Original Research Article

Study on genetic variability and heritability in rice landraces (*Oryza sativa*. L.) under sodicity

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A B S T R A C T

The study was conducted to identify salt tolerant rice landraces among 71 genotypes including 64 landraces and seven cultivars. Analysis of variance exhibited significant differences among the genotypes for all the traits under study. High PCV and GCV were recorded for the traits *viz.*, number of productive tillers per plant, number of grains per panicle, Na^+/K^+ ratio, 1000 grain weight and grain yield per plant. High heritability coupled with high genetic advance were observed in the traits *viz.*, days to 50% flowering, plant height, number of productive tillers per plant, number of grains per panicle, Na^+/K^+ ratio, 1000 grain weight and grain yield per plant. *Poovan samba*, *Rajamannar*, *Katta samba* and *Sornakuruvai* were identified as highest yielding among the landraces under sodicity. Hence, these landraces could be used as donors in development of salt tolerant lines in future breeding programme.

Introduction

Rice (*Oryza sativa* L.) is the major source of food for one-third of the global population and 70% of Indian population. Salt affected areas in India were found to be 6.7 mha. Out of which 2.9 mha areas were saline and 3.7 mha area were sodic (Mandal *et al.,* 2011). In India, rice is grown in 43.79 million ha area with production and productivity of 116.42 million tonnes and 2.7 tonnes/ha. Tamil Nadu accounts for 6.45 million tonnes of production and 3.7 tonnes/ha and productivity of rice in

an area of 1.72 mha (Agricultural statistics, 2019)

Salt stress adversely affects crop growth by reducing photosynthetic capacity of plants. High level of sodium in soil causes osmotic stress on cell water relations and increase the toxicity of sodium in the cytosol leading to damage of cell metabolism and photosynthesis (Gupta *et al.,* 2020).

Na^+ and K^+ show similar ionic as well as physical and chemical properties. K^+ plays

major role in many physiological process and cell metabolism for normal growth and development. Under salt stress conditions, Na^+ concentration exceeds the optimal level, reducing K^+ uptake in roots. This causes lesser retention of K^+ in different plant parts. Na^+ enters K^+ pathway and alters ion ratio in the cytosol leading to toxicity. Salt tolerant plants maintain low cytosolic Na^+/ K^+ ratio through some strategies *viz.*, extrusion of excess Na^+ through roots and compartmentalization in different parts, which in turn decreases Na^+ concentration in cytosol. This osmotic adjustment aids in overcoming adverse salt effects, thus producing considerable yield (Chakraborty *et al.,* 2018).

Due to continuous cultivation of high yielding varieties there is loss of variability in local cultivars. Landraces have high genetic variability and are highly tolerant to abiotic and biotic stresses owing to reasonable yield. Hence, landraces should be conserved and utilized as parents in breeding programme to prevent loss of genetic variability.

The genetic variability parameters such as Phenotypic Coefficient of Variation (PCV), Genotypic Coefficient of variation (GCV), Heritability and Genetic Advance as percent Mean (GAM) are useful in identifying the extent of variation present in the population. The present investigation was undertaken to assess the variability parameters contributing to yield and to identify salt tolerant rice landraces.

Materials and Methods

The present study was carried out at Anbil Dharmalingam Agricultural College and Research Institute, Tamil Nadu Agricultural University, Trichy, Tamil Nadu during October 2019 to February 2020 (late *samba* 2019) under sodic soil condition with EC 1.3 dSm^{-1}; pH 8.85 and ESP 43.2 respectively.

The experimental material composed of 71 genotypes including 64 landraces and seven cultivars (Table 1). The experimental field was laid out using randomized block design with three replications. Seeds were sown on raised nursery beds and transplanted in the experimental field by adapting spacing of 20x20 cm. Recommended agricultural practices were practiced for normal establishment of crop.

