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Impact of saline water irrigation on growth, yield and quality of rice (*Oryza sativa* L.) varieties

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Abstract
A pot experiments were conducted in Complete Randomized Design (CRD) with Five replications at Wire net house, Department of Crop Physiology Chandra Shekhar Azad University of Agriculture & Technology Kanpur, during *Kharif* seasons in the year 2022-23 and 2023-24.
The study the effect of Salinity water irrigation with various levels (Five level of Saline $T_{0.}$ (Control), $T_{1.}$ ECiw 3(dSm^{-1}), $T_{2.}$ ECiw 6(dSm^{-1}), $T_{3.}$ ECiw 9(dSm^{-1}), $T_{4.}$ ECiw 12(dSm^{-1}), and Five variety on Pant-24, Pusa Basmati-1509, Sampurna (KP)-108, Narendra-2065, CSR- 46 plants traits *i.e.* physiological, phenological biochemical, yield and its components of Rice. Results revealed that growth in terms of plant height, total dry matter accumulation, number of leaves, leaf area index, growth parameters, physiological characters, phenological, biochemical development yield and its components varied significantly all the treatments during both year of experimentation. The results indicated that application of recorded higher value of plant height, dry matter accumulation (g), number of panicle $plant^{-1}$, number of grain $plant^{-1}$, biological yield, 1000 seeds weight (g) and ultimately higher grain yield (g) $plant^{-1}$ as compared to all other corresponding tested treatments. Further, these treatment ECiw 3(dSm^{-1}) significantly maximum days for their phenological stages i.e., days of heading, anthesis and 75% flowering and days of physiological maturity as compared to all other treatments.
Based on overall relative performance proved to be more beneficial with ECiw 3(dSm^{-1}) it was concluded that were found to be better perform with respect of grain yield and other studied traits as compared to other treatment.

Keywords: Characters, biological yield, experiment, maturity, treatments, varieties

Introduction
Rice (*Oryza sativa* L.) is C_3, self-pollinated crop plant, belongs to family Poaceae. The genus Oryza consists of 24 species, of which 2 species *i.e., Oryza sativa* and *Oryza glaberrima,* are commercially cultivated. Rice is a staple food for more than half of the world's population. Rice is the most prominent crop of India as it is the staple food for most of the people of the country. This crop is the backbone of livelihood for millions of rural households and plays vital role in the country's food security, so the term "rice is life" is most appropriate in Indian context. India occupies an important position both in area and production of rice. By the adoption of improved production technologies such as high-yielding varieties/hybrids, expansion of irrigation potential, and use of chemical fertilizer, supply of rice in the country has kept pace with the increase in demand. Rice is cultivated worldwide over an area of about 163.06 million ha with an annual production of about 523.9 million tons and productivity 49.60 tons/ ha in 2023-24 (USDA 2023-24). About 85-90% of all rice grown in world is produced and consumed in asian region. Among rice growing countries India has the largest area followed by China and Indonesia. In respect to production India ranks 1nd and second China. Rice is grown in almost all the states of India, whereas West Bengal, Uttar Pradesh, Odisha, Andhra Pradesh, Telangana, Bihar, Tamil Nadu, Punjab, & Chhattisgarhi are major rice producing states. In India rice is grown over an area of about 43.79 million ha, which produces 137.86 million tons with an average productivity of 4256 kg/ha. In U. P. rice is grown an area of about 6.40 million ha with production of 14.1% of total rice in India. (Ministry of Agriculture and Farmers Welfare).

In 21st century, there will be need of about 250 million tons of food grains to feed the rapidly increasing population. To meet the demand of increasing population & maintain self-sufficiency, the present production level need to be increased additional of 29 million tons by 2025, which can be achieved only by increasing rice production by over 2.0 million tons year/year in coming decade.

