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Influence of Soil Salinity on Growth, Yield Attributes and Yield of Sorghum

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ABSTRACT

A pot culture experiment was conducted to study the performance of sorghum cultivars in saline soils during *rabi* 2015-2016 at Department of Soil Science and Agricultural Chemistry, Agricultural College, Bapatla. Soils of different salinity (1.5, 5, 8 and 12 dS m^{-1} of ECe) collected from Uppugunduru region were tested using three cultivars (Hytech, Laxmi and Mahalaxmi) in completely randomized design with factorial concept replicating thrice. The salinity levels, cultivars and their interaction significantly influenced the percent germination, plant height, number of days to flowering and maturity, drymatter at flowering, yield attributes and yield (grain and stover). Considerable reduction in germination per cent, plant height, yield attributes and yield was observed at the maximum EC tested (12 dS m^{-1}). The flowering and maturity were delayed at maximum salinity in all the cultivars compared to the lowest salinity of 1.5 dS m^{-1}. The maximum grain (21.93 g pot^{-1}) and stover (48.23 g pot^{-1}) yield was observed in treatment combination 1.5 dS m^{-1} x Hytech.

Key words: *Drymatter producton, Percent germination, Plant height.*

Soil salinity is one of the major abiotic stresses affecting germination, crop growth and productivity (Sairam *et al*., 2002). The detrimental effects of high salinity on plants may be expected as decreased productivity or even death of plants. Many plants have developed mechanisms either to exclude salt from their cells or to tolerate within the cells (Asishkumar et al., 2005). For the marginal Indian farmer having limited resources, reclamation of saline soils is too expensive and time taking. Thus it is economical to identify the extent of salt tolerance in crop varieties which can be grown successfully under saline environment. Among agricultural crops, sorghum (*Sorghum bicolor* L. Moench) is the fifth most important cereal crop of the world and third most important source of staple food after rice and wheat for millions of people in India. It is naturally drought and salt-tolerant and can produce high biomass yields with low input. It can thrive in places that do not support corn, sugarcane and other food crops. Keeping this in view the present study was conducted to check the performance of three commonly grown sorghum cultivars at different salinity levels.

MATERIAL AND METHODS

The experiment was conducted at Green House, Dept of Soil Science and Agricultural Chemistry, Agricultural College, Bapatla, using soils collected from Uppugunduru region, which were similar in all characteristics but variable in electrical conductivity of saturation extract (1.5, 5, 8 and 12 dS m^{-1} of ECe). Three sorghum cultivars (Hytech, Laxmi and Mahalaxmi) were tested in a completely randomized design with factorial concept replicating thrice. Recommended agronomic practices and plant protection measures were followed during crop growth. Per cent germination, plant height (cm) at flowering and harvest, days to 50% flowering and maturity, drymatter production at flowering stage, length of earhead, number of grains $earhead^{-1}$, grain weight $earhead^{-1}$, hundred grain weight (g), grain yield and stover yield (g pot^{-1}) were recorded.

RESULTS AND DISCUSSION

Growth parameters

Per cent Germination

The per cent germination decreased with increasing salt concentration and degree of reduction varied with the salinity levels. The data revealed a significant influence of salinity levels, cultivars and their interaction on per cent germination of sorghum (Table1). As the salinity increased from 1.5 to 12 dS m^{-1} (S_1 to S_4) the per cent germination decreased significantly from 96.68 to 51.29, with the highest and the lowest recoded at 1.5 and 12 dS m^{-1}, respectively. Perusal of the data indicated that, the per cent germination decreased by 46.94 per cent at the highest ECe tested. The decline in per cent germination was significant at each level of salinity and is conformity with the previous findings of Maliwal and Palival, (2002) and Ali *et al.* (2014). Among cultivars, the per cent germination was maximum in Hytech (77.73) followed by Laxmi (75.65) and both recorded significantly higher than Mahalaxmi (V_3). The interaction between two factors (S X V) was significant. The maximum percent germination (97.23) was recorded by the treatment combination S_1V_1 (1.5 dS m^{-1} X Hytech), which was on par with the treatment combinations S_1V_2 (96.96) and S_1V_3 (95.84) and were significant over rest of treatment combinations. The lowest value of 50.18 per cent was recorded by the combination S_4V_3. Above data indicated a decrease in per cent germination and seedling emergence with enhanced salinity. This might be due to high salt stress which can disturb osmotic and ionic homeostasis that limit the availability of water to the seeds and ultimately cause slow and poor germination. Marked difference in tolerance of the sorghum genotypes against salinity stress was also observed by Tigabu *et al.* (2013).

