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Genetic variability among rice (*Oryza sativa* subsp. *indica*) genotypes for submergence tolerance in Konkan region

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Abstract
The present study was carried out during the Kharif 2022 at the Breeding Farm, Regional Agricultural Research Station, Karjat, Dist. Raigad to estimate the genetic variability among rice genotypes for submergence tolerance. In the experiment, 39 genotypes were laid down into a Randomized block design (RBD) having three treatments viz., Control, 7 days and 14 days under submergence and two replications. According to the analysis of variance in the current experiment, genetic variations were significant for all the characters studied, which revealed that genotypes reported a wide range of variation. The results showed that environmental variance for characters spikelet fertility and starch was higher than genotypic variance at non-stress and 7 day stress. Days to fifty percent flowering and spikelet fertility had the highest phenotypic and genotypic variance at 14 day submergence stress. The PCV and GCV were high for all character at 14 days submergence, survival percentage having highest of all. Spikelet fertility and starch showed moderate heritability, while other parameters had high heritability (>60%). This implies that the genotypes used in the study have a varied genetic background and selection for these qualities may help the genetic improvement of crops.

Keywords: Rice, genetic variability, phenotypic variance, genotypic variance, heritability and genetic advance

Introduction
One of the most significant cereal crops in the world, rice (*Oryza sativa* L.) provides the main staple food for half of the global population. Rice is a highly prized crop that contributes significantly to the country's foreign exchange earnings. It is a member of the ‘Poaceae’ family. Of the 24 species in the genus, two are cultivated: ‘*Oryza sativa*’ and ‘*Oryza glaberrima*’. There are three subspecies of "*Oryza sativa*": *Japonica*, *Jamaica*, and *Indica*. The number of chromosomes is (2n=2x=24). It is a short-day plant that self-pollinates.
Rice is the only cereal crop that can be grown in a flood-prone rainfed lowland ecosystem. However, when the upper organs are partially to entirely flooded and the root systems are fully buried, crop yield is dramatically reduced. Complete submergence brought on by recurrent floods may have a detrimental effect on the plant's growth and output. Flooding, both sudden and prolonged, can have a detrimental effect on plant stands in lowland environments. Depending on the length of the submergence stress, this might lead to anoxia, which is regarded as the third major obstacle to high yield in India.
It has long been believed that deep-water and rainfed lowland rice locations should prioritise breeding for rice varieties that can withstand submersion. Even with this consent, India's efforts to create better submergence-tolerant cultivars have not yielded much progress. While a number of high-yielding rice cultivars have been introduced for various lowland conditions across the States, the majority lack the necessary degree of submersion tolerance. Water stagnation is a prevalent issue in most lowland coastal locations. Variations in the level of submergence tolerance across varieties have been noted frequently, and this genetic resource has been employed in a number of traditional breeding initiatives throughout Asia.

Materials and Methods
The pot culture experiment was carried out at the Breeding farm, Regional Agricultural Research Station, Karjat Dist. Raigad, during Kharif 2022, using a Randomised Block Design (RBD) with two replications and three treatments: control, 7 days, and 14 days under submergence.

Three nine genotypes, with five pots per genotype in each replication, were kept in a 16 x 2.5 x 1.2 m pond. For each replication, the subsequent information was gathered: Plant height, days to 50% flowering, panicle length (cm), spikelet fertility (%), test weight (g), grain yield per plant (g), starch content in leaves, and survival percentage.

For every parameter under each replication, the average of all the plants was analysed (Panse and Sukhathme, 1967) [1]. The estimate of genotypic and phenotypic variance was computed using the mean square values from the ANOVA table, in accordance with the protocol suggested by Johnson *et al*. (1955) [4]. The method suggested by Burton *et al*. (1953) was used to estimate the genotypic and phenotypic coefficients of variance. While Robinson *et al*. (1949) [3] methods were employed to identify traits as having high, moderate, or low heritability, the general approach described by Lush (1949) [2] was used to estimate the percentage of heredity.

