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Studies on Genetic Variability and Heritability for Several Morpho-Physiological Traits under various Sodicity Levels in Rice (*Oryza sativa* L.)

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ABSTRACT: Rice is an effective supply of carbohydrate, proteins, fiber, lipid and fat, minerals (potassium, phosphorous, magnesium, calcium, sodium and iodine) and nutrients (thiamine, riboflavin, niacin, pyridoxine and folic acid). Rice is often consumed in poor countries with limited access to meat and fish, resulting in a deficiency in key minerals and nutrients in the diet. About 90% of the world's rice is produced and consumed in Asia, making it a staple meal. Seventy-three distinct rice genotypes, including three checks from two different farms with varying levels of sodicity i.e., pH 8.4 (at Agronomy Farm) and pH 9.5 (at Main Experiment Station) during *kharif* 2021-22, were investigated for genetic variability, heritability, and genetic advance following randomized complete block design. A collection of diverse genotypes was evaluated for fifteen various morpho-physiological traits *viz*., days to 50% flowering, plant height (cm), productive tillers per plant, panicle length (cm), flag leaf area (cm^2), fertile spikelet/panicle, spikelet fertility percent, chlorophyll content, L/B ration, leaf nitrogen, leaf temperature (SPAD Value), biological yield per plant (g), harvest-index (%), 1000-grains weight (g) and grain yield per plant (g). The analysis of variance revealed highly significant differences among the genotypes for all the traits. A look at the coefficient of variability revealed that the GCV and PCV at Agronomy Farm (pH 8.4, E_1) were quite high for productive tiller/plant, flag leaf area, biological yield/plant, chlorophyll content, and grains yield, while being moderate for plant height, fertile spikelet/panicle, and leaf nitrogen, and having the lowest values noted for days to 50% flowering, panicle length, spikelet fertility, harvest index, leaf temperature, and 1000-grain weight. PCV and GCV, on the other hand, were moderate for plant height, fertile spikelet/panicle, L/B ratio, and leaf nitrogen, and quite high for productive tiller/plant, flag leaf area, biological yield/plant, chlorophyll content, and grains yield at the main experiment station farm (E_2). They were, however, lowest for days to 50% flowering panicle length, leaf temperature, and 1000-grain weight (g) at this farm. For E_1 (pH 8.4), a high estimate of heredity was obtained for every parameter, while for E_2 (pH 9.6), a high estimate of heritability was found for every parameter with the exception of Leaf temperature. The majority of the features' high heritability and high genetic progress suggested that additive gene action predominated. In our breeding programme, selection can be used to enhance these features.

Keywords: Rice, sodicity, variability, heritability, genetic advance, *Oryza sativa*.

INTRODUCTION

More than 3.5 billion people worldwide eat rice, which is a key staple meal. The primary dietary source and a significant economic and social force for consumers in many Asian nations, rice is valued for both its nutritional value and importance as an energy and food source (Li *et al*., 2018). 90% of the world's rice is grown and consumed in this area. Due to its adaptability and ability to grow in a number of soil types and climates, rice is a crucial component of sustainable agriculture. Millions of people worldwide eat rice as a staple food since it is cheap and healthy. It is a crop that is adaptable to a range of soil types and climates and is a rich provider of nutrients.

