Evaluation of the Salinity Tolerance of some Rice (Oryza Sativa) Genotypes of Kashmir Valley

Subzar Ahmad Sheikh[1] Mohd Rafiq Wani[2]
[1,2]Department of Botany
[1,2]Govt. Degree College (Boys) Anantnag, J and K (India)

Abstract— The salinity tolerance of four rice genotypes, at germination and early seedling stages was evaluated using six salinity levels of Nacl and Kcl. Data regarding final germination percentage, germination energy percentage, plumule and radical length and seedling dry weight were recorded. Salinity decreased the various parameters studied in different varieties and the degree of inhibition increased with increasing salinity level. At 20 dS m-1 salinity level, germination was completely inhibited for all four genotypes. Using seedling dry matter reduction as the criteria, the genotypes were categorized as tolerant (T), moderately tolerant (MT), moderately susceptible (MS) or susceptible (S). Jhelum showed greater dry matter accumulation and better salt tolerance during germination and early seedling growth compared to other three genotypes. The results suggest that Jhelum can be recommended to be cultivated on the slightly saline soils.

Key words **:** salinity, germination, dry matter, tolerance

I. INTRODUCTION

Plants face a range of stresses such as salinity, drought, temperature and toxic heavy metals during their cultivation. These stresses affect the growth and production of majority of the crops. Salty soils have rich concentration of various salts such as sodium chloride (NaCl). These soils show low production [1] and are an environmental concern in arid and semi-arid regions of the globe. According to reference [2], in India alone, there is nearly about 9.38 million ha of salt affected land, including 5.5 million ha of saline soils and 3.88 million ha of alkaline soils. They spread from Jammu and Kashmir in north to Kanyakumari in south and Andaman Nicobar in east to Gujarat in west. There are about 955 million ha of primary salt affected and 77 million ha of secondary affected, with half of them being irrigated ones [3]. According to reference [4], salinity is a leading concern over enormous areas in south and south East Asia. Irrigation water salts are the primary cause of man-made salinization and the water logging in irrigated lands being the secondary. Many workers have reported that salinity is one of the most detrimental stresses for crop productivity [5], [6]. Escalating problem of soil salinity has become a grave concern as it affects productivity and threatens the sustainability of agriculture [7]. Crops vary in their response to salinity and some crops are sensitive and others are resistant. Sensitive plant species lose their vigor even in marginally saline soils whereas resistant species not only thrive but perform well even in the severely saline soils. Reference [8], reported that plant growth is suppressed even at low salt concentrations and higher concentration can lead to the death of the plant. Salt stress affects many metabolic and physiological processes in plants, like germination, growth, photosynthetic activity, protein synthesis, energy and lipid metabolism. The detrimental effects of salinity on plant growth are associated with one or a combination of, low osmotic potential, nutritional imbalance and salt stress [9]. Many workers have reported variations in germination ability in different crop species under saline conditions, and a significant variation was also experienced between the varieties of the same crop [10], [11]. Reference [12], reported an evident variation in germination of rice varieties under the influence of salinity. Based on the classification of crop species tolerance to salinity, the rice crop is within the sensitive division from 0 to 8 dS m-1 [11]. A number of workers have reported that most rice varieties are very sensitive to salinity during germination, and early seedling growth and developmental stages [13], [14]. Rice becomes very sensitive at the young seedling stage, which impacts the stand density in salt affected fields [15]. Two essential parameters sufficient for expressing salt tolerance i.e. Threshold - maximum allowable salinity without yield reduction and slope -the percent of yield reduction per unit increasing in salinity beyond the threshold for rice are 3.0 dSm^{-1} and 12 % per dSm^{-1} of saturated soil extract (ECe), respectively [16]. Relative salt tolerance of rice at 50% yield and at 50 % emergence are 3.6 dSm^{-1} and 18 dSm^{-1} of ECe, respectively[17].