Observations were recorded for ten traits including eight morphological and two physiological traits *viz.*, days to 50% flowering, plant height, number of productive tillers per plant, panicle length, number of grains per panicle, spikelet fertility percentage, chlorophyll content, Na^+/K^+ Ratio, 1000 grain weight and grain yield per plant. Na^+/K^+ Ratio for the rice landraces were estimated by flame photometry method and chlorophyll content was recorded using SPAD (Soil Plant Analysis Development) meter. Analysis of variance and estimates of coefficient of variation (phenotypic and genotypic) were estimated as per the methodology proposed by Panse and Sukhatme (1967) and Burton (1952). Heritability in broad sense (Lush, 1940) and genetic advance as percent of mean (Johnson *et al.,* 1955) were also estimated for the characters studied. The range of heritability was classified as low (10-30%), medium (30-60%) and high (>60%) as suggested by Johnson *et al.,* (1955).The genetic advance for the traits were classified as high (>20%), moderate (10-20%) or low (<10%) as given by Johnson *et al.,* (1955). The statistical analysis was carried out using TNAUSTAT software.

Results and Discussion

Genetic variability is much essential for the survival of species. The extent of variation present in the genotypes should be exploited

for choosing the breeding programme to be adapted and for the improvement of cultivars. Analysis of variance showed that the mean sum of squares for genotypes were highly significant for all the characters studied (Table 1). It indicates that presence of high variability for the traits in rice landraces used in the study.

Table 3. represents mean and range for different traits of rice genotypes *Pokkali*, AC39389 (*Chettivirippu*) and AC39394 (*Chettivirippu*) recorded minimum number of days to 50% flowering (72.0) followed by *Thattan samba* (75.0), *Kuthir* (76.0) and *Poongar* (76.7) and the maximum number of days to 50% flowering was registered by *Poovan samba* (108.3). The trait plant height showed wide range of variation from 91.67 cm to 201.07 cm with a mean value of 142.25 cm. Landrace *Kaatuyaanam* (91.67 cm) was found to be the tallest genotype and TKM 13 (201.07 cm) was the shortest. The landrace *Navaraan* (16.47) produced maximum number of tillers and *Malayalathan samba* (6.13) produced least number of tillers. The mean value of the above trait was 10.58. The shortest panicle length was observed in the landrace *Jeeraga samba* (18.41 cm) while longest panicle length was observed in *Kichali samba* (28.66 cm). This trait registered mean value of 23.36 cm. The range of number of grains per panicle varied from 63.78 to 244.67 with a mean value of 136.88. *Karunguruvai* produced minimum (63.78) and *Rajamannar* (244.67) produced maximum number of grains per panicle. The trait spikelet fertility percentage ranged from 73.66 % to 98.06% with a mean value of 90.06%. *Milagu samba* (98.06%) expressed highest and *Pisini* (73.66%) expressed lowest spikelet fertility percentage. The mean value observed for chlorophyll content was 32.78. *Sandikar* recorded (24.60) low and AC39389 (41.79) recorded high chlorophyll content. Na^{+}/K^{+} ratio varied from 0.03 ppm (*Poovan*

samba) to 0.94 ppm (*Mattakuruvai*) with mean Na^{+}/K^{+} ratio of 0.35 ppm. Range for 1000 grain weight varied from 13.80 g to 32.58 g with an average of 22.98 g. *Malayalathan samba* (32.58 g) was found to be the landrace with highest 1000 grain weight and TKM 13 found to be the lowest with 13.80 g. TRY 3 was identified as the highest yielding genotype with grain yield per plant of 43.36 g followed by the landraces *Poovan samba* (43.29 g), *Rajamannar* (41.81), *Katta samba* (41.68 g) and *Sorna kuruvai* (40.60 g). *Mattakuruvai* recorded lowest grain yield per plant of 9.74 g followed by *Kichali samba* (11.90 g), *Kuliyadichan* (13.02 g), *Karunguruvai* (13.86 g) and *Shenmolgi* (14.75 g).

Estimates of genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), broad sense (h^2) heritability and genetic advance as per cent of mean (GAM) were given in Table 3. PCV and GCV along with heritability and genetic advance as percent mean for the traits favours in determining the breeding programme to be followed for the purpose of crop improvement.

