

Original Research Article

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Variation in Physiological Responses to Salt Stress in Sorghum [*Sorghum bicolor* L. Moench]

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ABSTRACT

Salt stress is one of the most important environmental stresses that adversely affect the crop growth and productivity worldwide. A pot experiment was conducted to examine the salt tolerance potential in different sorghum genotypes at CCS Haryana Agricultural University, Hisar (India) during *khariif* 2017. Sampling was made at fifty per cent flowering stage in response to different salinity levels (8 and 10 dS m⁻¹). Control pots were irrigated with canal water. Days to fifty per cent flowering generally showed an increasing trend in most of the sorghum genotypes. Reversibly, results also revealed that as the salt stress increased plant height (147.75 to 55.87 cm), no. of leaves plant⁻¹ (11.60 to 5.92), green leaf area (1374.03 to 499.41 cm² plant⁻¹), total fresh biomass (110.47 to 37.69 g), total dry weight (28.92 to 7.05 g) showed declining trend. Similarly, relative water content (RWC) (91.64 to 44.01%), total chlorophyll content (1.88 to 0.88 mg g⁻¹) and chlorophyll content (SPAD units) were also decreased with the increasing levels of salt stress. Ionic contents like Na⁺ enhanced (34.88 to 48.69 mg g⁻¹) with the increment of salt stress. However, K⁺ (36.53 to 15.01 mg g⁻¹) and Ca²⁺ (0.65 to 0.25 mg g⁻¹) followed the reverse trend. Sorghum genotypes *viz.* SPH 1798, SPH 1858 SS, SPH 1892, SPH 1893, SPH 1895, SPH 2458, SPV 2525, SPV 2527, SPV 2531, CSV 19SS, CSV 24SS, HJ 541, SSG 59-3 and HC 308 performed better under salt stress.

Keywords

Salt stress, 50% flowering, ionic content, *Sorghum bicolor* L.

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Introduction

Salt stress is one of the major constrain that inadequately affect the crop growth and productivity worldwide (Devi *et al.*, 2018). Generally, high yielding genotypes even did not perform better under salinity. Hence, it's the need of hour to screen and find out the

suitable salt tolerant genotypes that can achieve the productivity goal well under salt stress conditions.

In India 6.73 mha of the land is salt affected out of which 3.77 and 2.96 mha are affected by sodicity and salinity (Ashwani *et al.*, 2016). Saline area is continuously increasing

throughout the world. High salt concentrations in the soil cause reduction in plant growth through osmotic disturbance resulting into inhibition of water uptake by roots (Khan *et al.*, 2012). Physiological responses of salt stress are relatively intricate and ultimately lead to metabolic disturbance that finally causes economic yield loss.

It is a complex phenomenon to study the salt stress effects on plant growth and physiological mechanism is also involved to confer the tolerance to salt stress at special growth stages (Dashti *et al.*, 2009).

Osmotic and ionic disturbance occurs with the onset of salt stress (Ahmed *et al.*, 2013). Different physiological parameters like total biomass production, plant water status, chlorophyll index and ionic status are usually assessed under salt stress over their respective control (Sameera, 2014).

Sorghum is the world's fifth most important cereal crop and has economic importance for their dual purpose *i.e.* food and fodder. Sorghum is considered as moderately salt tolerant crop and can be grown in arid and semi-arid regions where salinity is the major problem (Roy *et al.*, 2014; Manish *et al.*, 2019). Its salt tolerance potential can also be exploited for reclamation of saline soils.

Therefore, this attempt was made to investigate the response of twenty sorghum genotypes for salt stress based on physiological traits. Sorghum [*Sorghum bicolor* (L.) Moench] being a resilient dryland cereal crop with wide adaptation having high water, nutrient, and radiation use efficiencies is really expected to enhance food, feed, fodder, and fuel security for the world (Rao *et al.*, 2016). Therefore, this experiment was conducted to investigate the response of twenty sorghum genotypes for salt stress with respect to physiological studies.

Materials and Methods

Twenty sorghum genotypes [SPH 1798, SPH 1858 (SS), SPH 1892, SPH 1893, SPH 1895, SPH 2324, SPH 2458, SPV 2462, SPV 2524, SPV 2525, SPV 2526, SPV 2527, SPV 2530, SPV 2531, CSV 19SS (C), CSH 24 SS (C), HJ 541, HJ 513, SSG 59-3 and HC 308] were grown under screen house conditions of the Department of Botany and Plant Physiology, CCS Haryana Agricultural university, Hisar, India. The two factor experiment (salinity levels and genotypes) was conducted in CRD with three replicates during rainy (*kharif*) season of 2017.

