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Effect salinity on germination percentage (%) and seed vigour index of rice (*Oryza sativa* L.)

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Abstract
Present investigation was conducted during *Kharif* 2017-18 in laboratory, at experimental study Department of Crop Physiology, Narendra Deva University of Agriculture and technology, Kumarganj Faizabad (U.P.). Soil salinity has become a severe threat to ensure food security, salinity-imposed limitations on plant growth. At the present, salinity level stimulates many of the metabolic processes involved in phases (2nd, 4th, 6th, 8th and 10th day) of germination, resulting in an improved performance of germination and higher. Experiment was laid out in complete randomized design (CRD) with three replication on six genotypes of rice crop *i.e.* tolerant- CSR-36, CSR-43, Usar Dhan-3 and Susceptible- Swarna Sub-1, IR-28, Pusa-44. Present investigation was carried to study the effect of salinity with 0, 50 and 100 mM concentration of NaCl on germination. The exposure of rice varieties to increasing concentration of NaCl had significantly increased germination (%), seed vigour index. It is evident from the result that concentration with NaCl significantly improved the germination and enzymatic activities of rice genotypes. The concentration are effective in increasing the germination percent, Seed vigour index, radicle length, plumule length, and enzymatic activities like α- amylase, catalase and carbohydrates biochemical parameters like proline accumulation, in all varieties under normal as well as under laboratory condition. The concentration with NaCl 0, 50 and 100 mM influences the germination and biochemical changes under normal as well as under anaerobic condition and might be useful in mitigating the adverse effect of laboratory condition or helpful in increasing the yield and yield attributes in all the varieties. Thus, it may be recommended that salinity level with concentration (0, 50 and 100 mM) of NaCl is the most desirable for mitigating the adverse effect of salinity.

Keywords: Rice, salinity, NaCl, Seed vigor, anaerobic condition

Introduction
Rice (*Oryza sativa* L., 2n= 24), belongs to the family Poaceae (Graminae). Rice is the most important food crop of the developing world and is the staple food of more than half of the world's population. It is especially important crop of Asia, where more than 90% of world rice is grown and consumed and where more than half of world's people live. Rice is the most important cereal food crop of India. It occupies about 23.3% of gross cropped area of the country and plays vital role in the national food grain supply. Rice is rich in nutrients and contains a number of vitamins and minerals. It is an excellent source of complex carbohydrates the best source of energy. It contains a reasonable amount of protein 6-10%, carbohydrate 70-80%, mineral 1.2-2.0% and vitamins (Riboflavin, Thiamine, Niacin and vitamin E). Rice contributes 43% of total food grain production and 46% of the total cereal production of the country. At least 114 countries grow rice and more than 50 have an annual production of 100,000 or more. Asian farmers produce about 90% of the total, with two countries, China and India more than the half. Among the rice growing countries in the world, India has the largest area under rice crop and ranks second in production next to China.

Salinity is a common environmental stress seriously affecting crop growth, food production and crop yield in many regions, particularly in arid and semi-arid regions. It is estimated that over 800 million hectares of land in the world are affected by both salinity and sodicity globally (Munns, 2005) [6]. Salt contaminated soils (ECe> 4 dS m^{-1} or 40 mM NaCl or osmotic potential < 0.117 MPa) are defined as saline land, which directly affects plant growth and development in vegetative growth prior to reproductive stage, especially crop species. Some of crop species are susceptible to salt stress (ECe 1.0-1.8 dS m^{-1}), which decline crop growth and productivity about 6-19% *i.e.* rice, corn, bean, eggplant, onion, potato, pepper, sugarcane and cabbage. In general, biochemical, physiological, anatomical and morphological characteristics of plants directly affected by soil salinity. In terms of responses to salinity stress, plants can be divided into two group's halophyte or glycophyte—based on their level of salinity tolerance. Halophytes are plants that tolerate relatively high salt concentrations (400 mM NaCl), while glycophyte tolerate low concentrations (Maas, E.V.; Nieman, R.H). Salt stress causes both ionic and osmotic effects in plants, leading to membrane disorganization, metabolic toxicity, and genesis of reactive oxygen species (ROS) such as hydrogen peroxide (H_2O_2), which may cause oxidative damage (Halliwell, 1987; Chaparzadeh *et al*., 2004).