High PCV and GCV was expressed by the traits such as Na^{+}/K^{+} ratio (59.33%, 57.66%), grain yield per plant (31.11%, 30.54%), number of grains per panicle (28.59%, 28.54%), number of productive tillers per plant (23.75%, 22.99%) and 1000 grain weight (23.20%, 23.07%). Similar findings were reported by Dhakal *et al.,* (2020) for number of productive tillers per plant, Kumar *et al.,* (2020) for number of grains per panicle and Devi *et al.,* (2020) for 1000 grain weight and grain yield per plant and Keerthana *et al.,* (2019) for Na^{+}/K^{+} ratio.

The traits plant height (18.78%, 18.68%) and days to 50% flowering (10.73%, 10.65%) showed moderate PCV and GCV. These

findings were in agreement with Akter *et al.,* (2018) for plant height and Behera *et al.,* (2018) for days to 50% flowering.

The traits, panicle length (11.05%, 9.76%) and chlorophyll content (10.53%, 9.62%) exhibited moderate PCV and low GCV.

Spikelet fertility percentage (6.61%, 6.30%) showed low PCV and GCV. The results were in accordance with the findings of Jadhav *et al.,* (2020) for panicle length and spikelet fertility percentage and Shrivastav *et al.,* (2020) for chlorophyll content.

Table.1 List of rice landraces

S. No	Genotypes	S. No	Genotypes
1.	*Singinikar*	37.	*Poombalai*
2.	*Vaadan samba*	38.	*Kichali samba*
3.	*Kaatu samba*	39.	*Kulivedichan*
4.	*Katarni*	40.	*Murugankar*
5.	*Navaraan*	41.	*Katta samba*
6.	*Vaal sigappu*	42.	*Shenmolgi*
7.	*Jeeraga samba*	43.	*Vellaichithirai kar*
8.	*Swarna kichadi*	44.	*Malayalathan samba*
9.	*Sandikar*	45.	*Kodai*
10.	*Milagu samba*	46.	*Sorna kuruvai*
11.	*Rajamudi*	47.	*Kattikar*
12.	*Salem samba*	48.	*Ponmani samba*
13.	*Karuthakar*	49.	*Seevana samba*
14.	*Karunguruvai*	50.	*Matta kuruvai*
15.	*Rasakedam*	51.	*Sirumani*
16.	*Pisini*	52.	*Palkachaka*
17.	*Rajamannar*	53.	*Mattaikar*
18.	*Kottara samba*	54.	*Vadivel*
19.	*Rathasali*	55.	*Panamara samba*
20.	*Iluppaipoo samba*	56.	*Kalarkar*
21.	*Poongar*	57.	*Thillainayagam*
22.	*Kalanamak*	58.	*Norungan*
23.	*Kuliyadichan*	59.	*Thattan samba*
24.	*Kothamalli samba*	60.	*Senkar*
25.	*Koombalai*	61.	*Pokkali*
26.	*Kaatu ponni*	62.	AC 39389 (*Chettivirippu*)
27.	*Thooyamalli*	63.	AC 39394 (*Chettivirippu*)
28.	*Cochin samba*	64.	*Kuthir*
29.	*Kavuni sigappu*	65.	Bhavani
30.	*Kaatuyaanam*	66.	TRY 1
31.	*Garudan samba*	67.	TRY 2
32.	*Poovan samba*	68.	TRY 3
33.	*Kallimadayan*	69.	ADT 43
34.	*Vasaramundan*	70.	ADT 53
35.	*Karuppu kavuni*	71.	TKM 13
36.	*Iravaipandi*		

Table.2 Analysis of variance for plant architectural and biometrical traits in rice landraces

Source	df	Mean squares									
		DFF	PH	NPT	PL	NGPP	SFP	CC	Na$^+$/K$^+$	TGW	GYP
Genotype	70	261.93	2125.78**	18.13**	17.05**	4584.04**	99.73**	31.81**	0.13**	84.62**	164.37**
Replication	2	51.56	19.29	0.41	2.40	24.27	3.68	5.09	0.01	0.10	2.22
Error	140	1.31	8.13	0.40	1.47	4.56	3.27	1.96	0.00	0.32	2.03