All the pots were saturated with desired levels of salt (8 and 10 dS m⁻¹) and normal water (control). Each pot contains 10 kg of dune sand (*Typic torrismaments*). Standard agronomic practices were followed and crop was monitored every day and data was recorded for days to 50 % flowering, plant height, no of leaves plant⁻¹, green leaf area plant⁻¹, total fresh biomass plant⁻¹, total dry biomass plant⁻¹ at 50 % flowering stage. Total dry weight was measured from the oven dried samples (60°C) and leaf area (cm² plant⁻¹) with the help of leaf area meter (Model LI 3000, LICOR Ltd., Nebraska, USA). Relative water content (RWC %) was estimated by using the method of Weatherly (1950):

$$\text{RWC (\%)} = \left(\frac{\text{Fresh weight} - \text{Dry weight}}{\text{Turgid weight} - \text{Dry weight}} \right) \times 100$$

Sawhney and Singh (2002) method was used to estimate the total chlorophyll content (mg g⁻¹ FW) and chlorophyll content was also determined by SPAD 502 plus instrument by measuring the absorbance of the leaf in two wavelength regions (Blue 400-500nm and Red 600-700nm). Chlorophyll stability index (CSI) was calculated by the formula given by Sairam *et al.*, (1997):

$$CSI (\%) = \left(\frac{\text{Total chlorophyll under stress}}{\text{Total chlorophyll under control}} \right) \times 100$$

Standardized methods given in USDA, Handbook (1954) were used to estimate the ionic contents *i.e.* sodium (Na), potassium (K) using flame photometer (Model Elico, New Delhi) and expressed as mg g⁻¹ DW and Ca²⁺ (%) content in the digested material were estimated by EDTA titration.

Statistical analysis

The data was analyzed statistically for ANOVA using complete randomized design (CRD) by using OPSTAT programme (Sheoran *et. al.*, 1998). Treatments were compared with CD values at 5% level of significance.

Results and Discussion

Statistical analysis attributed the significant differences between sorghum genotypes for all the physiological traits. Days to 50%

flowering increased with the increasing levels of salinity in most of the sorghum genotypes (Fig. 1A). However, in three local varieties *i.e.* SSG 59-3, HJ 513 and HJ 541 declining trend was observed. Maximum days were noticed in SPH 1798 (123), CSH 24SS (C) (123) followed by SPV 2531 (122) and minimum in SSG 59-3 (99) at 10 dS m⁻¹ of salinity. Plant height (cm) decreased with increasing levels of salinity from control to 10 dS m⁻¹ (Fig. 1B). Same trend was noticed in no. of leaves (Fig. 1C), green leaf area (Fig 1D), total biomass (Fig. 2A) and total dry weight (Fig. 2B) in all the genotypes.

The value of green leaf area was ranged from 1374.03 to 499.41 cm² plant⁻¹. Maximum per cent decline in total biomass (g plant⁻¹) was noticed in HJ 541 (71.48) and minimum in SPV 2527 (1.21), whereas highest per cent decline in total dry biomass (g plant⁻¹) was observed in HJ 541 (75.53) and lowest in SPV 2527 (2.96) at 8 dS m⁻¹ of salinity over their respective control.

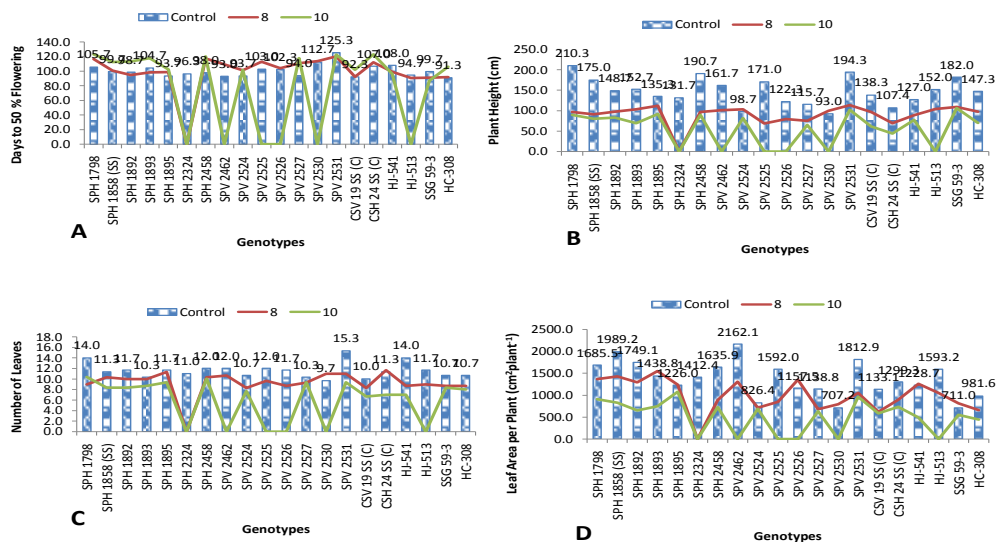


Fig.1 Effect of different salt levels on days to 50% flowering (A), plant height (B), number of leaves (C) and leaf area (D) of sorghum genotypes at 50 per cent flowering