Material Methods

The present investigation was conducted in laboratory, at experimental study Department of Crop Physiology, N.D. University of Agriculture & Technology, Kumarganj, Faizabad (U.P.) during *Kharif* season of 2017-18. The experiment was conducted in laboratory condition (Petridish). Three tolerant varieties (CSR 36, CSR 43, Usar Dhan 3 and three susceptible varieties (Swarna Sub 1, IR 28, Pusa 44) used in experiment. Experiment consists of three NaCl concentrations (0, 50, 100 mM) and eighteen treatments *viz*; CSR 36+control (Distilled water), CSR 36+S1 (50 mM NaCl), CSR 36+S2(100 mM NaCl), CSR 43+Control (Distilled water), CSR 43+S1 (50 mM NaCl), CSR 43+S2 (100 mM NaCl), Usar Dhan 3+control(Distilled water),Usar Dhan 3+S1 (50 mM NaCl),Usar Dhan 3+S2: 50 ppm +100 mM NaCl, Swarna Sub 1+control(Distilled water), Swarna Sub 1+S1 (50 mM NaCl), Swarna Sub 1+S2 (100 mM NaCl), IR 28+Control (Distilled water), IR 28+S1 (50 mM NaCl), IR 28+S2 (100 mM NaCl), Pusa 44+control(Distilled water), Pusa 44+S1 (50 mM NaCl),Pusa 44+S2: (100 mM NaCl). Seed germination was recorded as rate as well as percentage during successive period of germination. It was recorded alternately up to 10 days. The germination percentage was calculated using the following formula:

$$\text{Germination per cent} = \frac{\text{Number of seed germinated}}{\text{Total number of seeds}} \times 100$$

The vigour index of seedlings was calculated by adopting the method suggested by Abdul-Baki and Anderson (1973) [1] and expressed in whole number.
Seed Vigour index = Germination (%) × [Shoot length + Root length]

Result and Discussion

Effect of NaCl on Germination% and seed vigour index of different rice varieties:

Germination is a complex phenomenon involving many physiological and biochemical changes that lead to the activation of embryo. Salinity induces numerous disorders in seeds during germination. Firstly, it reduces the imbibitions of water because of lower osmotic potential of the medium (Munns & Tester, 2008) [5] and secondly it causes mineral imbalances and toxicity (Rajendran *et al*., 2009) [8]. Germination percentage is adversely affected by the different concentration of NaCl up to 10th day of seed germination. At 100 mM NaCl, seed germination in six varieties was completely inhibited. Susceptible varieties showed germination percentage of 1% to 10%. Whereas, tolerant varieties shows 15 to 20% seed germination at higher level of NaCl. Germination percentages were inversely related to level of salt concentration. The percentage of germination significantly decreased in all varieties due to increasing salinity level (Table 1). At the 0 mM NaCl, a germination percentage of more than 80 to 100% was observed in tolerant, whereas in susceptible varieties germination ranged from 20 to 95% from 2nd day to 10th day of germination. The variability has also been reported in salinity tolerance among rice varieties at germination by (Hakim *et al*., 2010) [3]. Presumably, the osmotic effect due to salinity was the main inhibitory factor that reduced germination as indicated by (Akbar *et al*., 1982) [2]. The germination of rice seeds declined steadily when external salinity increased, comparatively the salt tolerant genotypes which attain a higher germination rate under saline conditions (Walia *et al*., 2005) [9]. Growth parameter like seed vigour index was also significantly affected by the different concentration of NaCl (0mM, 50mM, 100mM). Seed vigour index of all the rice varieties decreased with an increase in salinity (table 2). Plumule length was completely inhibited in all either it is tolerant or susceptible varieties at 2nd day of germination in all the concentration of NaCl. However, maximum plumule length was obtained with 0 (control) concentration at 10th day. Reduction of seedling height is a common phenomenon of many crop plants grown under saline conditions (Hakim *et al*., 2010) [3]. Similarly, radicle length was also decreased with increased salinity level (table 1). Maximum radicle length was observed in 0 mM NaCl Concentration at 10th day. The gradual decrease in root length with increase in salinity might be due to more inhibitory effect of NaCl salt to root growth compared with shoot growth. It is due to the fact that Na^+ and Cl^- sequestered in the vacuole could decrease the internal osmotic potential and cause partial dehydration of cytoplasm. Such dehydration impairs the cellular metabolism and ultimately reduced the growth of the seedlings. This is in conformity with the findings of Hakim *et al*., (2010) [3] they observed that plumule and radicle length was conspicuously affected by salt.
Seed vigour index followed the similar trend as reported in plumule and radicle length. Lower mobilization efficiency under higher stress may be correlated with slow growth of embryo. The data pertaining to seed vigour index presented in (Table- 2) indicate that seed vigour index declined with the increase in salt concentration. Maximum increasing in seed vigour index was obtained in tolerant rice genotype Usar dhan-3 (1270.00) followed by CSR-43 (1170.00) and CSR-36 (1160.00) with 0 (control) mM concentration salinity level and minimum seed vigor index was obtained in susceptible rice genotypes IR-64 (864.50), IR-64 (836.00) and Swarn Sub-1 (798.00) with 0 (control) mM concentration respectively.

