	9.86
V_3-GHB-732	0.94	9.54
V_4-GHB-905	0.75	9.68
V_5-GHB-558	0.76	10.09
S.Em.±	0.02	0.23
C.D. (P=0.05)	0.05	NS
Salinity level (S) dS m^{-1}		
S_1 - < 2.0 (tap water)	1.01	10.30
S_2 - 4.0	0.98	9.83
S_3 - 6.0	0.79	9.63
S_4 - 8.0	0.74	9.65
S.Em.±	0.02	0.21
C.D. (P=0.05)	0.05	NS
Vx S Interaction		
S.Em.±	0.04	0.47
C.D. (P=0.05)	0.10	NS
C.V.%	6.97	8.19

Table 9: Interaction effect of varieties and salinity on 100 grain weight-test weight (g) of pearl millet

	S_1 - < 2.0 dS m^{-1} (tap water)	S_2 - 4.0 dS m^{-1}	S_3 - 6.0 dS m^{-1}	S_4 - 8.0 dS m^{-1}	Mean
V_1-GHB-538	1.20	1.09	0.87	0.83	0.98
V_2-GHB-744	1.13	1.15	0.76	0.72	0.95
V_3-GHB-732	1.10	1.04	0.83	0.77	0.94
V_4-GHB-905	0.83	0.78	0.73	0.68	0.75
V_5-GHB-558	0.82	0.78	0.75	0.70	0.76
Mean	1.01	0.98	0.79	0.74	
S.Em. ±	0.04		C.D. (P=0.05)	0.10	

Conclusion

On the basis of results, the pearl millet variety GHB-538 showed significantly higher values of yield (fodder and grain) and yield attributes (plant height, ear head length, total tillers $plant^{-1}$, effective tillers $plant^{-1}$ and grain fodder ratio) and quality parameters (test weight and protein content), over the salinity level. The pearl millet hybrid variety GHB-538 is found better up to EC 4 dS m^{-1} irrigation water. The tolerance order of pearl millet varieties to salinity in decreasing order of GHB-538 > GHB-732 > GHB-744 > GHB-558 > GHB-905 against salinity in silty clay soil.

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