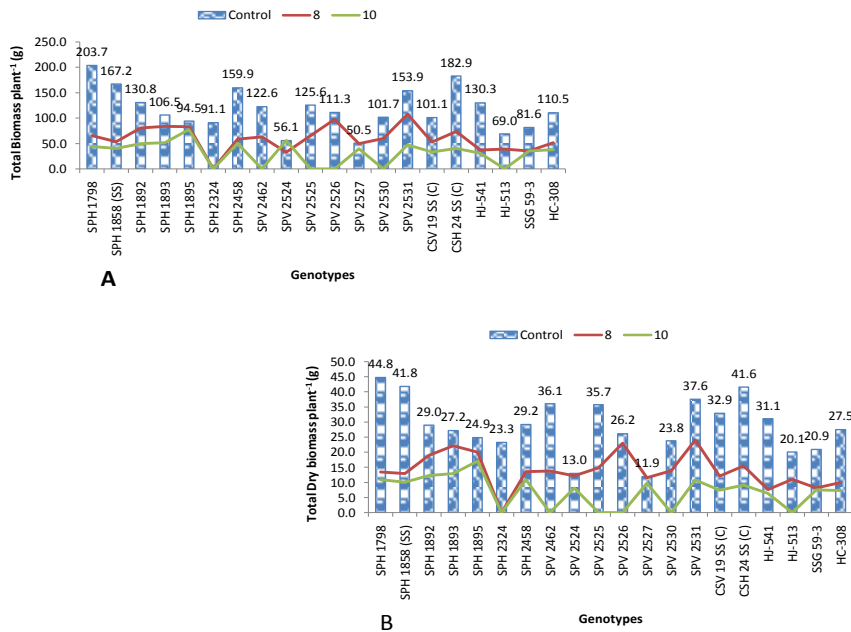


Fig.2 Effect of different salt levels on total biomass plant⁻¹(A) and total dry biomass plant⁻¹ (B) of sorghum genotypes at 50 per cent flowering

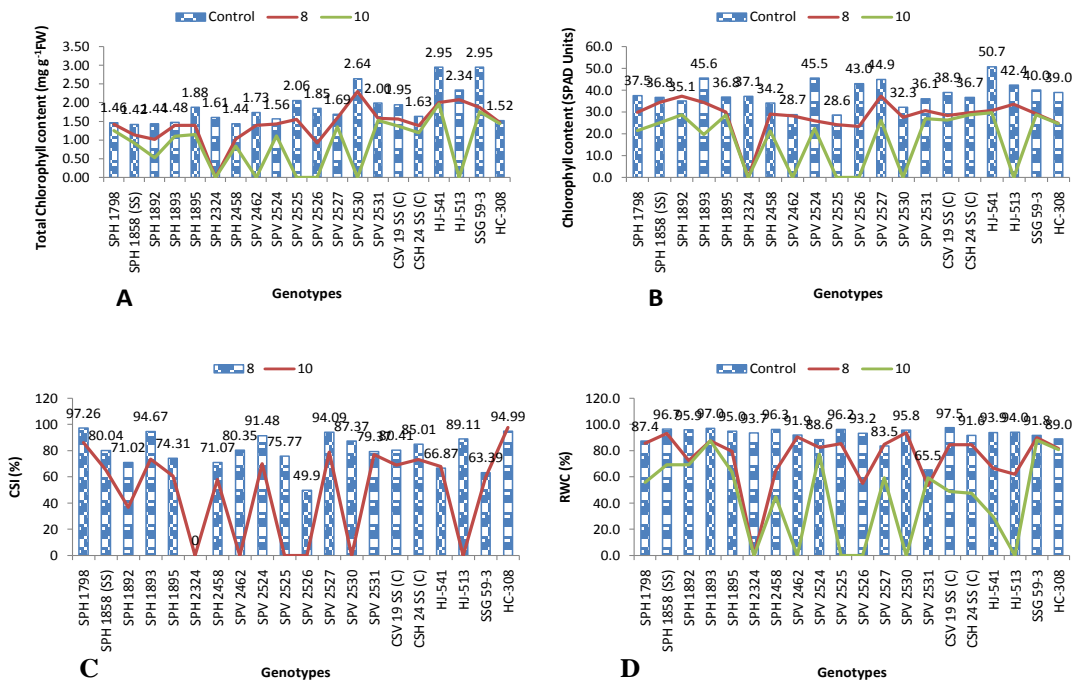


Fig.3 Effect of different salt levels on total chlorophyll content (A), total chlorophyll content (SPAD units) (B) and RWC (C) of sorghum genotypes at 50 per cent flowering

