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PHYSIOLOGICAL VARIABILITY OF SORGHUM [*SORGHUM BICOLOR* (L.) MOENCH] UNDER SALT STRESS

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SUMMARY

Sorghum is a major crop of the world, and its high economic value is due to its use of all plants parts for different purposes. It is moderately salt tolerant crop, more than maize and less than barley. Hence, its salt tolerance potential can be exploited for reclamation of saline soils. The study was conducted to evaluate the effect of salt stress on physiological maturity, affecting the economic yield of sorghum genotypes. To meet the objective, twenty one (SPH 1798, SPH1825, SPH 1858 (SS), SPH 1859, SPH 1860, SPH 1861, SPH 1862, SPV 2324, SPV 2456, SPV 2457, SPV 2458, SPV 2459, SPV 2460, SPV 2461, SPV 2462, CSH 22 SS (C), CSV 19 SS (C), CSV 24 SS (C), SSG 59-3, HJ-513 and HJ-541) sorghum genotypes were chosen and the crop was raised in plastic pots filled with dune sand saturated with two levels of salinity (8 and 10 dS/m) in screen house. Normal irrigated pots served as control. Physiological observation were recorded at different time intervals, but here the results obtained at physiological maturity *viz.* plant height, no. of leaves, total biomass, total dry weight and grain yield etc will be discussed. Overall, we found that 10 dS/m of salinity was more injurious to sorghum genotypes as only few could survive at this level and couldn't yield significantly than 8 dS/m of salinity. At 8 dS/m of salinity, decreasing trend was observed for plant height, no. of leaves, total biomass, total dry weight and grain yield over control. The sorghum genotypes *viz.* SPH 1859, SPH 1861, SPV 2457, SPV 2461, SPV 2462 and HJ 541 survived and performed better up to physiological maturity stage at 8 dS/m of salinity level. Their better performance can be attributed due to more green leaf area (sq. cm/plant), total biomass (g) and total dry weight (g) at physiological maturity. Seed setting was observed in SPH 1859, SPH 1861, SPV 2457, SPV 2461, SPV 2462 and HJ 541sorghum genotypes at 8 dS m^{-1} of salinity. However, only two genotypes *i.e.* SPV 2457 and CSH 22SS (C) set seeds at 10 dS m^{-1} of salinity.

Key words : Salt stress, sorghum, physiological maturity

Salinity is one of the major environmental stresses limiting plant growth and productivity (Munns and Tester, 2008). In India, about 6.73 million hectare of the cultivated land is affected by salinity and sodicity. In Haryana alone, it is 0.50 million ha area under salinity. It is estimated that every day between 2,000 and 4,000 ha of irrigated land in arid and semi-arid areas across the globe is degraded by salinity and become unsuitable for crop production (Shabala, 2013; Qadir *et al.,* 2014). Excess salt in the soil may adversely affect plant growth through osmotic disturbance resulting into inhibition of water uptake by roots or specific ion effects (Khan *et al*., 2012). The physiological, biochemical and molecular responses of salinity are quite complex in plant systems, that causes increased ion-toxicity, osmotic stress, nutritional acquisition, homeostasis, impaired stomatal conductance, increased cell-turgor loss, reduction in leaf water potential, altered physiological/ biochemical processes and elevated ROS-caused oxidative stress (Khan *et al.,* 2014, 2015). All these effects ultimately lead to disturbed metabolic processes that finally causes economic yield loses.

Sorghum (*Sorghum bicolor*) also known as great millet or jowari is a grass species cultivated for fodder, grain and ethanol production. In India, sorghum is popularly known as "Jowar" and is one of the important food and fodder cereal crops. Sorghum is the world's fifth most important cereal crop after rice, wheat, maize and barley. It is the staple food in the drier part of Africa, China and India. The largest growers of sorghum are India, America and Nigeria. World covers 39.6 million hectare area, producing 57.79 million tonnes with a productivity of 1404 kg/ha. Average yields are very high in the American sub continent, while they are low in India (Maikasuwa and Ala, 2013). India contributes 9.45% of the world's sorghum production with 5.82 million ha area and 5.39 million tonnes of total production (Gite *et al.*, 2015). In Haryana, sorghum covers 72,000 ha area with average grain yield of 550 kg/ha, annual grain production of 40 thousand tonnes (Anonymous, 2016) and 76.7% area covered under irrigation (Agriculture Statistics at a Glance, 2015). The advantage of the sorghum crop is that, it can be cultivated in both *kharif* and *rabi* season. It grows in clumps that may reach over 4 m high with small grain size (2 to 4 mm in diameter). Sorghum is very nutritious and is one of the most important staple foods both for animals and humans. The plant parts can be used as green fodder, dry stover and grain.