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Table 1: Effect of NaCl on Germination% of different rice varieties

2nd Day

NaCl levels	Varieties						Average
	V1	V2	V3	V4	V5	V6	
0	82.00	80.00	90.00	50.00	45.00	20.00	61.17
50	50.00	35.00	55.00	35.00	35.00	10.00	36.67
100	20.00	15.00	15.00	10.00	10.00	1.00	11.83
Average	50.67	43.33	53.33	31.67	30.00	10.33	36.56
	Varieties (V)		NaCl levels (N)		VxN		
SEm±	0.269		0.190		0.466		
CD at 5%	0.771		0.546		1.336		

4th Day

NaCl level	Varieties						Average
	V1	**V2**	**V3**	**V4**	**V5**	**V6**	
0	95.00	95.00	100.00	70.00	70.00	70.00	83.33
50	70.00	60.00	80.00	50.00	55.00	45.00	60.00
100	45.00	45.00	45.00	28.00	25.00	20.00	34.67
Average	70.00	66.67	75.00	49.33	50.00	45.00	59.33
		Varieties (V)		NaCl levels (N)		VxN	
SEm±		0.455		0.322		0.788	
CD at 5%		1.305		0.923		2.261	

6th Day

NaCl level	Varieties						Average
	V1	**V2**	**V3**	**V4**	**V5**	**V6**	
0	100.00	100.00	100.00	95.00	95.00	95.00	97.50
50	95.00	90.00	100.00	80.00	80.00	80.00	87.50
100	80.00	80.00	95.00	65.00	70.00	70.00	76.67
Average	91.67	90.00	98.33	80.00	81.67	81.67	87.22
		Varieties (V)		NaCl levels (N)		VxN	
SEm±	0.592	0.419		1.026		0.592	
CD at 5%	1.699	1.201		2.943		1.699	

8th Day

NaCl level	Varieties						Average
	V1	**V2**	**V3**	**V4**	**V5**	**V6**	
0	100.00	100.00	100.00	95.00	95.00	95.00	97.50
50	95.00	95.00	100.00	90.00	90.00	85.00	92.50
100	90.00	95.00	95.00	80.00	85.00	80.00	87.50
Average	95.00	96.67	98.33	88.33	90.00	86.67	92.50
		Varieties (V)		NaCl levels (N)		VxN	
SEm±		0.603		0.426		1.044	
CD at 5%		1.729		1.222		2.994	