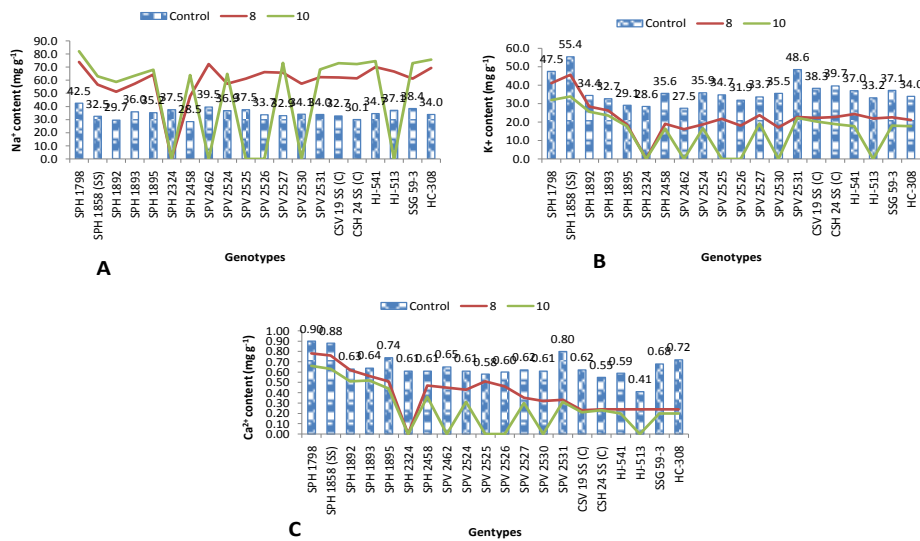


Fig.4 Effect of different salt levels on Na⁺ (A), K⁺ (B) and Ca²⁺ (C) content of sorghum genotypes at 50 per cent flowering

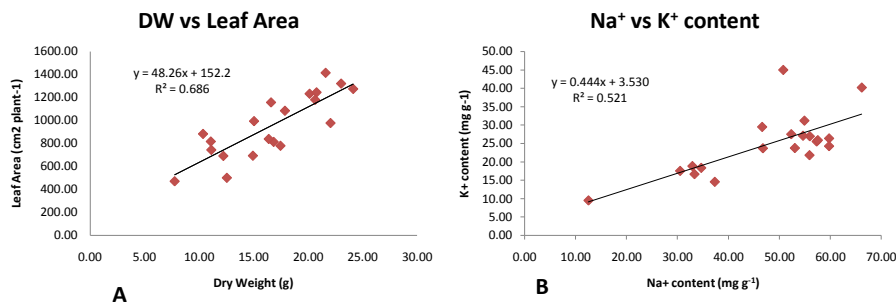


Fig.5 Correlation between dry weight, leaf area (A), chlorophyll content (B) and Na⁺, K⁺ content (C) of sorghum genotypes at 50 per cent flowering

Total chlorophyll content, chlorophyll content (SPAD units) and relative water content (%) (Fig. 3 A, B, D) also showed declining trend with the every increment of salinity in all the genotypes. CSI is an indication of salt tolerance capability of genotypes (Fig. 3 C). A high CSI value indicates that the salt stress did not have effect on chlorophyll content to a large extent and help in the survival of the genotype. The mean value of chlorophyll stability index was 76.32% at 8 and 48.79% at 10 dS m⁻¹ of salinity.

A slight increase in Na⁺ content (mg plant⁻¹) was observed with the increasing levels of salinity (Fig. 4A). Among the genotypes, maximum Na⁺ content was observed in SPH 1798 (82.04) followed by HC 308 (75.74) at 10 dS m⁻¹ of salinity.

Declining trend was noticed in K⁺ content (mg plant⁻¹) with the increasing levels of salinity *i.e.* from control to 10 d S m⁻¹ of salinity (Fig. 4B). Maximum K⁺ content was observed in CSV 1858 (33.90) followed by

SPH 1798 (32.03) sorghum genotypes at 10 dS m⁻¹ of salinity. Same trend was observed in Ca²⁺ content (mg plant⁻¹) and maximum Ca²⁺ content was estimated in SPH 1798 (0.66) followed by SPH 1858 SS (0.63) at 10 dS m⁻¹ of salinity (Fig. 4C).