Plant Height (cm)

Plant height (Table 1) was significantly affected by salinity levels in all sorghum cultivars and their interaction at both the stages of crop growth studied was also significant. At flowering stage the highest plant height of 82.52 cm was observed at a salinity level of 1.5 dS m^{-1} (S_1), which was superior to the remaining salinity levels whereas, the lowest plant height of 60.06 cm was observed at the maximum salinity level of 12 dS m^{-1} (S_4) and the percent decrease from salinity level S_1 to S_4 was 27.22. At harvest also similar trend was followed and the decline was 21.12 per cent. Among the three sorghum cultivars at both the stages, cultivar Laxmi (V_2) recorded the highest plant height and was found to be on par with Hytech and both were superior to Mahalaxmi (V_3). At flowering stage the highest plant height of 85.79 cm was recorded by the treatment combination S_1V_2 (1.5 dS m^{-1} X Laxmi), which was on par with treatment combination S_1V_1 (83.48), these two treatment combinations were significantly superior to rest of the treatment combinations. The lowest plant height (52.89) was recorded by the cultivar Mahalaxmi at the highest salinity level of 12 dS m^{-1} (S_4). At harvest stage the highest plant height of 93.70 cm was recorded by the treatment combination (S_1V_2), which was on par with S_1V_1 (91.25 cm) and S_2V_2 (90.55 cm) whereas, the lowest plant height of 66.70 cm was recorded by the treatment combination S_4V_2. The perusal of data indicated that, taller plants were produced at lower salinity levels. The reduction in plant height at high salt content might be due to lower water potential (øw) in saline soil in turn lower cell turgor causing reduction in cell elongation and cell division. Similar findings of lower plant height with increasing salinity were reported by Bandeoglu *et al*. (2004). Deivanai *et al*. (2011) also indicated that the retarded growth could be due to inhibition of cell elongation due to higher concentration of Na^+ which causes membrane disorganization, inhibition of cell division and expansion.

Days to 50% Flowering and Maturity

The data recorded on days to 50% flowering and maturity (Table 2) indicated significant difference with respect to salinity levels, sorghum cultivars and their interaction.

Among the four salinity levels, sorghum grown at a salinity level of 1.5 dS m^{-1} (S_1) reached flowering stage early (60.64 days) whereas, with increase in salinity the flowering was delayed with maximum days recorded at 12 dS m^{-1}. Among the three sorghum cultivars, cultivar Mahalaxmi took more days (65.89) to flower, which was on par with cultivar Laxmi (65.17), whereas cultivar Hytech (V_1) reached flowering stage in 64 days. The maximum number of days taken for flowering was recorded by the treatment combination S_4V_3 (73.41 days), which was on par with the treatment combination S_4V_2 (72.35). The minimum number of days for flowering was recorded by the treatment combination S_1V_1 (60.40).

Days to maturity followed almost similar trend to that of flowering with early maturity (93.27 days) observed in lowest salinity and delayed maturity (102.79 days) at the highest salinity. Among the three sorghum cultivars, Hytech (V_1) took less number of days (94.07 days) to mature whereas, Mahalaxmi (V_3) needed six more days to mature. The treatment combination S_1V_1 (87.76) recorded the lowest number of days to reach

Table 1. Per cent germination (%) and plant height (cm) of sorghum as influenced by salinity and cultivars.

Salinity levels (dS m^{-1})	Per cent germination (%)				Plant height (cm) at flowering stage				Plant height (cm) at harvest stage			
	Sorghum cultivars				Sorghum cultivars				Sorghum cultivars			
	V_1 (Hytech)	V_2 (Laxmi)	V_3 (Mahalaxmi)	Mean	V_1 (Hytech)	V_2 (Laxmi)	V_3 (Mahalaxmi)	Mean	V_1 (Hytech)	V_2 (Laxmi)	V_3 (Mahalaxmi)	Mean
S_1 (1.5)	97.23	96.96	95.84	96.68	83.48	85.79	78.30	82.52	91.25	93.70	84.36	89.77
S_2 (5)	88.07	83.62	72.51	81.40	77.23	80.74	74.72	77.56	82.39	90.55	81.37	84.77
S_3 (8)	72.22	71.72	69.29	71.08	73.73	73.51	69.27	72.17	81.70	82.04	78.40	80.71
S_4 (12)	53.40	50.29	50.18	51.29	62.10	65.19	52.89	60.06	73.37	66.70	72.37	70.81
Mean	77.73	75.65	71.96		74.14	76.31	68.80		82.18	83.25	79.12	
	SEm±	CD (0.05)	CV%		SEm±	CD (0.05)	CV%		SEm± 1.28	CD (0.05)	CV%	
Factor S	0.79	2.30	3.15		0.56	1.63	2.29		1.11	3.74	4.71	
Factor V	0.68	1.99			0.48	1.41			2.22	3.24		
S X V	1.37	3.99			0.97	2.82				6.47		