MATERIALS AND METHODS

Twenty one selected sorghum genotypes (SPH 1798, SPH1825, SPH 1858 (SS), SPH 1859, SPH 1860, SPH 1861, SPH 1862, SPV 2324, SPV 2456, SPV 2457, SPV 2458, SPV 2459, SPV 2460, SPV 2461, SPV 2462, CSH 22 SS (C), CSV 19 SS (C), CSV 24 SS (C), SSG 59-3, HJ-513 and HJ-541) were raised in the screen house of Department of Botany and Plant Physiology, CCS Haryana Agricultural University, Hisar during the year 2016 in plastic pots filled (three replications)with sand saturated with two levels of salinity (8 and 10 dS m^{-1}) and for control, with normal soil. Each pot was filled with 10 Kg of sandy dune soils (*Typic torrispaments*). Desired levels of salinity were maintained by irrigating the soil with saline water (mixed salinity), and for control with canal water. Crop was raised with standard recommended agronomic practices. Crop was monitored on daily basis and data was recorded for plant height, no. of leaves/plant, total biomass/plant,

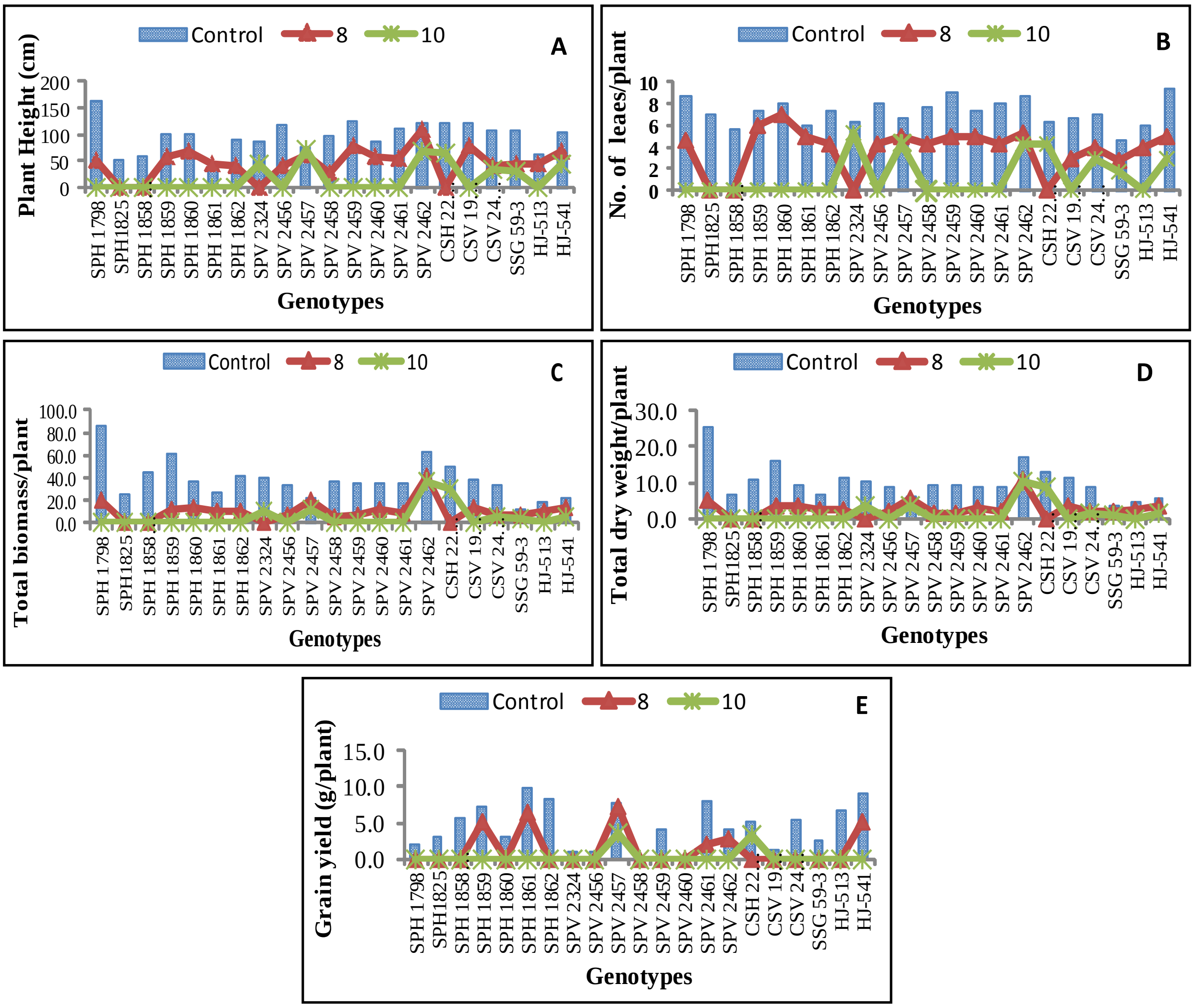

Fig. 1. Effect of salt stress (dS m-1) on plant height (A), no. of leaves (B), total biomass/plant (C), total dry weight/plant (D) and Grain yield (E) of sorghum genotypes at different salinity levels.

total dry weight/plant, grain yield at physiological maturity stage. For biomass, only the above ground plant parts were taken into account. Data obtained was analysed using the OPSTAT software and with Biplot analysis for analysis of variance and grouping the genotypes based on traits observed and its contribution to yield of the crop (Sheoran *et. al*., 1998).

RESULTS AND DISCUSSIONS