The rice plant, which belongs to the Poaceae (Gramineae) family and has the diploid chromosome 2n=24, is a short-day plant that is susceptible to photoperiodic conditions. However, there are varieties of rice that are not affected by this condition. There are roughly 24 species of rice in the genus *Oryza*, which is found in tropical, subtropical, and warm temperate parts of the world. Only the cultivated Asian rice species, *Oryza sativa*, is made up of two subspecies, *indica* and *japonica*. *Oryza sativa* is grown extensively in Asia and other nations. *Oryza glaberrima* is grown in Africa. The second largest agricultural land in the world is held by India. World rice varieties are typically divided into three subspecies: *indica*, *japonica*, and *javanica*. This subspecies of rice includes *indica*, which is farmed in India. Their leaves have a pale green tint and are slightly pubescent in texture. Indica either lacks awns entirely or has short, smooth awns. Elongated, thin, narrow, and slightly flattened, the fruit is a caryopsis. Varieties of *japonica* rice can be grown in subtropical and warm temperate climates. Most of its cultivars have grains that are oval and circular. They might have awns or be awnless, and their slender, dark green leaves are typically grown in Japan. The *javanica* are characterized by a stiff straw, long panicle with awned grains, sparse tillering habit, long duration, and low sensitivity. Its needs a hot and humid climate. High temperature Required for growth at the time of tillering. Temperature requirement for blooming ranges from 26.5 to 29.^{0}C. At the time of ripening the temperature should be between 20 to 25 ^{0}C.

Rice farming has a lengthy history in India. After China, it ranks first in the world for rice output and second in terms of rice area. 30% of the world's rice is produced there. In the nation, rice accounts for one-fourth of all cropped land, more than 40% of all food grain output, and a crucial part of the national food and livelihood security system. With an annual production and average productivity of 129.47 million tonnes and 2424 kg per hectare, respectively, rice is grown on an area of around 46. 5 million hectares in India (Anonymous, 2021-22). Over 13.43 million hectares are irrigated. According to the FAO, salt in soils affects about 6.5% (831 million ha) of the world's total land area (12.78 billion ha). It is projected that 2% of the state's rice fields have a salt problem.

State-level production of rice is significant in Uttar Pradesh. Since 80% of the state's residents live in rural areas and 75% of all workers are directly or indirectly employed in farming and cultivation, which accounts for 27% of the state's GDP, agriculture is the most significant industry in the state. Its 11.56 million hectares of arable land account for 70% of the country's total land area. Over 13.43 million hectares are irrigated. It is expected that 2% or less of the state's rice fields have salt issues. Sultanpur, Raebareli, Ayodhya Azamgarh, Unnao, Lucknow, and Pratapgarh districts are primarily home to inland salinity zones. About 60.20 lakh hectares and 32.64 million tonnes of rice are produced in this state, with a yield of 2358 kg per hectare (Anonymous 2021-22). Despite the fact that India's average rice productivity is significantly lower than the global average, the development of high-yielding, widely adapted pure-line rice varieties and improvements in production technology over the past four decades have allowed us to satisfactorily meet the demand for rice.

The nutrients thiamine, riboflavin, niacin, pyridoxine, and folic acid as well as the minerals potassium, phosphorus, magnesium, calcium, salt, and iodine are all present in rice in sufficient amounts. A sustainable and complementary strategy to address micronutrient deficiencies is to create rice varieties with higher amounts of bioavailable micronutrients Reinke *et al*. (2019).

This can be accomplished by transgenic or traditional breeding techniques.

Keeping the above facts in view the present investigation has been planned to evaluate the genetic variability and gene action involved in governing these traits so that a suitable breeding method can be adopted for improvement in grain yield.

MATERIALS AND METHODS

At the Agronomy Farm and Main Experiment Station Kumarganj in Ayodhya during the Kharif season 2021–2022, a field experiment was undertaken. The plot size was 5 metres, and there were three replications of each genotype. The inter- and intra-row spacings were 20 and 15 centimetres, respectively. The study's experimental materials included 73 unique genotypes that were gathered from various agroclimatic zones.

These genotypes were procured from germplasm lines available in rice Section of the Department of Genetics and Plant Breeding, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya. The observations, *viz.*, days to 50% flowering, plant height (cm), productive tillers per plant, panicle length (cm), flag leaf area (cm^2), fertile spikelet/panicle, spikelet fertility percent, chlorophyll content, L/B ration, leaf nitrogen, leaf temperature (SPAD Value), biological yield per plant (g), harvest-index (%)**,** 1000-grains weight (g) and grain yield per plant (g), were recorded on the basis of five randomly selected competitive plants in each plot.