Table 2. Days to 50% flowering and maturity of sorghum as influenced by salinity and cultivars.

Salinity levels (dS m^{-1})	Days to 50% flowering				Days to 50% maturity			
	Sorghum cultivars				Sorghum cultivars			
	V_1 (Hytech)	V_2 (Laxmi)	V_3 (Mahalaxmi)	Mean	V_1 (Hytech)	V_2 (Laxmi)	V_3 (Mahalaxmi)	Mean
S_1 (1.5)	60.40	60.64	60.87	60.64	87.76	93.51	798.53	93.27
S_2 (5)	61.27	62.32	63.32	62.31	92.51	93.76	96.85	94.38
S_3 (8)	64.58	65.35	65.98	65.30	95.98	96.99	100.00	97.66
S_4 (12)	69.73	72.35	73.41	71.83	100.03	103.32	105.03	102.79
Mean	64.00	65.17	65.89		94.07	96.90	100.10	
	SEm±	CD (0.05)	CV%		SEm±	CD (0.05)	CV%	
Factor S	0.25	0.73	1.16		0.60	1.75	1.85	
Factor V	0.22	0.64			0.52	1.51		
S X V	0.44	1.27			1.04	3.02		

maturity, followed by S_2V_1 (92.51) The maximum number of days was recorded for S_4V_3 (105.03). An increase in soil salinity delays flowering and maturity. Similar findings were observed in three different cotton species (Sarvottam, Laxmi and G. Cot-15) by Uma and Patil (1996). Varietal variation in time taken to 50% flowering was also recorded by Kaliappan and Rajagopal (1968).

Influence of salinity on drymatter production yield attributes and yield

Drymatter Production

The data presented in table 4 revealed that, salinity levels, sorghum cultivars and their interaction significantly influenced the drymatter accumulation at flowering. The drymatter production decreased significantly with each increment in salinity level irrespective of sorghum cultivars. Drymatter production at flowering was maximum at the salinity of 1.5 dS m^{-1} (32.33 g pot $^{-1}$) and proved significantly superior to rest of salinity levels while the minimum was observed at the salinity of 12 dS m^{-1} (10.45 g pot $^{-1}$). From the data it could be inferred that, as the salinity increased from 1.5 dS m^{-1} (S_1) to 12 dS m^{-1} (S_4) the drymatter accumulation was decreased by 67.68 per cent. This might be due to the disruption of normal growth and development of plant with increase in salinity. Among the three sorghum cultivars the highest drymatter accretion was registered in cultivar Hytech (20.12 g pot $^{-1}$), which was on par with cultivar Laxmi (19.70). The lowest drymatter of 19.07 g pot $^{-1}$ was registered in cultivar Mahalaxmi. The highest drymatter accumulation (32.59 g pot $^{-1}$) was recorded in S_1V_1, which was on par with S_1V_2 (32.29 g pot $^{-1}$) and S_1V_3 (32.09 g pot $^{-1}$) whereas, the lowest drymatter production of 9.31 g pot $^{-1}$ was observed in treatment combination S_4V_3. Such varietal variation in drymatter production with increasing levels of salinity was also reported earlier by More and Malewar, 1988). The reduction in drymatter production with increase in salt concentration could be ascribed to physiological scarcity of water caused by high concentration of salts in soil solution. Further the decrease in drymatter production was also associated with osmotic effect (on plant root), toxic effect of accumulated ions (in plant tissue) and the specific effect of constituent ions or combination of all these (Allison, 1964).

Yield attributes

Salinity levels and sorghum cultivars were found to influence the length of ear (cm), number of grains earhead^{-1} and 100 grain weight (g) to a statistically perceptible degree and their interaction also reached to a level of significance (Table 3).