Analysis of variance exhibited significant differences among the sorghum genotypes for all the parameters in response to the two levels of salt stress. Figure 1 showed the effect of salt stress on plant height (A), no. of leaves (B), total biomass/plant (C), total dry weight/plant (D) and Grain yield (E) of sorghum genotypes at both levels. Positive correlation was seen that with increase in plant height there was increase in grain yield. Only one variety SPH 1861 was outlier as it showed highest grain yield with plant height of less than 60 cm whereas CSH 22 SS (C), CSV 19 SS (C), SPV 2459 and SPV 2462 showed reduced yield with increased plant height. HJ-541 gave best yield at around 110 cm of plant height. The best performance under low plant height may be due to high translocation efficiency of source to sink.

Significant differential response of no. of leaves per plant was observed under different levels of salinity. The no. of leaves reduced to a great extent to the tune of zero at 10 dS/m of salt stress and lesser at 8 dS m^{-1} of salt stress. Reduction in values was ranged from 7.22 to 3.76 for no. of leaves. HJ 541 gave best yield with 10 numbers of leaves followed by SPV 2459, SPV 2462 and SPH 1798. The best performance with high number of leaves is due to more availability of source that is finally being converted to yield, also with better translocation efficiency.

Reduction in total biomass/plant ranged from 37.99 to 10.52 under different treatments. On comparison of means it was found that the total biomass/plant was negligible at 10 dS/m of salinity whereas some genotypes performed relatively far better at 8 dS m^{-1} of salinity. The genotypes showing higher yield with less decreased biomass over control, like SPV 2459 and SPV 2462 had higher plant height and more no of leaves as compared to other genotypes. Reduction in total grain yield /plant ranged from 4.59 to 1.38 under different treatments whereas total dry weight/plant from 10.19 to 2.74 g/plant. At 10 dS/m of salt stress, only two genotypes i.e. SPV 2457 and CSH 22SS (C) could show seed setting whereas other genotypes couldn't survive (Fig. 2 & Fig. 3).