The trials were carried out at Agronomy Farm and Main Experiment Station, respectively, in two distinct sodicity levels with pH values of 8.4 and 9.5. The fertilisers were administered using urea, DAP, and Murate of potash at rates of 120 kg nitrogen, 60 kg phosphorus, and 60 kg potash per ha, respectively. To create a better environment for crop growth, all of the advised cultural practises were implemented.

Biometrical analysis is done with Genetic variability parameter *viz.*, Analysis of variance (Panse and Sukhatme, 1967), coefficient of variation (Burton and de Vane, 1953), heritability (h^2bs) (Hanson *et al*., 1956) and Genetic advance (GA) (Johnson *et al*., 1955) among characters were calculated by following standard procedures.

RESULTS AND DISCUSSION

Tables 1(a) and 2(a), respectively, present the analysis of variance for the whole randomized block design for several characters in each scenario. For all the features in the two different sodic levels, the genotypes showed highly significant differences. There was enough variation in the materials at both research farms of varied sodicity levels, as evidenced by the high significance of the mean sum of squares owing to treatments for all characters. These results are consistent with those of Fukuda *et al*. (2004).

Table 1(a): Analysis of variance (ANOVA) for fifteen characters in seventy-three rice genotypes at Agronomy farm (pH-8.4) E_1

Source of variation	DF	Days to 50% flowering	Plant height (cm)	Productive tiller /plant	Panicle length (cm)	Flag leaf area (cm^2)	Fertile spikelet /panicle	Spikelet fertility %	Biological yield /plant (g)	Harvest index %	L/B ratio	Chlorophyll content	Leaf nitrogen	Leaf temperature	1000-grain weight (g)	Grains yield (g/plant)
Replications	2	6.99	2.01	0.127	1.352	2.54	39.74	0.88	0.03	0.06	0.005	0.01	0.0000	0.96	0.426	0.42
Treatments	72	224.72**	679.89**	7.546**	7.873**	149.02**	1273.13**	129.63**	701.97**	38.20**	0.725**	16.26**	0.0185**	8.64**	9.437**	88.63**
Error	144	12.40	13.64	0.046	0.608	0.61	16.07	8.53	2.31	2.07	0.010	0.14	0.0003	1.61	0.671	0.29

Table 1(b): Estimates of range, coefficient of variation, heritability and genetic advance at Agronomy Farm (pH-8.4) E_1.

Characters	Mean	Min	Max	var (g)	var (p)	Heritability (%)	GA	GA% mean	GCV (%)	PCV (%)	ECV (%)
Days to 50% flowering	95.23	73.01	113.54	70.77	83.17	85.09	15.99	16.79	8.83	9.58	3.70
Plant height (cm)	94.97	61.26	135.44	222.08	235.72	94.21	29.80	31.38	15.69	16.17	3.89
Productive tiller /plant	6.00	3.16	10.83	2.50	2.55	98.21	3.23	53.83	26.37	26.61	3.56
Panicle length (cm)	20.71	17.21	24.87	2.42	3.03	79.93	2.87	13.84	7.51	8.41	3.77
Flag leaf area (cm2)	20.82	8.42	41.21	49.47	50.08	98.78	14.40	69.16	33.78	33.99	3.75
Fertile spikelet /panicle	107.20	56.22	151.34	419.02	435.09	96.31	41.38	38.60	19.09	19.46	3.74
Spikelet fertility %	75.95	40.22	88.38	40.36	48.90	82.55	11.89	15.66	8.37	9.21	3.85
Biological yield /plant (g)	34.90	13.46	76.93	233.22	235.53	99.02	31.30	89.69	43.75	43.97	4.35
Harvest index %	36.25	30.05	44.79	12.04	14.12	85.31	6.60	18.21	9.57	10.36	3.97
L/B ratio	2.60	1.59	4.05	0.24	0.25	96.02	0.99	37.98	18.82	19.20	3.83
Chlrophyll content	9.16	4.01	13.69	5.37	5.51	97.47	4.71	51.45	25.30	25.63	4.08
Leaf nitrogen	0.45	0.27	0.68	0.01	0.01	95.00	0.16	34.56	17.21	17.66	3.95
Leaf temperature	32.41	26.23	35.62	2.34	3.95	59.23	2.43	7.49	4.72	6.14	3.92
1000-grain weight (g)	20.36	16.04	23.40	2.92	3.59	81.31	3.18	15.60	8.40	9.31	4.03
Grains yield (g/plant)	12.55	5.35	27.45	29.45	29.73	99.04	11.12	88.65	43.24	43.45	4.25