Length of earhead (cm)

Significantly longer earheads (13.44 cm) were observed at lower salinity level of 1.5 dS m^{-1} (S_1), which was significant over other salinity levels except S_2 (5 dS m^{-1}) having the earhead length of 13.06 cm. The lowest earhead length of 11.45 cm was observed at the highest salinity level of 12 dS m^{-1} (S_4). It was also observed that, the length of earheads at 12 dS m^{-1} (S_4) was 14.81 per cent lower when compared to the lowest salinity level of 1.5 dS m^{-1} (S_1). Among the three sorghum cultivars the highest earhead length of 12.70 cm was observed in cultivar Laxmi (V2), which was on par with cultivar Hytech (12.68 cm) and both were superior to Mahalaxmi having the lowest earhead length of 12.29 cm. The data also indicated that, the maximum earhead length (13.68) was observed in the treatment combination S_1V_1 (1.5 dS m^{-1} X Hytech), this was found to be on par with treatment combinations S_1V_2 (13.41), S_1V_3 (13.24), S_2V_1 (13.20) and S_2V_2 (13.10) whereas, the minimum earhead length of 10.21cm was observed in the treatment combination S_4V_3 (15 dS m^{-1} x Mahalaxmi).

Number of Grains earhead^{-1}

The number of grains earhead^{-1} was significantly influenced by salinity levels, sorghum cultivars and also by their interaction. The highest number of grains earhead^{-1} (179) was produced at lower salinity level of 1.5 dS m^{-1} (S_1), which was significant over the remaining salinity levels. Whereas, the lowest number of grains earhead^{-1} (91) was produced by sorghum sown at higher salinity level of 12 dS m^{-1} (S_4). There was a decline of 49.16 per cent in number of grains earhead^{-1} at the highest salinity level of 12 dS m^{-1} (S_4) compared to the lowest salinity level of 1.5 dS m^{-1} (S_1). Among the three sorghum cultivars, cultivar Hytech (V_1) showed higher number of grains earhead^{-1} (138) whereas, the lowest number of grains earhead^{-1} (132) was recorded in cultivar Mahalaxmi (V_3). The data indicated that, the treatment combination S_1V_1 (1.5 dS m^{-1} X Hytech) recorded significantly higher number of grains earhead^{-1} (184), which was on par with S_1V_2 (179). The lower number of grains earhead^{-1} (89) were recorded in the treatment combinations S_4V_2 and S_4V_3 (12 dS m^{-1}, Hytech).

100 grain weight (g)

The data pertaining to test weight of sorghum cultivars was significantly influenced by salinity levels, sorghum cultivars and also by their interaction. The highest test weight of 2.93 g was observed at lower salinity level of 1.5 dS m^{-1} (S_1), which was significant over remaining salinity levels. The lowest test weight of 2.29 g was observed with the maximum salinity level of 12 dS m^{-1} (S_4), which indicated a reduction of 21.84 per cent compared to 1.5 dS m^{-1}. The highest test weight was observed

Table 3. Yield attributes of sorghum as influenced by salinity and cultivars .

Salinity levels (dS m^{-1})	Length of earhead (cm)				Number of grains earhead^{-1}				Hundred grain weight (g)			
	Sorghum cultivars				Sorghum cultivars				Sorghum cultivars			
	V_1 (Hytech)	V_2 (Laxmi)	V_3 (Mahalaxmi)	Mean	V_1 (Hytech)	V_2 (Laxmi)	V_3 (Mahalaxmi)	Mean	V_1 (Hytech)	V_2 (Laxmi)	V_3 (Mahalaxmi)	Mean
S_1 (1.5)	13.68	13.41	13.24	13.44	184	179	175	179	2.99	2.93	2.89	2.93
S_2 (5)	13.20	13.10	12.88	13.06	144	134	133	137	2.80	2.78	2.80	2.79
S_3 (8)	11.34	12.67	12.83	12.28	129	130	133	131	2.47	2.42	2.36	2.42
S_4 (12)	12.49	11.64	10.21	11.45	94	89	89	91	2.32	2.26	2.30	2.29
Mean	12.68	12.70	12.29		138	133	132		2.64	2.59	2.59	
	SEm±	CD (0.05)	CV%		SEm±	CD (0.05)	CV%		SEm±	CD (0.05)	CV%	
Factor S	0.13	0.38	3.11		1.0	3	2.3		0.01	0.03	1.18	
Factor V	0.11	0.33			0.9	3			0.01	0.03		
S X V	0.23	0.66			1.8	5			0.02	0.05		

Table 4.Drymatter production, grain yield and stover yield (g pot^{-1}) of sorghum as influenced by salinity and cultivars.

