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SHORT COMMUNICATION

EFFECT OF VARYING LEVELS OF SALINITY ON GROWTH, YIELD AND QUALITY OF FORAGE SORGHUM GENOTYPES

PUMMY KUMARI[1,*], S. K. PAHUJA[1], R. S. SHEORAN[1], SATYAWAN ARYA[1] AND U. N. JOSHI[2]

[1]Forage Section, Department of Genetics & Plant Breeding
CCS Haryana Agricultural University,
Hisar-125 004 (Haryana), India
(e-mail : pummy.choudhary84@gmail.com)

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SUMMARY

Exploiting genetic variability to identify salt tolerant genotype is one of the strategies used to overcome salinity. The experimental treatments included four NaCl salinity levels (0, 4, 8 and 12 dS/m) and 11 sorghum genotypes. The experimental design was completely randomized design with three replicates. The data were recorded on various morphological and quality traits. The analysis of variance (ANOVA) for treatments, genotypes and their interaction was found to be highly significant ($P<0.001$) with regard to all parameters. All parameters measured showed to have an inverse relationship with increase in NaCl salinity levels. Significant decrease in the fodder yield and its components was observed with the increased level of salinity. The per cent loss of green fodder yield (GFY) and dry fodder yield (DFY) was maximum in terms of percentage in EC 3 (12.0 dS/m) followed by EC 2 (8.0 dS/m) and EC 1 (4.0 dS/m). The sorghum genotypes were SSG 9, IS 3237 and HJ 541 for Cl^- dominating salinity. So, these genotypes can be useful as genetic resources for crossing programme for the development of sorghum cultivars with improved agronomic and quality traits under salt stress.

Key words : NaCl, salinity tolerance, sorghum genotypes, fodder, quality

Due to climate change, there is continuous increase in saline soils thus creating urgent need for enhancement of genetic stock for salinity tolerance. The effect of salinity on plant growth is a complex trait that involves osmotic stress, ion toxicity, mineral deficiencies, physiological and biochemical perturbations. Salinity creates the specific problem of ion toxicity, because a high concentration of sodium is injurious for the cells. The toxic effects of salt can occur at relatively low concentrations, depending on the plant species, so the homeostasis of sodium is important for the tolerance of organisms to salt stress. The plants that grow in saline soils have diverse ionic compositions and a range in concentrations of dissolved salts. Seed germination in salt affected soils is influenced by the total concentration of dissolved salt as well as by the type of salt involved. For sorghum, it has been observed that salt stress reduce leaf growth rate, leaf emergence rate, and overall shoot development. In Haryana, 49157 ha land is affected by salinity and 1,83,399 ha is affected by sodicity (CSSRI, 2011). So, keeping in view, the experiment was planned for genetic enhancement of sorghum genotypes under various salinity levels.

To study the effect of salinity for various morphological and quality traits 11 forage sorghum genotypes viz., COFS 29, SSG 59-3, SSG 9, HC 136, HC 308, HJ 541, S 437-1, S 490, S 540, IS 2389 and IS 3237, an experiment was conducted in the Physiology Area of CCS Haryana Agricultural University, Hisar during **kharif** 2011. The crop was raised in cemented plots (2 × 2 × 2 m) filled with sand soil irrigated with four different levels of artificially prepared saline water i. e. control C, EC_1, EC_2 and EC_3 having salt conc. 0.25, 4.0, 8.0 and 12.0 dS/m respectively (Table 1). The experiment was conducted in randomized block design with three replications.

In all the treatments, the data were recorded on five randomly taken plants for plant height (cm), leaf length (cm), leaf breadth (cm), stem girth (mm), number of leaves/plant, number of tillers/plant, green fodder yield (GFY), dry fodder yield (DFY), chlorophyll content (mg/g), HCN on fresh weight basis and crude protein (%) (CP%) and *in vitro* dry matter digestibility (%) (IVDMD%) on dry weight basis. The data obtained were subjected to ANOVA according to two factorial completely randomized designs using appropriate statistically software.

[2]Department of Biochemistry.