Result and Discussion

The main condition for a crop breeding programme is genetic diversity. Plant breeders are therefore constantly searching for novel approaches to investigate and recombine genetic materials to collect or produce variation. Prior to employing multiple methods, plant breeders want to possess an extensive comprehension of the character, manifestation and scope of variation in the crop population.

Components of variation

The overall variation in each of the nine features may be divided into three categories: phenotypic, genotypic, and environmental variance. This helps identify the parts of the character variation that are heritable and non-heritable. Phenotypic variations were found to be comparatively larger than genotypic variants in the current experiment at all three submergence levels (non-stress, 7 days, and 14 days), suggesting that the environment has an impact on character expression. The maximum phenotypic and genotypic variance was found in the days to 50% flowering, survival percentage, grain yield per plant, and plant height under non-stress conditions. The lowest genotypic variance was found in the starch content, and the lowest phenotypic variance was found in the number of productive tillers. The phenotypic and genotypic variance was highest for days to fifty percent flowering, followed by spikelet fertility, survival percentage, and plant height, and lowest for the number of productive tillers under extended submergence stress conditions (i.e., 14 days). With the exception of spikelet fertility and starch content (under non-stress and seven-day stress conditions), the environmental variations were less than the genotypic variances for all nine traits.

Table 1: Analysis of variance for different characters studied in rice genotypes under different submergence stress levels.

Mean sum of squares (MSS)							
Sr. no	Characters	0 days submergence		7 days submergence		14 days submergence	
		Genotypes (38)	Error (38)	Genotypes (38)	Error (38)	Genotypes (38)	Error (38)
1	Survival Percentage (%)	188.94**	19.38	567.08**	12.50	755.22**	3.50
2	Plant height (cm)	46.10**	1.75	110.57**	5.94	737.06**	8.43
3	Panicle length (cm)	10.89**	1.21	8.77**	0.99	65.72**	0.76
4	Days to fifty per cent flowering (days)	318.45**	16.80	278.07**	36.38	2785.23**	53.70
5	Number of productive tillers (Nos.)	4.66**	0.20	5.63**	0.22	14.13**	0.20
6	Spikelet fertility (%)	20.80**	9.41	52.02**	21.67	996.43**	14.17
7	Test weight (gm)	38.96**	0.76	31.88**	1.02	88.67**	0.44
8	Total Starch content in leaf (mg/gm of dry weight)	6.49**	2.89	24.01**	8.26	200.72**	2.98
9	Grain yield per plant (gm)	59.52**	1.98	48.61**	2.01	112.88**	1.68

* Significant at 5 percent level of significance
** Significant at 1 percent level of significance

Coefficient of variation

The current investigation revealed that test weight had high PCV and GCV under non-stress conditions; on the other hand, spikelet fertility and starch were found to have lower magnitudes of PCV and GCV, while days to fifty percent flowering, panicle length, plant height, number of productive tillers, and grain yield per plant were found to have moderate phenotypic and genotypic coefficient of variation. Characteristics with high PCV and GCV at 7-day stress included survival percentage, test weight, and grain yield per plant; on the other hand, variables with moderate phenotypic and genotypic coefficient of variation were plant height, panicle length, days to 50% flowering and number of productive tillers.

Additionally, during 14 days of submergence, every character had a high genotypic and phenotypic coefficient of variation (i.e., >20%), with the survival percentage showing the highest PCV and GCV. Similar findings to those of Vange (2009) [5] suggest that these parameters had moderate genetic variability providing a decent range of opportunities for yield increase through selection. The following studies—Pratap *et al*. (2012) [6], Ketan and Sarkar (2014) [7], Fentie *et al*. (2014) [9], and Rahul (2016) [8]—reported similar results for grain yield per plant. The presence of substantial genetic diversity during yield enhancement therefore provides more room for the selection of those traits.