Salinity levels (dS m^{-1})	Drymatter production at flowering stage (g pot^{-1})				Grain yield (g pot^{-1})				Stover yield (g pot^{-1})			
	Sorghum cultivars				Sorghum cultivars				Sorghum cultivars			
	V_1 (Hytech)	V_2 (Laxmi)	V_3 (Mahalaxmi)	Mean	V_1 (Hytech)	V_2 (Laxmi)	V_3 (Mahalaxmi)	Mean	V_1 (Hytech)	V_2 (Laxmi)	V_3 (Mahalaxmi)	Mean
S_1 (1.5)	32.59	32.29	32.09	32.33	21.93	20.79	20.08	20.93	48.23	46.66	44.96	46.62
S_2 (5)	21.74	21.09	20.23	21.02	16.03	14.68	14.75	15.15	39.05	36.08	35.58	36.90
S_3 (8)	14.85	14.69	14.64	14.73	12.52	12.51	12.43	12.49	33.61	32.70	32.97	33.09
S_4 (12)	11.29	10.75	9.31	10.45	8.55	7.95	8.03	8.18	23.30	22.45	22.68	22.81
Mean	20.12	19.70	19.07		14.76	13.98	13.82		36.05	34.47	34.05	
	SEm±	CD	CV%		SEm±	CD	CV%		SEm±	CD	CV%	
	0.23	(0.05)				(0.05)				(0.05)		
Factor S	0.20	0.66	3.45		0.15	0.43	3.13		0.18	0.53	1.56	
Factor V	0.39	0.57			0.13	0.37			0.16	0.46		
S X V		1.14			0.26	0.75			0.31	0.92		

in cultivar Hytech (2.64 g), which was superior to the other cultivars. The maximum test weight of 2.99 g was observed in treatment combination S_1V_1 (1.5 dS m^{-1} x Hytech) whereas, minimum test weight of 2.26 g was observed in S_4V_2 (12 dS m^{-1} x Laxmi).

Grain and stover yield

Salinity was one of the major environmental factors limiting plant growth and yield (Parida and Das, 2005). The data pertaining to grain and stover yield was found to be significantly influenced by salinity levels, sorghum cultivars and also by their interaction (Table 4).

The highest grain yield of 20.93 g pot^{-1} was recorded with the salinity level of 1.5 dS m^{-1} (S_1), which was significant over the remaining salinity levels. The lowest grain yield of 8.18 g pot^{-1} was observed at the highest salinity level of 12 dS m^{-1} (S_4). The per cent reduction in grain yield from lowest to highest salinity level was 60.92. The reduction in yield per pot and yield components might be due to shrinkage of the cell contents, reduced development and differentiation of tissues, unbalanced nutrition, damage of membrane and disturbed avoidance mechanisms. Similar findings were reported by Ali *et al.*, 2014. Among the three sorghum cultivars, cultivar Hytech (V_1) produced the highest grain yield of 14.76 g pot^{-1} followed by cultivar Laxmi (13.98 g pot^{-1}) whereas, the lowest grain yield of 13.82 g pot^{-1} was recorded by cultivar Mahalaxmi (V_3). The interaction between salinity and varieties (S X V) indicated that, the maximum grain yield of 21.93 g pot^{-1} was attained in the combination S_1V_1 (1.5 dS m^{-1} x Hytech), which was significant over remaining treatment combinations. Whereas, the minimum grain yield (7.95 g pot^{-1}) was obtained in the combination S_4V_2 (12 dS m^{-1} x Laxmi). The significant and gradual reduction in grain yield with progressive increase in soil salinity could be mainly due to the cumulative effect of decrease in plant height, less weight per earhead due to it's size reduction and less number of filled grains per earhead.