Sorghum is moderately salt tolerant crop and experimental observation under salt stress showed declining growth and days to 50 % flowering varied in different genotypes. This decline in growth of plants was accompanied by decrease in water status, chlorophyll content, K⁺ and Ca²⁺ whereas Na⁺ content increased with the augmentation of salt stress (Dashti *et al.*, 2009, Jangra *et al.*, 2019).

A close relationship was noticed between dry weight and leaf area and in Na⁺ and K⁺ content (Fig. 5 A, B). In nutshell, progressive decrease in growth, plant height, leaf area, fresh biomass, dry biomass, plant water status and chlorophyll content of sorghum genotypes was observed with the increment of salinity.

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References

Ahmed, I.M., H. Dai, W. Zheng, F. Cao, G. Zhang, D. Sun and Wu F. 2013. Genotypic differences in physiological characteristics in the tolerance to drought and salinity combined stress between Tibetan wild and cultivated barley. *Plant Physiol. Biochem.* 63: 49-60.

Dashti, A., A.A. Khan and Collins J.C. 2009. Effects of salinity on growth, ionic relations and solute content of *Sorghum bicolor* (L.) Moench. *J. Plant Nutri.* 32: 1219-1236.

Devi, S., A.S. Nandwal, R.N. Arora, N. Kumar, S.K. Sharma and Bisht S.S. 2018. Water relations, quantum yield of PS-II, antioxidative enzymes, membrane integrity and ionic contents are indices of salinity stress tolerance in *Avena sativa* L. *Int. J. Nat. Sci. Res.* 1(1):1-17.

Jangra, M., S. Devi, N. Kumar, Satpal and Goyal V. 2019. Effect of salicylic acid on growth and plant water status of sorghum genotype under salt stress. *Int. J. Chemical Studies.* 7(2): 1180-84.

Khan, N.A. G. Habib, M. Altaf-ur-Rehman Suleman and G. Ullah. 2012. Evaluation of tree leaves as a crude protein and energy supplement to the low quality diets of dairy goats. In: *Proc. 1st Asia Dairy Goat*, Kuala Lumpur: 88-90.

Kumar, A., A. Kumar, C. Lata and Kumar S. 2016. Ecophysiological responses of *Aelurops lagopoides* (grass halophyte) and *Suaeda nudiflora* (non-grass halophyte) under individual and interactive sodic and salt stress. *South Afri. J. Bot.* 105: 36-44.

Rao, P. Srinivas, K.S. Vinutha, G.S. Anil Kumar, T. Chiranjeevi, A. Uma, P. Ankaj Lal, R. S. Prakasham, H.P. Singh, R. Sreenivasa Rao, Surinder Chopra and Jose Shibu. 2016. Sorghum: A Multipurpose Bioenergy Crop. In: *Sorghum: State of the Art and Future Perspectives*, American Society of Agronomy and Crop Science Society of America, Inc. doi:10.2134/agronmonogr58.2014.0074

Roy, S.J., S. Negrao and Tester M. 2014. Salt resistant crop plants. *Curr. Opin. Biotechnol.* 26: 115-124.

Sairam, R.K., P.S. Deshmukh, and Shukla

- D.S. 1997. Tolerance of drought and temperature stress in relation to increased antioxidant enzyme activity in wheat. *J. Agronomy Crop Sci.* 178: 171–178.
- Sameera, O.B. 2014. Physiological parameters of salt tolerance during germination and seedling growth of *Sorghum bicolor* cultivars of the same subtropical origin. *Saudi J. Biol. Sci.* 21: 300-304.
- Sawhney, V. and Singh D. P. 2002. Effect of chemical desiccation at the post anthesis stage on some physiological and biochemical change in flag leaf of contrasting wheat genotypes. *Field Crop Res.* 77: 1-6.
- Sheoran, O. P., Tonk, D. S., Kaushik L. S., Hasija, R. C. and Pannu, R. S. 1998 : Statistical Software Package for Agricultural Research Workers. Recent Advances in information theory, Statistics & Computer Applications by D.S. Hooda & R.C. Hasija, Department of Mathematics Statistics, CCS HAU, Hisar (139-143).
- USDA Handbook. Diagnosis and Improvement of Saline and Alkali Soils, No. 60. Oxford and IBH Publ. Co. New Delhi, 1954.
- Weatherley, P.E. 1950. Studies on the water relations of the cotton plant I, The field measurement of water deficit in leaves. *New Phytol.* 40: 81-97.

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