Table 2(a): Analysis of variance for fifteen characters in seventy-three rice genotypes at Main Experiment Station farm (pH-9.5) E2.

Source of variation	DF	Days to 50% flowering	Plant height (cm)	Productive tiller /plant	Panicle length (cm)	Flag leaf area (cm^2)	Fertile spikelet /panicle	Spikelet fertility %	Biological yield /plant (g)	Harvest index %	L/B ratio	Chlrophyll content	Leaf nitrogen	Leaf temperature	1000-grain weight (g)	Grains yield (g/plant)
Replications	2	0.25	1.76	0.005	1.194	-0.01	0.04	8.02	5.98	1.24	0.012	0.34	0.0000	0.98	0.237	0.23
Treatments	72	210.68**	729.13**	11.730**	9.693**	163.46**	1332.54**	136.07**	1252.00**	40.62**	0.794**	19.70**	0.0183**	15.39**	10.171**	151.29**
Error	144	13.80	15.03	0.095	0.776	0.84	22.89	8.52	3.00	1.74	0.010	0.14	0.0004	1.37	0.585	0.45

Table 2(b): Estimates of range, coefficient of variation, heritability and genetic advance at Main Experiment Station (pH-9.5) E2.

Characters	Mean	Min	Max	var (g)	var (p)	Heritability (%)	GA	GA% mean	GCV (%)	PCV (%)	ECV (%)
Days to 50% flowering	97.21	78.21	114.97	65.63	79.43	82.63	15.17	15.61	8.33	9.17	3.82
Plant height (cm)	97.74	62.18	142.67	238.03	253.06	94.06	30.82	31.54	15.78	16.28	3.97
Productive tiller /plant	7.34	4.10	13.34	3.88	3.97	97.62	4.01	54.58	26.82	27.14	4.19
Panicle length (cm)	22.11	17.50	25.88	2.97	3.75	79.29	3.16	14.31	7.80	8.76	3.99
Flag leaf area (cm2)	22.70	10.34	44.31	54.21	55.05	98.47	15.05	66.30	32.43	32.68	4.04
Fertile spikelet /panicle	115.53	60.25	155.54	436.55	459.44	95.02	41.96	36.31	18.08	18.55	4.14
Spikelet fertility %	79.47	42.55	90.42	42.52	51.04	83.31	12.26	15.43	8.21	8.99	3.67
Biological yield /plant (g)	46.68	18.36	97.46	416.33	419.33	99.28	41.88	89.72	43.71	43.87	3.71
Harvest index %	36.74	30.78	44.78	12.96	14.70	88.14	6.96	18.95	9.80	10.44	3.59
L/B ratio	2.67	1.65	3.95	0.26	0.27	96.46	1.03	38.80	19.18	19.53	3.67
Chlrophyll content	10.10	4.38	15.15	6.52	6.66	97.84	5.20	51.51	25.28	25.55	3.75
Leaf nitrogen	0.50	0.32	0.69	0.01	0.01	93.90	0.15	30.91	15.49	15.98	3.95
Leaf temperature	32.70	26.16	38.25	4.68	6.04	77.36	3.92	11.98	6.61	7.52	3.58
1000-grain weight (g)	20.78	16.14	25.75	3.20	3.78	84.51	3.39	16.29	8.60	9.36	3.68
Grains yield (g/plant)	16.98	6.54	36.23	50.28	50.73	99.12	14.54	85.63	41.75	41.94	3.94