Drought and salinity are two major abiotic determinants due to high magnitude of their impact and wide occurrence. In the present study rice varieties were analyzed for water and salt stress tolerance at germination and early seedling growth stage. Seeds of three rice varieties (Narendra-1, Sabarmati and Hybrid 312) were collected and kept under four water stress and six salt stress levels. Seed germination, seedling length, dry weight, seed vigor and other parameters were recorded. The results showed that with increasing water stress, germination in all the varieties was delayed and decreased from 68.8% in control to 4.4% in highest stress (-15 bar) level. Dry weight of shoot and root, shoot and root length, fresh weight of stem and root decreased in all rice varieties with the increase in water stress level. Narendra-1 and Sabarmati showed better response while Hybrid-312 failed to germinate in all water stress levels. The increase in salt stress also reduced every measured trait significantly in all the varieties. Seed germination decreased from 100% in control to 65% in highest (20 ds/m) salt stress level. Maximum germination percentage 100% was observed in Hybrid 312 under all the salt stress levels. These results could be helpful in identification of the tolerant varieties which can be studied further and economically exploited. Shahi C, *et al.*, (2015) [8].

2. Materials and Methods

2.1 Experimental Site

The experiment was conducted in wire net house of the department of Crop Physiology, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, during *Kharif* seasons of 2022-23 and 2023-24.

2.2 Climate and Topography

The Campus of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur is situated in central Uttar Pradesh at latitude of 28° 58' North and longitude of 80° 34' at an altitude of 125 meters above sea level in gangatic alluvium soil The seasonal rainfall of about 820 mm received mostly from IInd Fortnight of June or first Fortnight of July to mid- October with a few showers in winter season.

2.3 Experimental Soil

For conduct of the experiment, the normal soil was taken from the lot available for the purpose in the department of Crop Physiology, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. This soil was clay loam in soil texture having average fertility. Before preparation of the soil and fertilizer application, soil samples were collected, air dried, pulverised and sieved in laboratory to make homogenous mixture.

2.4 Experimental materials

Seeds of five Rice varieties *viz.* Pant-24, Pusa basmati-1509, Sampurna-108, Narendra-2065 and CSR-46 were obtained both years from the Economic Botanist (*Kharif* Cereals), C.S. Azad University of agriculture and Technology, Kanpur.

2.5 Treatments

A treatment comprises 25 combinations of 5 Levels of salinity and 5 Rice varieties as detailed below:

Levels of salinity	Varieties
T_0 - Control (Normal water irrigation)	V_1 - Pant-24
T_1- ECiw, 3 (dSm^{-1}), saline water irrigation	V_2 - PB-1509
T_2 - ECiw, 6(dSm^{-1}), saline water irrigation	V_3 - Sampurna-108
T_3- ECiw, 9 (dSm^{-1}), saline water irrigation	V_4 - Narenda-2065
T_4 - ECiw, 12 (dSm^{-1}), saline water irrigation	V_5 - CSR-46

- **Replication:** 5
- **Experimental design and layout:** Complete Randomized design (CRD)
- **Fertilizer level:** 100 kg N, 60 P_2O_5 and 40 K_2O kg ha^{-1}
- **Irrigation**
- Irrigation water of the EC 3,6,9,12 $dSm^{-}1$ salinity was prepared in laboratory by adding NaCl and $CaCl_2$ (4:1) and tap water was used to maintain the EC of 3,6,9, and 12 dSm^{-1}. Watering was done at 7 days interval on so with equal water *i.e.* one liter in each pot at a time.

2.6 Observation recorded

1. Number of tillers $plant^{-1}$
2. Dry matter Production $plant^{-1}$ (g)
3. Number of grains/panicle
4. Grain weight/plant (g)
5. Proline content pre and post anthesis (µg/ g)

2.7 Preparation of samples

Observation will be recorded during the Two years of investigation tillering, heading, dough and maturity stages of crop growth. Which happened to occur at 30, 60, 90 and 120 days after transplanting?

2.8 Number of tillers $plant^{-1}$ at different growth stages

The total number of tillers was counted which emerged out from the tagged mother plant at different growth stage.

2.9 Dry matter production $plant^{-1}$ (gm^{-1})

The oven dried samples were weighted separately and dry matter content of stem, leaf and whole plant were weighted and recorded.

2.10 Number of grains/Panicle

Numbers of grains produced by per panicle of each observation were counted.

2.11 Grain weight/plants (g)

The grain weight per plant was taken by physical balance in g.