Rice (*Oryza sativa*) commonly known as Asian rice is a monocot plant bearing the edible seed, caryopsis. Though normally grown as an annual plant, it can survive as a perennial in tropical areas. It is the most widely consumed staple food for a large part of the world's population, especially in Asia and the West Indies. With a total production of 718,345,380 tonnes, rice ranked at second position in terms of global production in 2012 [18]. China ranks first and India at second position in terms of total rice production. Rice is grown at varying altitude, on a range of soils under various climatic and hydrological conditions, including waterlogged ill drained soils, rain fed soils, irrigated conditions etc. In India, rice growing seasons vary in different parts of the country. In eastern and southern parts, 2 to 3 crops of rice are grown per year because of favourable temperature for rice cultivation, while as due to low winter temperature, only one rice crop is grown in northern and western parts. The main rice growing season in the country is the 'Kharif'.

Rice production is an important component of India’s food security and national economy. India's rice production reached to a record high of 104.32 million tonnes in 2011-2012. Keeping in view the significance of rice in Indian agriculture, its pivotal role in the nutritional scenario and the extent of salinity affected soils in the country, this study was undertaken to screen and identify the genotypes for salinity tolerance.

II. MATERIAL AND METHODS

The experiment was conducted in the seed technology laboratory of the Government Degree College Boy’s

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Anantnag, during August 2012. Seeds of four rice varieties namely Jhelum, China, Shalimar and a local cultivar Gymnasary were used for the experiment. The seeds of varieties Jhelum, China and Shalimar were obtained from SKAUST rice research Centre Khudwani, and the seeds of local cultivar, Gymnasary were obtained from a farmer from the village Larnoo, Kokernag of Anantnag District. The seeds were first surface sterilized with 1% sodium hypochlorite for ten minutes and then washed thoroughly with distilled water. The experiment was carried out in glass Petri dishes of nine centimeter diameter. Each Petri dish was lined with fresh sterilized cotton. On each Petri dish 20 seeds of particular variety were placed. Solutions of NaCl and Kcl with different salinity levels ranging from 0, 2, 4, 6, 8, 12, 16 and 20 ds m^{-1} were prepared. The cotton in each Petri dish was moistened with a solution of particular salinity levels. The experiment was conducted in completely randomized design with three replications for each treatment and for each variety. The Petri dishes were placed in the germinator and were maintained at a temperature of 25±10C.The number of seeds that germinated was recorded per day, up to 14 days. After final count, final germination percent (FGP) and germination energy percentage (GE %) was calculated as per the formulae of [19] and [20]. Plumule and radical length of the ten randomly selected seed lings were measured at the time of the harvest i.e. 14 days after treatment. Shoot and root dry weights were recorded after oven drying them at 70^0C for three days. As per the criteria of [21], based on the extent of the reduction (%) in the total dry weight the genotypes were categorized as tolerant (T = with 0 - 20% reduction), moderately tolerant (MT = with 21 - 41% reduction), moderately susceptible (MS =with 41 - 60% reduction) and susceptible(S =with greater than 60% reduction).

FGP= final number of germinated seeds/ total number of seeds tested ×100

GE (%) = Number of germinated seeds at 4 DAS /Total number of seeds tested×100

Salt solution of desired salinity levels were prepared using the equation of [22]

EC = TDS/640 Where, EC = Electrical conductivity and TDS = Concentration of soluble salts in mg/L

III. RESULTS

The data regarding Final germination percent (FGP), Germination Energy (%), Plumule length, Radicle length and Seedling dry weight is given in table 1.

The final germination percentage decreased drastically with the increasing salinity concentrations. The decrease in germination percentage was more significant in higher salinity concentrations of both the salts and for all the four varieties tried. At 20 ds m-1 salinity, there was no germination for all the four varieties and in both salts. The germination percentages were inversely related to the salinity levels. At all concentrations of salinity varietal difference were observed. Among various salinity concentrations highest germination percentage were recorded at 4 ds m^{-1} for every variety and in both salts.