The genotypic coefficient of variation (GCV) value was higher than the phenotypic coefficient of variation (PCV), indicating a negligible environmental influence in the phenotypic expression of traits. At sodicity level E_1 (pH 8.4), the highest variability (genotypic and phenotypic) was exhibited in Fertile spikelet /panicle (419.02 and 435.09) and at pH 9.5, the highest variability also found in plant height (436.55 and 459.44). High variability Fertile spikelet /panicle was also reported by Sumanth *et al.* (2017,) Sheera *et al.* (2021) and Jasmine *et al.* (2022). According to Siva Subramanian and Menon's estimation of the GCV and PCV range in 1973, values greater than 20% are deemed high, while values lower than 10% are regarded low and values between 10% and 20% are considered moderate. This means that the majority of features [Table 1(b) and 2(b)] have high to intermediate GCV and PCV. This suggested that by using selection and hybridization, these features could be enhanced for breeding rice types with high yields.

According to Johnson, Robinson and Comstock (1955), broad sense heritability classified as low (<25%), medium (25% to 75%) and high (>75%). This shows most of the traits studied can be easily improved through selection. At Agronomy Farm (E_1) has all traits found high heritability value (>75%) and at Main Experiment Station(E_2) the medium heritability in Leaf temperature (59.23s%) showed the more influence of environment on this trait. Therefore, direct selection for this trait is not effective. Since heritability do not always indicate genetic gain, heritability coupled with genetic advance is more effective for selection. These results are in accordance the earlier reports of Krishna and Raju (2020) and Sheera *et al*. (2021).

Genetic advancement denotes the anticipated evolution brought on through selection. In polygenetic traits, it was once employed to estimate the type of gene action. Genetic progress is rated as low (10%), moderate (10%–20%), and high (>20%) as a percentage of the mean. At pH 8.4, the range for biological yield per plant (g) is 7.49 leaf temperature to 89.69%, while at pH 9.5, it is 11.98% leaf temperature to 89.72%. The majority of the characteristics, including grain yield, showed high heritability and high genetic progress at both sodicity levels (Table 2b), indicating that these qualities were regulated by additive gene action and were simple to select through phenotypic selection. Gyawali *et al*. (2018), Bandi *et al.* (2018) and Yadav *et al*. (2019) also observed similar reports in their study.

Although a character with a high heritability value is least affected by external influences, this does not necessarily mean that such qualities should not be chosen for improvement (Singh et al., 2018). Days to 50% blooming exhibits strong heritability and modest genetic progress at both sodicity levels, demonstrating that this characteristic is influenced by both additive and non-additive gene activity. This demonstrated that there is a chance for direct selection of this character. Therefore, breeding for such features could use heterosis. The findings on genetic variation indicated that PCV (phenotypic coefficient of variation) was generally larger than GCV (genetic coefficient of variation). This outcome demonstrated how each trait's phenotypic expression is influenced by the environment. However, there is a distinction between the phenotypic and genotypic coefficients of variation. Similar pattern of variability was also earlier noted by Supriya *et al*. (2017), Jan and Kashyap (2020) and Jasmine *et al*. (2022).

CONCLUSION

In the current experiment, it was determined that plant height (cm), productive tiller / plant, flag leaf area (cm^2), fertile spikelet / panicle, biological yield / plant (g), L/B ratio, chlorophyll content, leaf nitrogen, and grains yield (g/plant) are the most significant characters at both Sodicity levels because they have high heritability coeficients. This suggests that the regulating gene responsible for these features involves additive gene activity. Therefore, these traits could be enhanced through selection in generations that are segregated. The total outcome demonstrated that the genotypes under study had sufficient diversity. Using the right breeding methods and programmes, this diversity could be successfully managed to create better cultivars. Most qualities at both farms of the two distinct sodicity levels showed high estimates of heritability and genetic progress, showing the preponderance of additive gene action and the potential for direct selection through these traits.

REFERENCES

Anonymous (2021-22). Department of Agriculture and Farmers Welfare, MOA & FW.