2.12 Proline content pre and post anthesis (µg/g fresh weight)

Proline content in leaves was determined by the method of Bates *et al.* (1937). Leaf material was extracted with 3% aqueous 5 sulfosalicylic acid for proline determination. It was recorded in µg/g fresh weight.

3. Results and Discussion

3.1 Number of tillers per plants

Influence of levels of salinity on tiller production was significant and drastic reduction in tiller production per plant was observed at higher levels of salinity *viz.*, 6, 9 and 12dSm^{-1}. Trend of reduction was linear to increase in level of salinity, except 3dSm^{-1}. A slight increase in tiller production was noticed over at all the observation stages during both the years.

Varieties differed significantly among themselves in term of tiller number per plant. On the basis of mean value of tiller production at initial tillering stages, varieties, CSR-46 were recorded significantly superior over the rest of varieties tested followed by Narendra-2065 during both the year.

Varieties Pant-24, Pusa basmati-1509 and Sampurna (KP)-108 were in same bar during both the year at this stage. At maximum shoot stage, maximum tiller per plant were noted (at 30, 60, 90 and 120 DAT) in variety CSR-46 (8.0 and 8.20, 12.68 and 13.21, 14.12 and 14.68, 15.44 and 15.92) during 2022- 23 and 2023-24 respectively. Narendra-2065 got next better place in this regard. Variety Sampurna(KP)-108 was recorded as lowest tiller producing variety during both year of experiment

Table 1: Effect of saline water irrigation on number of tillers per plants (2022-23).

Varieties / Salinity levels	EC of Irrigated water					
	Pant-24	**Pusa basmati-1509**	**Sampurna-(KP)108**	**Narendra -2065**	**CSR-46**	**Mean**
T_0 (Control)	17.00	16.80	16.40	17.20	17.60	17.00
T_1 (ECiw,3 dSm^{-1})	19.00	18.60	18.20	19.20	19.80	18.96
T_2 (ECiw,6 dSm^{-1})	14.80	14.40	14.00	15.20	15.60	14.80
T_3 (ECiw,9 dSm^{-1})	12.40	12.00	11.80	12.80	13.20	12.44
T_4 (ECiw,12 dSm^{-1})	10.20	9.80	9.60	10.60	11.00	10.24
Mean	14.68	14.32	14.00	15.00	15.44	
	Salinity level		Varieties		Interaction	
SE. m±	0.123		0.123		0.194	
CD (P=0.05)	0.244		0.244		0.000	

Table 2: Effect of saline water irrigation on number of tillers per plants (2023-24).

Varieties / Salinity levels	EC of Irrigated water					
	Pant-24	**Pusa basmati-1509**	**Sampurna-(KP)108**	**Narendra -2065**	**CSR-46**	**Mean**
T_0 (Control)	17.40	17.00	16.80	17.80	18.20	17.44
T_1 (ECiw,3dSm-1)	20.00	19.60	19.20	20.00	20.40	19.84
T_2 (ECiw,6dSm-1)	15.20	14.80	14.60	15.60	16.00	15.24
T_3 (ECiw,9dSm-1)	12.80	12.60	12.20	13.00	13.40	12.80
T_4 (ECiw,12dSm-1)	10.80	10.20	10.00	11.20	11.60	10.76
Mean	15.24	14.84	14.56	15.52	15.92	
	Salinity level		Varieties		Interaction	
SE. m±	0.127		0.127		0.201	
CD (P=0.05)	0.253		0.253		0.000	

3.2 Dry weight of plant^{-1} (g)

Data at 120 DAT revealed that variety Pant-24 accumulated significantly higher dry weight plant^{-1} (45.07 and 46.86 g) followed by Pusa Basmati-1509 (45.03 and 44.43 g) during both the years. However, least dry weight plant^{-1} (43.94 and 42.74 g) was recorded with variety CSR-46. Similar trend was also observed during both the experimental years.

Salinity level of ECiw 3 dSm^{-1}produced significantly Dry weight plant^{-1} than control at all stages during both the years. Increasing salinity levels above ECiw 3 dSm^{-1} up to ECiw 12 dSm^{-1} showed significant reduction in plant dry weight plant^{-1} significantly in all cases of observations. Among variety Pusa Basmati-1509 produced significantly dry weight plant^{-1} than other varieties.

