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Suvarna
Assistant Professor, Department of Genetics and Plant Breeding, College of Agriculture, Raichur, University of Agricultural Sciences, Raichur, Karnataka, India

Patil RP
Assistant Professor, Department of Crop Physiology, College of Agriculture, Raichur, University of Agricultural Sciences, Raichur, Karnataka, India

Vijaya Wali
Assistant Professor (Statistics), Department of Extension, College of Agriculture, Raichur, University of Agricultural Sciences, Raichur, Karnataka, India

Amaregouda A
Professor, Department of Crop Physiology, College of Agriculture, Raichur, University of Agricultural Sciences, Raichur, Karnataka, India

Corresponding Author:
Suvarna
Assistant Professor, Department of Genetics and Plant Breeding, College of Agriculture, Raichur, University of Agricultural Sciences, Raichur, Karnataka, India

Studies on salt stress effect on germination of foxtail millet

Suvarna, Patil RP, Vijaya Wali and Amaregouda A

Abstract
Foxtail millet (Navane) is an important minor millet which is neglected and consumption has been reduced. It is nutritious millet. It is tolerant to drought and salt. It is free from major pests and diseases and its cultivable area has been reduced. Soil salinity is one of the main important constraints for agricultural production, are being spoiled to the greater extent by accumulation of salts in high concentration with irrigation systems for crop production. The physiological toxic effects of salt stress include decreased germination and seedling growth, reduced leaf expansion which causes a reduction in the photosynthetic area and dry matter production. To study the effect of different concentrations of salt stress on germination of foxtail millet a laboratory experiment was conducted at College of Agriculture, Raichur. The experiment included two varieties Srilakshmi and HMT 100 -1 of foxtail millet and ten salt (NaCl) concentrations 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0% and one control (0%). The experiment was replicated twice. 25 seeds were kept in a petridish containing filter paper dipped in different salt concentrations. Germination was observed from the next day onwards. The germinated seeds were counted every two days interval up to 10th day of sowing. At 10th day, shoot length and root length were measured and the germination percentage was worked out. The data was subjected to statistical analysis according to the two factor complete block design. The significant differences were observed for concentration for all the three characters and variety for shoot length and germination percentage and variety and concentration interaction was significant for only germination percentage. Among concentrations, there was no significant difference from control up to 0.4% NaCl salt concentrations, which indicates that foxtail millet crop can performs better up to NaCl salt concentrations of 0.4%. Among the two varieties, variety HMT 100-1 showed better germination percentage as compared to the variety Sri lakshmi.

Keywords: salt stress, germination, foxtail millet

Introduction
Foxtail millet (Navane) is an important minor millet belonging to the family poaceae. This is a neglected crop and its consumption has been reduced. It is suited to conditions of low and moderate rainfall area due to early maturity period. It is tolerant to drought and salt. It is free from major pests and diseases and its cultivable area has been reduced. Besides India, it is also grown in China, Russia, Japan, USA and other African and East Asian countries. In India, the cultivation of fox millet is confined to Andhra Pradesh, Karnataka, and Tamil Nadu. The potentiality of foxtail millet is not yet exploited properly in India, The yield levels in China is 11 t /ha, whereas in India it is just ranging between 0.4-0.8t/ha suggesting a greater scope for exploitation of this millet under Indian conditions (Jiayju, 1996). Foxtail millet is nutritious millet.

Soil salinity is one of the main important constraints for agricultural production, are being spoiled to the greater extent by accumulation of salts in high concentration with irrigation systems for crop production. Worldwide, approximately 100 million hectares of arable lands are affected by salinity, which accounts for about 6-7% of total land (Munns and James, 2003) [6], whereas only in India around 13.3 million hectares of land is affected by salinity (Consortium for Unfavorable Rice Environment, IRRI, 2003) [3]. The physiological toxic effects of salt stress include decreased germination and seedling growth, reduced leaf expansion which causes a reduction in the photosynthetic area and dry matter production.

Enormous work has been done on various crops with reference to salinity, however, little information is known regarding the effect of salinity on foxtail millet. Therefore, the present study was conducted to determine the effect of different concentrations of NaCl salt stress on germination of foxtail millet varieties.

Material and Methods

A laboratory experiment was conducted at College of Agriculture, Raichur, Department of Crop Physiology, to assess the salt tolerance levels of navane varieties. The two varieties were tested with different salt concentrations viz., 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0 % Nacl and control. The experiment was replicated twice. The two varieties namely HMT 100-1 and Sri lakshmi were used. The salt concentrations were made by dissolving 1g of NaCl in one litre of distilled water to obtain 0.1% NaCl, likewise other concentrations were prepared. For control, the distilled water was used. The petriplates of equal sizes were used for the experiment. Filter papers were placed inside the petri plates. 25 seeds of a variety were placed on the filter paper in equal distance and 10 ml of the different salt concentrations was poured into the petriplates. Total 22 treatments were imposed. Germination of seeds was counted every two days interval after sowing. At the tenth day the final germination of seeds were counted. The shoot length and root length was measured. The speed of germination was calculated by the following formula

Germination rate = (a/1) + (b/2) + (c/3) + ---------- + (n/N),

Where, a, b, c, ---, n are the number of seeds germinated and 1, 2, 3, ---, N are the days after sowing on which day germinated seeds counted.