Bandi, H. K., Rao, K. N., Krishna, K. V. and Srinivasulu, K. (2018). Variability, Heritability and Genetic Advance for Quantitative Characters in Rice Fallow Blackgram [*Vigna mungo* (L.) Hepper] *International Journal of Current Microbiological Applied Science*, *7*(2), 171-176.

Burton, G. M., de Vane, E. H. (1953). Estimating heritability in tall fescue (*Festuca arundinacea*) from replicated clonal material. *Agronomy Journal, 45*, 471-81.

Fukuda, A., Nakamura, A., Tagiri, A., Tanaka, H., Miyao, A., Hirochika, H., & Tanaka, Y. (2004). Function, intracellular localization and the importance in salt tolerance of a vacuolar Na+/H+ antiporter from rice. *Plant and cell physiology*, *45*(2), 146-159.

Gyawali, S., Poudel, A. and Poudel, S. (2018). Genetic Variability and Association Analysis in Different Rice Genotypes in Mid-Hill of Western Nepal. *Acta Scientific Agriculture*, *2*(9), 69-76.

Hanson, C. H., Robinson, H. F., Comstock, R. E. (1956). Biometrical studies of yield in segregating population of Korean Lespedeza. *Agronomy Journal, 45*, 268-272.

Jan, N. and Kashyap, S. C. (2020). Studies on variability, heritability and genetic gain for quality traits in rice. *Journal of Pharmacognosy and Phytochemistry, 9*(3), 537-540.

Jasmine, C., Shivani, D., Senguttuvel, P., and Naik, D. S. (2022). Genetic variability and association studies in maintainer and restorer lines of rice [*Oryza sativa* (L.)]. *The Pharma Innovation Journal*, *11*(1), 569-76.

Johnson, H. W., Robinson, H. F., Comstock, R. (1955). Estimates of Genetic and Environmental Variability in Soybeans 1. *Agronomy Journal*, *47*, 314-318.

Krishna, L. and Raju, C. H. (2020). Genetic variability, heritability and genetic advance of grain yield and quality in aromatic rice. *International Journal of Chemical Studies*, *8*(3), 947-949.

Li, Y., Xiao, J., Chen, L., Huang, X., Cheng, Z., Han, B., and Wu, C. (2018). Rice functional genomics research: past decade and future. *Molecular plant*, *11*(3), 359-380.

Panse, V. G. and Sukhatme, P. V. (1967). Statistical Methods for Agric. Workers. *IInd Edition.*, p.p.152-157.

Sheera, A., Aftab, N., Rout, S., Mishra, U. N., Sharma, B., and Sivasankar, R. (2021). Assessment of Genetic Variability and Transmissibility Index in Rice Genotypes (*Oryza sativa* L.). *International Journal of Plant & Soil Science*, *33*(18), 34-42.

Singh, K. S., Singh, M., Vennela, R. P., Singh, K. D., Kujur, S. N. and Kumar, D. (2018). Studies on genetic variability, heritability and genetic advance for yield and yield components in drought tolerant rice (*Oryza sativa* L.) landraces. *International Journal Current Microbiological Applied Sciences*, *7*(3), 299-305.

Sumanth, V., Suresh, B. G., Ram, B. J., Srujana, G. (2017). Estimation of genetic variability, heritability and genetic advance for grain yield components in rice (*Oryza sativa* L.). *Journal of Pharmacognosy and Phytochemistry*, *6*, 1437-1439.

Supriya, K., Vanisri, S., Jagadeeswar, R. and Sreedhar, M. (2017). Genetic diversity for yield, its contributing characters in rice (*Oryza sativa* L.) *International Journal of Current Microbiological Applied Science, 6*(10), 2424-2428.

Yadav, V. P., Singh, P. K. and Verma, O. P. (2019). Genetic variation and heritability for quantitative traits in rice (*Oryza sativa)* under sodic soil. *Indian Journal of Agricultural Sciences*, *90*(2), 316–9.

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