10th Day

NaCl level	Varieties						Average
	V1	**V2**	**V3**	**V4**	**V5**	**V6**	
0	100.00	100.00	100.00	95.00	95.00	95.00	97.50
50	95.00	95.00	100.00	90.00	90.00	85.00	92.50
100	90.00	95.00	95.00	80.00	85.00	80.00	87.50
Average	95.00	96.67	98.33	88.33	90.00	86.67	92.50
		Varieties (V)		NaCl levels (N)		VxN	
SEm±		0.715		0.506		1.239	
CD at 5%		2.051		1.45		3.553	

Table 2: Effect of NaCl on seed vigour index of different rice varieties

2nd Day

NaCl level	Varieties						Average
	V1	**V2**	**V3**	**V4**	**V5**	**V6**	
0	229.60	216.00	297.00	55.00	54.00	20.00	145.27
50	40.00	24.50	121.00	10.50	14.00	2.00	35.33
100	6.00	4.50	27.00	1.00	2.00	0.00	6.75
Average	91.87	81.67	148.33	22.17	23.33	7.33	62.45
		Varieties (V)		NaCl levels (S)		VxS	
SEm±		2.698		1.908		4.673	
CD at 5%		7.739		5.472		13.404	

4th Day

NaCl level	Varieties						Average
	V1	**V2**	**V3**	**V4**	**V5**	**V6**	
0	579.50	541.50	690.00	224.00	231.00	203.00	411.50
50	231.00	174.00	400.00	100.00	121.00	58.50	180.75
100	99.00	81.00	175.50	39.20	35.00	16.00	74.28
Average	303.17	265.50	421.83	121.07	129.00	92.50	222.18
		Varieties (V)		NaCl levels (S)		VxS	
SEm±		6.849		4.843		11.863	
CD at 5%		19.644		13.891		34.025	

6th Day

NaCl level	Varieties						Average
	V1	**V2**	**V3**	**V4**	**V5**	**V6**	
0	780.00	760.00	860.00	456.00	494.00	456.00	634.33
50	608.00	486.00	670.00	296.00	296.00	248.00	434.00
100	440.00	344.00	570.00	208.00	224.00	168.00	325.67
Average	609.33	530.00	700.00	320.00	338.00	290.67	464.67
		Varieties (V)		NaCl levels (S)		VxS	
SEm±		12.92		9.136		22.379	
CD at 5%		37.058		26.204		64.186	

8th Day

NaCl level	Varieties						Average
	V1	**V2**	**V3**	**V4**	**V5**	**V6**	
0	980.00	990.00	1030.00	646.00	674.50	674.50	832.50
50	693.50	760.00	900.00	513.00	522.00	391.00	629.92
100	666.00	636.50	788.50	408.00	442.00	304.00	540.83
Average	779.83	795.50	906.17	522.33	546.17	456.50	667.75
		Varieties (V)		NaCl levels (S)		VxS	
SEm±		14.192		10.035		24.582	
CD at 5%		40.706		28.783		70.504	

10th Day

NaCl mM	Varieties						Average
	V1	**V2**	**V3**	**V4**	**V5**	**V6**	
0	1160.00	1170.00	1270.00	798.00	836.00	864.50	1016.42
50	921.50	931.00	1130.00	684.00	693.00	527.00	814.42
100	882.00	845.50	988.00	544.00	603.50	440.00	717.17
Average	987.83	982.17	1129.33	675.33	710.83	610.50	849.33
		Varieties (V)		NaCl levels (S)		VxS	
SEm±		21.176		14.974		36.679	
CD at 5%		60.738		42.948		105.201	

Conclusion

The decrease in seed germination and seed vigour index of rice genotypes under higher salinity was due to reduced rate of water imbibitions and disturbed metabolic status of the germinating seeds as evident by proline accumulation, decreased enzyme activity and carbohydrate content and enhanced salt accumulation. For rapid screening of salt tolerant rice genotypes seed germination percentage (%) and seed vigour index could be picked up as the probable indices under existing conditions.

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