Seed vigour index was also calculated by using the formula,

Seed vigour index = (Shoot length + root length) x germination percentage.

The data on these characters were analysed using the software Design.

Results and Discussion

The data was subjected to statistical analysis according to the design. From the anova it was found that there was a significant difference existed for variety, concentration and variety and concentration interaction for germination percentage. The significant differences were observed among varieties and concentrations treatments for shoot length. And there was no significant difference was observed for interaction. For root length, only significant difference was observed for concentrations.

Germination percentage

Among the two varieties, variety HMT 100-1 showed better germination percentage as compared to the variety Sri lakshmi. The salt concentrations 0.1%, 0.2%, 0.3% and 0.4% effect on seed germination was non significant from the control, which indicates that germination was not affected by 0% to 0.4% NaCl salt concentration. When interaction of variety and concentration was observed, the germination percentage of variety HMT 100-1 was significantly high in all concentrations except for 1.0% NaCl concentration. The germination percentage was more than 90% up to salt concentrations 0.7% for variety HMT 100-1. Afterwards salt concentrations, germination percentage was affected in this variety. Whereas for another variety, Sri laksmi, the germination percentage was affected from 0.4% Nacl onwards. This indicates that variety HMT 100-1 is salt tolerant than the variety Sri lakshmi.

Seed germination is the most crucial and sensitive stage of a plants life cycle, particularly in the presence of environmental stresses. The soluble salts in the rhizosphere, beyond a critical limit, adversely influence germination and subsequent growth. Germination is one of the most salt-sensitive stages of plant growth and is severely inhibited with increasing salinity particularly in glycophytes. The present findings same results were also reported in other crops also in rice (Anbumalarmathi & Preeti Mehta, 2013) [2] and in sorghum (Ahmed *et al*., 2012) [1].

The seed germination in different varieties of finger millet had been differentially affected at different salinity levels. In general, seed germination was not significantly affected at initial level of salinity i.e. 3 dSm^{-1}, but significant reductions were noted at 6 to 14 dSm^{-1} (Sanjay Agarwal *et al*., 2011**)** [7]. Germination percentage was reduced by 125mM NaCl salt concentration onwards for almost all varieties except HD-6859 wheat cultivar (Datta *et al.*, 2009) [4].

Shoot length and root length

For shoot length character, variety Sri laksmi performed better than HMT 100-1. The shoot length did not differed significantly from control upto salt concentration 0.4%. There was significant difference for root length for concentration. Like shoot length, root length was also didnot differed significantly from control up to salt concentrations 0.4%. The same results of decreasing the length of shoot and root were observed in rice by Anbumalarmathi & Preeti Mehta, 2013 [2], in sorghum by Ahmed *et al*., 2012 [1].

From all these characters, it indicates that the navane variety HMT 100-1 is superior to Sri lakshmi and both can perform upto 0.4% NaCl salt concentration.

Table 1: Mean data of germination percentage, shoot length and root length of two foxtail millet varieties at different NaCl salt concentrations

NaCl Salt Concentration	Shoot length			Root length			Germination %			Germination rate			Seedling length vigour index		
	HMT 100-1	Sri lakshmi	Mean	HMT 100-1	Sri lakshmi	Mean	HMT 100-1	Sri lakshmi	Mean	HMT 100-1	Sri lakshmi	Mean	HMT 100-1	Sri lakshmi	Mean
0.0%	6.88	6.68	6.78	11.05	10.18	10.61	98	78	88	25.05	16.08	20.56	1757	1314	1535.30
0.1%	5.43	5.47	5.45	10.19	9.52	9.85	96	78	87	24.44	19.05	21.75	1500	1166	1332.93
0.2%	5.12	6.34	5.73	9.15	9.62	9.38	98	74	86	24.26	15.45	19.86	1399	1177	1288.12
0.3%	4.98	5.80	5.39	8.54	9.29	8.91	96	84	90	24.40	20.25	22.32	1298	1267	1282.64
0.4%	4.96	5.10	5.03	9.71	9.05	9.38	94	64	79	25.2	16.12	20.6	1377	907	1142.

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0.5%	3.06	4.57	3.82	2.35	2.23	2.29	94	55	74.5	9.70	5.07	7.39	510.1	246.2	378.12
0.6%	3.17	3.77	3.47	3.31	2.98	3.15	92	56	74	15.55	10.55	13.05	584.2	377.7	480.98
0.7%	3.45	2.69	3.07	2.60	0.82	1.71	92	62	77	18.13	5.76	11.95	556.6	216.2	386.40
0.8%	2.35	3.59	2.97	2.22	3.23	2.73	74	62	68	11.50	8.72	10.11	335.3	424.2	379.74
0.9%	2.21	3.49	2.85	1.39	2.47	1.93	74	58	66	9.81	8.39	9.10	263.4	350.6	307.01
1.0%	1.67	3.04	2.35	1.40	2.00	1.70	56	50	53	6.86	8.27	7.56	195.6	253.5	224.52
Mean	3.93	4.59	4.26	5.63	5.58	5.60	87.6	65.5	76.6	17.72	12.15	14.94	888.71	700.00	794.36
CD @ 5% for variety			0.406			NS			2.32			1.72			31.31
CD @ 5% for concentration			0.954			1.27			5.45			4.036			152.64
CD @ 5% for variety and concentration			NS			NS			7.708			5.708			215.86

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