Interaction effect of varieties and micronutrients could not reach to level of significance at any growth stages studied. At all stages varietal, position against salinity was almost similar to main effect with one exception that reduction in plant dry weight due to salinity beyond ECiw 12 dSm^{-1}. One thing may also be seen from interaction effect that maximum dry weight plant^{-1} was in variety Pusa Basmati-1509 while minimum in variety Sampurna (KP)-108 during both the years.

Table 3: Effect of saline water irrigation on dry matter production plant (2022-23).

Varieties / Salinity levels	EC of Irrigated water					
	Pant-24	**Pusa basmati-1509**	**Sampurna-(KP)108**	**Narendra -2065**	**CSR-46**	**Mean**
T_0 (Control)	48.49	40.99	44.67	42.05	46.55	44.55
T_1 (ECiw, 3 dSm^{-1})	47.15	49.2	47.53	45.39	45.52	46.95
T_2 (ECiw, 6 dSm^{-1})	48.49	40.99	44.67	42.05	46.55	44.55
T_3 (ECiw, 9 dSm^{-1})	47.34	40.6	43.21	41.46	44.89	43.50
T_4 (ECiw, 12 dSm^{-1})	36.12	34.49	34.04	36.68	36.94	35.65
Mean	45.07	45.03	42.282	41.24	43.492	
	Salinity level		Varieties		Interaction	
SE. m±	0.295		0.295		0.517	
CD (P=0.05)	0.517		0.517		1.625	

Table 4: Effect of saline water irrigation on dry matter production plant (2023-24).

Varieties / Salinity levels	EC of Irrigated water					
	Pant-24	**Pusa basmati-1509**	**Sampurna-(KP)108**	**Narendra -2065**	**CSR-46**	**Mean**
T_0 (Control)	46.86	44.43	40.11	42.74	44.43	44.50
T_1 (ECiw, 3 dSm^{-1})	45.53	43.40	48.32	45.60	43.40	46.95
T_2 (ECiw, 6 dSm^{-1})	45.72	42.77	49.72	41.27	42.77	43.50
T_3 (ECiw, 9 dSm^{-1})	45.72	49.72	41.27	40.37	42.77	43.50
T_4 (ECiw, 12 dSm^{-1})	32.75	33.14	35.80	30.40	33.14	35.65
Mean	46.86	44.43	40.11	42.74	44.43	
	Salinity level		Varieties		Interaction	
SE. m±	0.307		0.307		0.762	
CD (P=0.05)	0.525		0.525		1.636	

3.3 Number of grains/panicle

The rice varieties maximum Number of grain per panicles was found in variety Narendra-2065 (114.08 and 117.80) while minimum was observed in Pant-24 (108.32 and 112.04). During both years of experimentation**.** Number of grain per panicles maximum value counted in with salinity level of ECiw 3 dSm^{-1} (132.44 and 137.64) as compare with salinity level of ECiw 6 dSm^{-1} (109.92 and 113.52) and lowest Number of grain per panicles with salinity level of ECiw 12 dSm^{-1}(91.24 and 93.44) during both cropping seasons.

The varieties and salinity levels interact effect were found to be non-significant during both years of experimentation, respectively.

Table 5: Effect of saline water irrigation on Number of grain/plants (2022-23).

Varieties / Salinity levels	EC of Irrigated water					
	Pant-24	**Pusa basmati-1509**	**Sampurna-(KP)108**	**Narendra -2065**	**CSR-46**	**Mean**
T0(Control)	120.60	121.80	124.40	125.60	123.00	123.08
T1(ECiw,3dSm^{-1})	129.20	131.60	133.40	135.80	132.20	132.44
T2(ECiw,6dSm^{-1})	107.40	108.00	111.20	113.60	109.40	109.92
T3(ECiw,9dSm^{-1})	96.20	97.60	100.00	101.60	98.40	98.76
T4(ECiw,12dSm^{-1})	88.20	90.60	92.20	93.80	91.40	91.24
Mean	108.32	109.92	112.24	114.08	110.88	
	Salinity level		Varieties		Interaction	
SE. m±	0.916		0.916		1.448	
CD(P=0.05)	1.819		1.819		0.000	