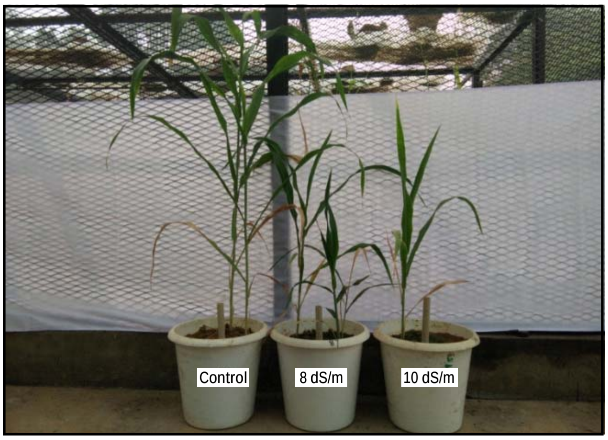

Fig. 2. SPV 2457

Fig. 3. CSH 22SS (C)

The possible reason for reduction in plant height in saline conditions is the changed osmotic potential of the soil, due more accumulation of sodium ions in the plant cells which cause toxicity. Similar kind of results are also been reported in *Phaseolus* species by Jenette *et al*, 2002. The decreased shoot length is the result of increased water potential (more negative) due to high concentration of salts that are ultimately affecting the physiological functions that causes yield losses. These results clearly indicates that threshold level of sorghum to salinity is 8 dS/m and further it is deleterious and challenge is to breed the sorghum genotypes that can tolerate salt stress of more than 8 dS m^{-1} as the saline areas of Haryana are having more than this level of salinity.

CONCLUSION

Based on the results, it can be concluded that at 8 dS/m of salinity level, two sorghum hybrids (SPH 1859, SPH 1861), three varieties (SPV 2457, SPV 2461, SPV 2462) and one local check–single cut forage sorghum variety (HJ 541) survived, performed better up to physiological maturity and also set seeds. Their better performance can be attributed due to more green leaf area, total biomass and total dry weight at physiological maturity. 10 dS/m of salinity level was more injurious to sorghum genotypes as only few could survive at this level and couldn't yield significantly than 8 dS/m of salinity. However, only two genotypes *i. e.* SPV 2457 and CSH 22 SS (C) could set the seeds at 10 dS m^{-1} of salinity.

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REFERENCES

Agriculture Statistics at a Glance 2015 : Ministry of Agriculture and Farmers Welfare, Government of India, Krishi Bhawan New Delhi-110001, pp: 95.

Anonymous 2016 : All-India Area, Production and Yield along with coverage under Irrigation. *Agricultural Statistics at a Glance 2016.*

Gite, A. G. Kute, N. S. and Patil, V. R. 2015. Heterosis studies for yield and component traits in rabi sorghum [*Sorghum bicolor* (L.) Moench]. *J. Global Biosci.* **4** : 3207-3219.

Khan, N. A. Habib, G. Altaf-ur-Rehman. Suleman, M. Ullah, G. 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.

Khan, M. I. R. Asgher, M. and Khan, N. A. 2014 : Alleviation of salt-induced photosynthesis and growth inhibition by salicylic acid involves glycine betaine and ethylene in mungbean (*Vigna radiata* L.). *Plant Physiol. Biochem.* **80** : 67-74.

Khan, M. I. R. Fatma, M. Per, T. S. Anjum, N. A. and Khan, N. A. 2015 : Salicylic acid-induced abiotic stress tolerance and underlying mechanisms in plants. *Front. Plant Sci.* doi:10.3389/fpls.2015.00462.

Jenette, S. Craig, R. and Lynch, J. P. 2002 : Salinity tolerance of *Phaseolus* species during germination and early seedling growth. *Crop Sci.* **42** : 1584-1594.

Maikasuwa, M. A. and Ala, A. L. 2013 : Trend analysis of area and productivity of Sorghum in Sokoto state, Nigeria. *Exp. Scientific J.* **9** : 1857-7881.

Munns, R. and Tester, M. 2008 : Mechnaism of salinity tolerance. *Ann. Rev.Plant Biol.* **59** : 651-681.

Qadir, M. Quillérou, E. Nangia, V. Murtaza, G. Singh, M. Thomas, R. J. Drechsel, P. and Noble, A. D. 2014 : Economics of salt?induced land degradation and restoration. *Nat. Reso. Forum.* **38** : 282-295.

Shabala, S. 2013 : Learning from halophytes: physiological basis and strategies to improve abiotic stress tolerance in crops. *Ann. Bot.* **112** : 1209-1221.

Sheoran, O. P., D. S. Tonk, L. S. Kaushik, R. C. Hasija, and R. S. Pannu. 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).