TABLE 1
Amount of salts used for artificial preparation of saline water

S. No.	Type of water	Desired EC dS/m	Total dissolved salts (TDS)	Na	Ca	Mg	Cl	SO_4
1.	C	0.25	-	-	-	-	-	-
2.	EC 1	4.0	50	25.0	6.25	18.75	35.0	15.0
3.	EC 2	8.0	105	52.5	13.13	39.37	73.5	31.5
4.	EC 3	12.0	152	76.0	19.0	57.0	106.4	45.6

Effect of Salinity on Morphological Traits

The results showed that fodder yield, quality and its component traits were significantly affected by salt concentrations. At different salt concentrations, different sorghum genotypes viz., COFS 29, S 490-1, S 540, IS 2389, SSG 59-3, HC 136, IS 3237, SSG 9, S 541, HC 308 and S 437-1 had performed differentially. Significant decrease in the fodder yield and its component traits was observed with the increased level of salinity. The per cent loss of GFY and DFY was maximum in terms of percentage in EC 3 (12.0 dS/m) followed by EC 2 (8.0 dSm^{-1}) and EC 1 (4.0 dS/m). On the basis of decrease in green and dry fodder yield under increasing level of salinity, genotypes IS 3237 and SSG 9 were found to be tolerant to salinity.

The morphological traits like plant height, number of leaves per plant, green fodder yield and dry fodder yield decreased under various levels of salinity. Differences among salt stress treatments were significant. A maximum 62 and 44 per cent reduction in plant height and number of leaves was observed in SSG 9 and SSG 59-3 genotypes, respectively, as compared to that of control (Table 2). There was a significant decrease in plant height, plant fresh weight and plant dry weight with increasing salinity. This decrease in growth might be due to too much Na^+ in the soil which result in delayed maturity of the crop (McConnell *et al*., 2008). Ali *et al.* (2014) reported that the increasing NaCl concentration affected seed germination, germination percentage, plumule length, radical length, fresh and dry weights of plumule and radical of both millet and sorghum. Because the large amount of salt found in soil affected by salinity makes it hard for the plant to absorb all the nutrients necessary for healthy growth of plant. As a result, most of the plants become weaker, and in some cases, end up dying.

Out of these genotypes, HC 308 had maximum reduction in fresh and dry weight and other agronomical traits as compared to control with varying levels of salinity. The impact of salt stress was also correlated with some morphological traits like reduction in fresh and dry weight (Chartzoulakis and Klapaki, 2000). The detrimental effects of NaCl on dry weight of shoot may be due to the direct effect on photosynthesis. NaCl caused reduction in photosynthesis through its adverse impact on gas exchange parameters such as stomatal conductance and photosynthetic rate. It was suggested that the formation of chlorocomplexes increased the toxic effects of salinity with a subsequent effect on shoot and root dry weight (Weggler-Beaton *et al.*, 2000). Salinity generates oxidative stress in plants and the surrounding environment, leading to growth inhibition and even plant death. Oxidative stress is the phenomenon implicated as one of the main causes of cellular damage in all organisms exposed to a wide variety of stress conditions (Liu *et al.*, 2006). Similar results were reported by Tigabu *et al.* (2012) that in NaCl salinity levels different genotypes responded differently to salt stress with respect to all parameters. The reduction was sharp at 8 and 16 dS/m NaCl salinity levels. This could be due to toxic effects of certain ions.

Effect of Salinity on Biochemical Parameters

As far as quality of forage sorghum is concerned it was observed that CP per cent and IVDMD per cent also decreased in some genotypes under salinity stress. HCN content was highest in COFS 29 (157 µg/g on fresh wt. basis) and lowest in HC 136 (25 µg/g) was observed, respectively, at the highest salinity levels. Crude protein and IVDMD percentages ranged from 6.73 (HJ 541) to 7.60 (S 540) and 37.0 (IS 3237) to 43.8 (SSG 9), respectively, at highest level of salinity. Similarly, protein and IVDMD percentages ranged 8.75 (COFS 29) to 10.28 (SSG 59-3) and 43.3 (HJ 541) to 53.2 (HC 308), respectively, in the control. Minimum crude protein under EC_3 was reported in S 437-1 and maximum was reported in SSG 9.