Table 6: Effect of saline water irrigation on Number of grain/plants

Varieties / Salinity levels	EC of Irrigated water					
	Pant-24	**Pusa basmati-1509**	**Sampurna-(KP)108**	**Narendra -2065**	**CSR-46**	**Mean**
T_0 (Control)	125.40	126.60	129.20	130.40	127.80	127.88
T_1 (ECiw,3 dSm^{-1})	134.40	136.80	138.60	141.00	137.40	137.64
T_2 (ECiw,6 dSm^{-1})	111.00	111.60	114.80	117.20	113.00	113.52
T_3 (ECiw,9 dSm^{-1})	99.00	100.40	102.80	104.40	101.20	101.56
T_4 (ECiw,12 dSm^{-1})	90.40	92.80	94.40	96.00	93.60	93.44
Mean	112.04	113.64	115.96	117.80	114.60	
	Salinity level		Varieties		Interaction	
SE. m±	0.947		0.947		1.498	
CD(P=0.05)	1.882		1.882		0.000	

3.4 Grain weight/plant (g)

The maximum improvement in grain weight per plant was recorded with the variety Pusa Basmati-1509 (20.65, 24.08 g) followed by Narendra-2065 (19.74, 23.10 g) and minimum grain weight found Pant-24 (17.45, 20.65 g) during both the year of experimentation.

Levels of saline water irrigation variably improved their grain yield per plant the maximum grain weight per plant was recorded with the (ECiw,3 dSm^{-1}) (31.17,37.30 g) closely followed by (ECiw,6dSm^{-1}) (17.63, 20.40 g) and (ECiw,12 dSm^{-1}) (9.22, 10.24 g) showed minimum grain weight of per plant during in the year 2022-23 and 2023-24, respectively.

Combination of varieties and salinity levels revealed that showed significant improvement of seeds per plant but statically superior all treatments compared to saline level (ECiw,12 dSm^{-1}) during two years of experimentation.

Table 7: Effect of saline water irrigation on Grain weight/plant

Varieties / Salinity levels	EC of Irrigated water					
	Pant-24	**Pusa basmati-1509**	**Sampurna-(KP)108**	**Narendra -2065**	**CSR-46**	**Mean**
T_0 (Control)	22.06	25.82	23.81	24.75	22.93	23.87
T_1 (ECiw,3dSm^{-1})	28.88	33.52	31.09	32.12	30.23	31.17
T_2 (ECiw,6dSm^{-1})	16.45	19.37	17.39	18.32	16.59	17.63
T_3 (ECiw,9dSm^{-1})	11.72	14.46	12.98	13.70	12.35	13.04
T_4 (ECiw,12dSm^{-1})	8.13	10.05	9.30	9.82	8.78	9.22
Mean	17.45	20.65	18.92	19.74	18.18	

	Salinity level	Varieties	Interaction
SE. m±	0.168	0.168	0.265
CD(P=0.05)	0.334	0.334	0.746

Table 8: Effect of saline water irrigation on Grain weight/plant

Varieties / Salinity levels	EC of Irrigated water					
	Pant-24	**Pusa basmati-1509**	**Sampurna-(KP)108**	**Narendra -2065**	**CSR-46**	**Mean**
T_0 (Control)	26.51	30.67	28.47	29.60	27.46	28.54
T_1 (ECiw,3dSm^{-1})	34.76	39.99	37.20	38.36	36.17	37.30
T_2 (ECiw,6dSm^{-1})	19.05	22.27	20.19	21.18	19.31	20.40
T_3 (ECiw,9dSm^{-1})	13.36	16.34	14.69	15.49	14.04	14.79
T_4 (ECiw,12dSm^{-1})	9.09	11.14	10.31	10.86	9.80	10.24
Mean	20.56	24.08	22.17	23.10	21.35	
	Salinity level		Varieties		Interaction	
SE. m±	0.198		0.198		0.314	
CD(P=0.05)	0.394		0.394		0.882	