Variety	Treatment	Salinity level (ds m^{-1})	Germination (%)	Germination energy (%)	Plumule length (cm)	Radical length (cm)	Seedling dry weight g/10plants	Reduction in dry weight (%)	Toler-ance
Jhelum	Nacl	0	96.00	80.00	6.3	6.0	0.096	-	-
		4	96.00	76.00	6.2	5.2	0.090	6.25	T
		8	86.66	61.33	5.5	4.9	0.087	11.46	T
		12	74.66	50.66	3.9	4.5	0.066	36.46	MT
		16	44.66	34.66	2.5	3.8	0.057	46.87	MS
		LSD	7.23	8.46	0.43	0.5	0.003	-	-
	Kcl	0	96.00	80.00	6.3	6.0	0.096	-	-
		4	96.00	74.00	5.9	4.9	0.089	4.16	T
		8	84.00	61.33	4.8	4.6	0.080	11.46	T
		12	69.33	43.33	2.9	3.7	0.063	38.54	MT
		16	36.66	30.00	1.9	3.1	0.050	53.13	MS
		LSD	6.32	6.84	0.52	0.6	0.003	-	-
China	Nacl	0	93.33	77.33	6.3	5.8	0.095	-	-
		4	84.00	62.66	6.0	4.8	0.082	13.68	T
		8	69.33	46.66	5.8	4.3	0.071	25.00	MT
		12	58.66	34.66	4.0	3.7	0.056	41.10	MS
		16	22.66	21.33	2.2	2.7	0.044	53.68	MS
		LSD	7.55	5.24	0.44	0.5	0.005	-	-
	Kcl	0	93.33	77.33	6.3	5.8	0.095	-	-
		4	78.66	60.00	5.3	4.4	0.073	23.20	MT

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		8	62.66	40.00	4.2	3.8	0.064	32.63	MT
		12	49.33	32.00	2.4	3.3	0.054	43.16	MS
		16	18.66	18.66	0.9	2.8	0.040	57.90	MS
		LSD	7.98	5.63	0.62	0.3	0.004	-	-
Shalimar	Nacl	0	96.00	78.66	6.1	5.7	0.088	-	-
		4	90.66	64.00	5.4	4.3	0.080	9.10	T
		8	77.33	52.00	4.0	3.8	0.069	21.60	MT
		12	54.66	37.33	2.2	3.2	0.054	38.64	MT
		16	26.66	17.33	0.9	2.4	0.044	50.00	MS
		LSD	5.20	4.42	0.42	0.4	0.006	-	-
	Kcl	0	96.00	78.66	6.1	5.7	0.088	-	-
		4	80.00	61.33	4.9	3.9	0.072	18.18	T
		8	69.33	46.66	3.7	3.4	0.061	30.70	MT
		12	54.66	34.66	1.8	2.8	0.050	43.20	MS
		16	20.00	14.66	0.7	2.3	0.038	56.82	MS
		LSD	8.23	4.57	0.40	0.3	0.005	-	-
Gymnasari	Nacl	0	93.33	76.00	6.0	4.9	0.082	-	-
		4	86.66	64.00	5.1	3.9	0.064	21.95	MT
		8	73.33	50.66	3.8	3.2	0.053	35.37	MT
		12	52.00	36.00	1.7	2.7	0.039	52.44	MS
		16	21.33	16.00	0.4	1.9	0.028	65.85	S
		LSD	5.60	4.72	0.51	0.6	0.007	-	-
	Kcl	0	93.33	76.00	6.0	4.9	0.082	-	-
		4	74.66	58.66	4.5	3.5	0.057	30.49	MT
		8	58.66	44.00	3.2	3.1	0.044	46.34	MS
		12	45.33	28.00	1.4	2.4	0.036	56.10	MS
		16	17.33	14.66	0.5	1.6	0.025	69.50	S

For all four varieties and almost at every concentration KCL had more negative /inhibitory effect on germination than the corresponding concentrations of NaCl. With the exception of Jhelum variety, both the salts inhibited the germination at every concentration. The effect on variety Jhelum was least in comparison to the other varieties and its final germination percent remained same as that of the control (96%) at4 ds m^{-1} of NaCl as well as Kcl. At 4 ds m^{-1} concentration of NaCl all the varieties showed more than 80% germination but in case of KCL even at this concentration the germination percentage of varieties China and Gymnasari was reduced to below 80%. At all levels of salt concentration the variety Jhelum showed the highest germination percentage than the other three varieties. The differences in salinity tolerance between rice genotypes at germination have been observed by many workers [23], [24]. Hakim et al. [25] also observed varietal difference to salinity in rice varieties. The reduction in germination is possibly because of the osmotic effect of the salinity [26].