The highest stover yield of 46.62 g pot^{-1} was recorded with salinity level of 1.5 dS m^{-1} (S_1), which was significant over remaining salinity levels and the next highest stover yield (36.90 g pot^{-1}) was recorded with salinity level of 5 dS m^{-1} (S_2). The lowest stover yield of 22.81 g pot^{-1} was observed at higher salinity level of 12 dS m^{-1} (S_4). The per cent reduction in stover yield from lower salinity level to higher salinity level was 51.07. Among the three sorghum cultivars, cultivar Hytech (V_1) recorded the highest stover yield of 36.05 g pot^{-1} followed by cultivar Laxmi (34.47 g pot^{-1}). The maximum stover yield (48.23 g pot^{-1}) was attained in the treatment combination S_1V_1 (1.5 dS m^{-1}X Hytech) whereas, the minimum stover yield (22.45 g pot^{-1}) was observed in the combination S_4V_2 (12 dS m^{-1} X Laxmi). All the three varieties at lower salinity levels recorded relatively high stover yield. The reduction in yield at high salinity could be due to presence of excess soluble salts in the root zone, which negatively affects plant growth and yield through osmotic effects, nutritional imbalances, and specific ion toxicities (Tahir *et al.*, 2006). Beatriz (2001) reported a decrease in number of grains per panicle and harvest index at higher salinity. Pollen viability, a very important trait, governing the ultimate grain yield was found to be greatly influenced by the ionic toxicity under salinity (Mohammadinejada *et al.,* 2010) .

Conclusion

Finally it can be concluded that, the performance of sorghum in terms of germination, growth and yield was decreased as the salinity increased from 1.5 to 12 dS m^{-1}. Among the cultivars, Hytech, recorded maximum per cent germination even at 12 dS m^{-1} and resulted in highest number of grains per ear and grain and stover yield at all salinity levels followed by the cultivar Laxmi.

LITERATURE CITED

Ali D, Ahmad A and Mohsen N 2014 Investigation effects of different salinity levels on *Sorghum bicolor* seed germination characters. *Indian Journal of Scientific Research,* 7(1): 1031-1034.

Allison L E 1964 Salinity in relation to irrigation. *Advances in Agronomy*. Academic press Inc. (London) Ltd. 16: 139-180.

Asishkumar P Bandhu and Das A 2005 Salt tolerance and salinity effects on plants: a review. *Ecotoxicology and Environmental Safety,* 60, 324-349.

Bandeoglu E, Eyidogon F, Yucel M and Oktem H A 2004 Antioxidant responses of shoots and roots of lentil to NaCL-Salinity Stress. *Plant Growth Regulation,* 42: 69-77.

Beatriz G, Piestun N and Bernstein N 2001 Salinity induced inhibition of leaf elongation in maize is not mediated by changes in cell wall. *Plant Physiology,* 125: 1419–1428.

Deivanai S, Xavier R, Vinod V, Timalata K and Lim O F 2011 Role of exogenous proline in ameliorating salt stress at early stage in two rice cultivars. *Journal of Stress Physiology and Biochemistry,* 7(4): 157-174.

Kaliappan R and Rajagopal A 1968 Effect of salinity on the south Indian field crops duration and grain setting in ragi (*Eleusine coracana* Gaertn). *Madras Agricutural Journal,* 55: 125-128.

Maliwal G L and Paliwal K U 2002 Salt tolerance of some paddy, maize, sorghum, cotton and tobacco varieties at germination and early growth stage. *Agricultural Science,* 18(3): 147-149.

Mohammadinejada G, Singhb R K, Arzanic A, Rezaiec A M, Sabourid H and Gregoriob G B 2010 Evaluation of salinity tolerance in rice genotypes. *International Journal of Plant Production,* 4(3): 199–207.

More S D and Malewar G U 1988 Salt tolerance studies on sorghum and cotton. *Journal of Maharashtra Agricultural University,* 13: 20-22.

Parida A K and Das D B 2005 Salt tolerance and salinity effects on plants: A review. *Ecotoxicol Environment Safety,* 60: 324-349.

Sairam R K, Veerabhadra Rao K and Srivastava G C 2002 Differential response of wheat genotypes to long term salinity stress in relation to oxidative stress, antioxidant activity and osmolyte concentration. *Plant Sciences*, 163, 1037-1046.

Tahir M, Rahmatullah A, Aziz T, Ashraf M, Kanwal S and Muhammad A 2006 Beneficial effects of silicon in wheat under salinity stress-pot culture. *Pakistan Journal of Botany,* 38: 1715-1722.

Tigabu E, Andargie M and Tesfaye K 2013 Genotypic variation for salinity tolerance in sorghum (*Sorghum bicolor* (L.) Moench) genotypes at early growth stages. *Journal of Stress Physiology and Biochemistry,* 9(2): 253-262.

Uma M S and Patil B C 1996 Inter species variation in the performance of cotton under soil salinity stress. *Karnataka Journal of Agricultural Science,* 9(1): 73-77.

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