**Significant at 1% level
DFF-Days to 50% flowering; PH-Plant height; NPT-Number of productive tillers/plant; PL-Panicle length; NGPP-Number of grains per panicle; SFP-Spikelet fertility percentage; CC-Chlorophyll content; Na$^+$/K$^+$-Na$^+$/K$^+$ Ratio; TGW-1000 grain weight; GYP-Grain yield per plant

Table.3 Variability parameters for biometrical and physiological traits in rice landraces

S. No.	Characters	Mean	Range		Coefficient of variation		h^2 (%)	GAM (%)
			Minimum	Maximum	PCV (%)	GCV (%)		
1	Days to 50% flowering	87.52	72.00	108.33	10.73	10.65	98.52	21.78
2	Plant height (cm)	142.25	91.67	201.07	18.78	18.68	98.86	38.26
3	Number of productive tillers per plant	10.58	6.13	16.47	23.75	22.99	93.68	45.83
4	Panicle length (cm)	23.36	18.41	28.66	11.05	9.76	77.92	17.74
5	Number of grains per panicle	136.88	63.78	244.67	28.59	28.54	99.70	58.71
6	Spikelet Fertility Percentage	90.06	73.66	98.06	6.61	6.30	90.78	12.36
7	Chlorophyll Content	32.78	24.60	41.79	10.53	9.62	83.52	18.11
8	Na$^+$/K$^+$ ratio (ppm)	0.35	0.03	0.94	59.33	57.66	94.45	115.44
9	1000 grain weight (g)	22.98	13.80	32.58	23.20	23.07	98.89	47.26
10	Grain yield per plant (g)	24.09	9.74	43.36	31.11	30.54	96.39	61.77

PCV - Phenotypic Coefficient of variation; GCV - Genotypic Coefficient of variation; GAM - Genetic advance as percent of mean

Heritability along with genetic advance is considered as more efficient tool for prediction of the method of improvement to be applied. High heritability coupled with high GAM were revealed by the characters *viz*., number of grains per panicle (99.70%, 58.71%), 1000 grain weight (98.89%, 47.26%), plant height (98.86%, 38.26%), days to 50% flowering (98.52%, 21.78%), grain yield per plant (96.39%, 61.77%), Na$^+$/K$^+$ Ratio (94.45%, 115.44%), and number of productive tillers per plant (93.68%, 45.83%) which implies less influence of environment hence, phenotypic selection of genotypes based on these characters could be effective. Identical findings were reported by Kushwaha *et al.,* (2020) for plant height, thousand grain weight, days to 50% flowering, and grain yield per plant. Divya *et al.,* (2018) obtained similar results for number of productive tillers per plant and number of grains per panicle.

The traits spikelet fertility percentage (90.78%, 12.36%), chlorophyll content (83.52%, 18.11%) and panicle length (77.92%, 17.74%) exhibited high heritability and moderate GAM. The results were supported by Nithya *et al.,* (2020) for spikelet fertility percentage and Shrivastav *et al.,* (2020) for chlorophyll content and Jadhav *et al.,* (2020) for panicle length,

In this study high PCV and GCV was revealed by the traits Na^+/K^+ ratio, grain yield per plant, number of grains per panicle, 1000 grain weight and number of productive tillers per plant. It indicated prevalence of variation within the population. The characters *viz*., number of grains per panicle**,** 1000 grain weight, plant height**,** days to 50% flowering, Na^+/K^+ ratio**,** grain yield per plant and number of productive tillers per plant registered high heritability along with high GAM. Hence, selection of genotypes based on these characters could be effective due to additive gene action. Further, the genotype TRY 3 recorded high grain yield per plant followed by the landraces *Poovan samba*, *Rajamannar*, *Katta samba* and *Sornakuruvai*. Hence, these genotypes may be used as parents in developing improved salt tolerant lines in future breeding programme under sodic soil condition.

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