The germination energy percent was calculated after 4th day of soaking. The germination energy decreased significantly at all levels of salinity in both salts, but the effect was moderate at the lower salinity concentrations than the higher concentrations. The effect was more adverse with KCl than NaCl. Further the varietal difference in terms of germination energy was observed in their response to the salt concentrations. Among the four varieties tested Jhelum variety showed the highest germination energy (%) in comparison to the other varieties almost on every concentration and for the both salts tested.

Plumule length significantly decreased in all the varieties in all the salt concentrations except for 4dsm-1 Nacl for Jhelum and China were the decrease was not significant. The decrease in plumule length was less at low salinity levels, but at the salinity level of 8 ds m^{-1} and higher levels the decrease in the plumule lengths was drastic. Out of the four varieties tested the variety Jhelum showed lesser decrease in the plumule length in all saline levels compared to the other varieties.

Like the plumule length the radical length also decreased in the different saline levels in all the four varieties. The decrease was significant at all levels. Compared to other varieties, Jhelum showed lesser inhibition in the radical length in the different saline levels.

The seedling dry weight was inversely proportional to the salinity levels. The seedling dry weight decreased significantly with the increased salinity levels and it reduced drastically beyond the levels of 12 ds m^{-1} and higher. The decrease in seedling dry weight was low in the variety Jhelum compared to the other three varieties. Variety

Jhelum proved to be tolerant in most of the salinity levels where as the other three varieties proved to be susceptible in most cases.

IV. DISCUSSION

A decrease in final germination percent was recorded in the present study. Further variation in salinity tolerance among rice genotypes at germination has also been observed and same has been reported by many workers earlier [23], [24]. Probably, the osmotic effect of the salinity was the main inhibitory factor for germination as specified by [26], [27]. The final germination percentage decreased as the level of salinity increased. High levels of salinity inhibit the seed germination significantly. This agrees with previous record of [28] in *Suaeda salsa* and [27] in *Sorghum biolor*. With the increase in the salinity, there was decrease in the germination energy in all levels. These results are in agreement with those of [29] and [12] who observed that salinity delayed germination processes. Folkard and Wopereis [30] and Hakim et al. [25] while working with rice also observed that increase in salinity delayed germination. According to [31], salinity stress seemed to effect germination by inadequate water absorption [32], excessive nutrient pool use [33] and protein synthesis disorders. Further, salinity stress also effects alpha and beta amylase during seed germination [34], [31].

The consistent decrease in radicle length with the increasing salinity observed in this study might be due to inhibitory effect of NaCl salt more to root growth compared to that of shoot growth [35], [25]. Many workers [29], [36] suggest that crop plants grown under saline conditions show reduced seedling height. Similarly, [37] observed that shoot length, root lengths and dry weight were decreased with increasing salt stress. The seedling dry weight reduction under increased salinity level reported in this study is in agreement with the result of many workers and previous reports in wheat [38], and sugar beet, cabbage, amaranth and pak-choi [39] , in sorghum [40] and in *Sorghum biolor* [27].

The rice varieties like China , Shalimar and Gymnasari were less salt affected during germination implies that these cultivars are salt tolerant during germination than subsequent growth like seedling biomass production. As their biomass considerably decreases therefore they cannot be cultivated even at the low saline soils.It is in agreement with the view of [41], who suggest that a crop may germinate successfully under salt stress but its seedling growth may be reduced. Many workers like [42] in rice, [40] in sorghum and [27] in *Sorghum bicolor*, have reported that a crop can be salt sensitive during both germination and seedling growth. Since the rice cultivar, Jhelum had highest Final Germination Percentage, germination energy and seedling dry weight production; it can effectively establish itself on moderately saline soils.

V. CONCLUSIONS

The results in the current study revealed the presence of variation among rice genotypes in response to salinity stress during seed germination and early seedling growth-biomass production. The results proved that variety Jhelum was the most salt tolerant of the four genotypes studied and for both the salts tested. It showed highest germination percentage, germination energy, seedling growth and biomass compared to other cultivars, thus it could be cultivated on slightly saline soils. However because of the fact that at higher saline concentrations the germination percentage, germination energy, seedling growth and biomass production was also reduced considerably in case of the Jhelum variety also, therefore it indicates that it also is not fit for cultivation at higher salinity levels. Further, need of the hour is to screen the other available rice genotypes for salinity tolerance or aim at elevating the tolerance level of the Jhelum genotype by different breeding procedures.

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