3.5 Determination of proline content

The proline content of leaves was ascertained using the procedure of to determine proline; leaf material was extracted using 3% aqueous solution of 5 sulfosalicylic acid. The proline content in the leaves was calculated using the method outlined by Bates et al. (1973) and recorded in µg/g fresh weight. In short, 5 ml of 3% sul-fosalcylic acid was mixed with 0.1 g of rice leaves, and the resulting combination was filtered. Two milliliters of the filtered mixture and two milliliters each of acid-ninhydrin and glacial acetic acid were put to a test tube. After using a Vortex mixer to combine the mixture, it was cooked for one hour at 100 °C. After that, the mixture was put on ice, mixed with 4 milliliters of toluene, and allowed to stand for five to ten minutes. At 520 nm, the reddish-pink up-per phase's absorbance was measured in comparison to a toluene blank.

Proline content pre and post-anthesis (*µ*moles)

Pre anthesis stage, the increasing levels of 3,6, 9 and 12 dSm^{-1} salinity over control increased proline content in leaves by 192.40, 172.41, 164.20 and 158.42 times in of study. Similarly at post-anthesis stage, increase in salinity from control to 3, 6, 9 and 12 dSm^{-1} levels increased proline content by 112.0, 115.4, 110.2, and 112.4 times in year, respectively. These figures indicated that effect of salinity on proline was more pronounced at post anthesis stage than pre anthesis.

Among varieties, significantly maximum proline content was estimated in leaves at anthesis stage, variety Pusa Basmati-1509, contained 231.72 and 242.00 more proline in year, as compared to varieties Narendra-2065, Pant-24, CSR-46 and Sampurna KP-108, respectively. Similarly, at post anthesis stage during both years.

Table 9: Effect of saline water irrigation on Proline content pre-anthesis (μ moles)

Varieties / Salinity levels	EC of Irrigated water					
	Pant-24	**Pusa basmati-1509**	**Sampurna-(KP)108**	**Narendra -2065**	**CSR-46**	**Mean**
T_0 (Control)	185.27	192.72	180.24	190.67	182.82	186.34
T_1 (ECiw,3dSm^{-1})	191.44	199.13	186.24	197.02	188.17	192.40
T_2 (ECiw,6dSm^{-1})	171.54	178.43	166.88	176.54	168.61	172.41
T_3 (ECiw,9dSm^{-1})	163.38	169.95	158.95	168.14	160.59	164.20
T_4 (ECiw,12dSm^{-1})	137.21	146.74	140.77	144.12	143.16	158.42
Mean	169.76	177.39	166.61	175.29	168.67	
	Salinity level		Varieties		Interaction	
SE. m±	0.853		0.853		0.729	
CD(P=0.05)	2.681		2.681		0.000	

Table 10: Effect of saline water irrigation on Proline content post-anthesis (μ moles)

Varieties / Salinity levels	EC of Irrigated water					
	Pant-24	**Pusa basmati-1509**	**Sampurna-(KP)108**	**Narendra -2065**	**CSR-46**	**Mean**
T_0 (Control)	108.75	117.14	105.18	114.84	103.09	109.8
T_1 (ECiw, 3 dSm^{-1})	110.14	119.63	107.53	117.29	105.41	112.0
T_2 (ECiw, 6 dSm^{-1})	114.32	122.94	110.66	120.57	108.51	115.4
T_3 (ECiw, 9 dSm^{-1})	105.17	113.42	101.66	111.15	119.60	110.2
T_4 (ECiw, 12 dSm^{-1})	119.40	107.41	115.99	105.21	113.99	112.4
Mean	112.50	116.10	108.20	113.81	110.12	
	Salinity level		Varieties		Interaction	
SE. m±	0.648		0.648		0.579	
CD(P=0.05)	1.118		1.118		0.000	

4. Conclusion

The result of present investigation could be concluded that irrigation with saline water of 3dsm^{-1} had no adverse effect on crop plants; rather it was beneficial to the crop. In case of Rice variety, CSR-46 can be recommended for cultivation in the areas prone to saline water irrigation. Due to better germination ability, dry matter accumulation, less sodium and higher potassium content low sodium and potassium ratio, better yield attributes rice variety CSR-46 can be utilized by breeders in varietal improvement programme for salt tolerance under saline water irrigation.

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