Crude protein and *in vitro* dry matter digestibility content decreased under all levels of salinity. For quality parameters, maximum reduction was observed in genotypes COFS 29 and IS 2389 as compared to control and minimum reduction was observed in genotypes SSG 9 and HJ 541, respectively. Such reduction in crude

TABLE 2
Effect of salinity levels on growth, yield and quality of forage sorghum genotypes

S. No.	Genotypes	Plant height (cm)	Leaf length (cm)	Leaf breadth (cm)	Stem girth (cm)	No. of leaves/ plant	No. of tillers/ plant	Green fodder yield (q/ha)	Dry fodder yield (q/ha)	Crude protein (%)	IVDMD (%)	HCN (µg/g) on fresh wt. basis
1.	COFS 29	139.8	80.4	3.1	2.9	14.4	6.6	154.5	51.1	8.0	44.4	98.5
2.	SSG59-3	184.6	73.4	4.1	3.2	16.3	3.5	215.2	48.1	8.9	43.2	20.5
3.	SSG 9	145.8	70.4	4.4	3.6	14.2	2.7	104.6	28.6	8.8	45.7	37.6
4.	HC 136	154.2	72.9	4.8	4.0	13.0	1.2	143.2	39.2	8.6	43.0	16.6
5.	HC 308	154.7	70.0	5.1	3.2	13.3	1.1	212.0	67.1	8.5	46.8	41.3
6.	HJ 541	166.0	70.1	4.7	3.5	14.8	1.9	260.7	110.3	8.2	40.9	26.6
7.	S 437-1	201.2	71.7	5.1	4.0	15.3	1.5	283.5	79.1	8.3	40.7	31.0
8.	S 490-1	218.9	76.9	5.1	4.4	12.7	1.3	256.4	70.7	8.4	41.6	88.5
9.	S 540	203.0	78.5	4.6	4.2	13.6	1.3	251.1	74.9	8.7	43.1	37.1
10.	IS 2389	192.1	71.7	3.3	3.5	12.0	1.0	149.2	47.6	8.2	45.5	21.3
11.	IS 3237	158.4	76.4	4.6	3.5	13.0	1.1	158.8	34.9	8.7	40.5	52.0
	S. Em±	2.99	3.0	0.9	0.1	0.0	0.3	0.1	3.0	1.7	0.0	0.5
	C. D. (P=0.05)	8.43	8.4	2.5	0.2	0.1	1.0	0.4	8.5	4.8	0.1	1.3
Treatments												
1.	0.25 d/Sm	195.4	79.0	5.3	4.2	15.7	2.2	280.1	81.2	9.3	46.7	26.9
2.	4 dS/m	185.8	75.1	4.4	3.6	15.1	2.1	207.8	62.5	8.8	43.8	35.6
3.	8 dS/m	167.5	72.2	4.2	3.5	12.3	2.2	170.8	52.4	8.6	42.6	0.1
4.	12 dS/m	149.0	69.2	3.9	3.3	12.3	1.8	137.4	41.0	7.2	39.8	63.4
	S. Em±	1.81	0.54	0.04	0.02	0.21	0.08	1.82	1.02	0.02	0.27	0.69
	C. D. (P=0.05)	5.09	1.53	0.11	0.05	0.58	0.22	5.12	2.87	0.07	0.76	1.94
	C. V. (%)	6.50	4.20	5.00	2.70	9.00	19.60	5.20	9.90	2.20	3.40	9.20

protein per cent may be due to failure of plants to make full utilization of nitrogen compounds, the accumulation of nitrogen compounds was more rapid than their utilization in building more cells and organs. These results are in agreement with those reported by several researchers (Petropoulo *et al.*, 2009; Olfa *et al.*, 2009). Lower level of protein in salt stressed plant parts may be due to decreased synthesis of protein as well as increased activities of protein hydrolyzing enzymes. Similarly, Kumari *et al.* (2016) reported that chlorophyll content in sorghum leaves decreased with the increase in the salinity levels in the soil.

The sorghum genotypes viz., IS 3237 and SSG 9 (for fodder) and HJ 541 and SSG 9 (for quality) can be useful genetic resources for crossing programme to develop cultivars with improved agronomic and quality traits under salt stress.

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