Table 2: Estimates of coefficient of variation and genetic parameters for morpho-physiological parameters of 39 rice cultivars exposed to non-stress (control) condition.

Sr.no.	Characters	PCV (%)	GCV (%)	ECV (%)	H^2b (%)	GA	GAM (%)
1	Survival Percentage (%)	11.00	9.92	4.74	81.40	17.11	18.44
2	Plant height (cm)	12.36	11.90	3.35	92.67	9.34	23.59
3	Panicle length (cm)	11.42	10.21	5.10	80.02	4.06	18.82
4	Days to fifty per cent flowering (days)	14.05	13.33	4.45	89.98	24.00	26.05
5	Number of productive tillers (Nos.)	11.85	11.35	3.41	91.71	2.94	22.39
6	Spikelet fertility (%)	4.75	2.92	3.75	37.73	3.02	3.69
7	Test weight (gm)	20.89	20.48	4.10	96.16	8.83	41.37
8	Total Starch content in leaf (mg/gm of dry weight)	2.94	1.82	2.31	38.33	1.71	2.32
9	Grain yield per plant (gm)	17.45	16.88	4.43	93.56	10.69	33.64

Table 3: Estimates of coefficient of variation, heritability and genetic advance for morpho-physiological parameters for 39 rice cultivars exposed to 7 days submergence stress condition.

Sr. no.	Characters	PCV (%)	GCV (%)	ECV (%)	H^2b (%)	GA	GAM (%)
1	Survival Percentage (%)	26.24	25.67	5.45	95.69	33.56	51.72
2	Plant height (cm)	15.34	14.54	4.90	89.81	14.12	28.38
3	Panicle length (cm)	11.96	10.68	5.38	79.76	3.63	19.66
4	Days to fifty per cent flowering (days)	12.38	10.86	5.96	76.86	19.85	19.61
5	Number of productive tillers (Nos.)	19.17	18.43	5.30	92.35	3.25	36.48
6	Spikelet fertility (%)	8.74	5.61	6.70	41.18	5.15	7.41
7	Test weight (gm)	22.49	21.79	5.60	93.80	7.84	43.47
8	Total Starch content in leaf (mg/gm of dry weight)	7.42	5.18	5.31	48.82	4.04	7.46
9	Grain yield per plant (gm)	21.29	20.43	6.01	92.04	9.54	40.37

Table 4: Estimates of coefficient of variation, heritability and genetic advance for morpho-physiological parameters for 39 rice cultivars exposed to 14 days submergence stress condition.

Sr.no.	Characters	PCV (%)	GCV (%)	ECV (%)	H^2b (%)	GA	GAM (%)
1	Survival Percentage (%)	56.77	56.51	5.45	99.10	39.75	99.07
2	Plant height (cm)	42.62	42.13	6.41	97.70	38.87	85.81
3	Panicle length (cm)	42.28	41.79	6.41	97.70	11.60	85.09
4	Days to fifty per cent flowering (days)	40.84	40.06	7.94	96.20	74.68	80.95
5	Number of productive tillers (Nos.)	47.21	46.56	7.80	97.30	5.36	94.59
6	Spikelet fertility (%)	40.70	40.13	6.82	97.20	45.01	81.49
7	Test weight (gm)	47.62	47.39	4.75	99.00	13.61	97.13
8	Total Starch content in leaf (mg/gm of dry weight)	41.16	40.55	7.04	97.10	20.18	82.30
9	Grain yield per plant (gm)	47.02	46.32	8.04	97.10	15.13	94.02

Heritability and Genetic advance

When estimating the ideal genotypes, heritability estimates combined with genetic advancement are more helpful than estimations of variability. Estimating the impact of environment on character expression and the degree to which improvement is feasible after selection is guided by heritability and genetic advancement. In the current study, test weight, grain yield per plant, plant height, and the number of productive tillers were found to have the highest heritability under non-stress conditions. The characters spikelet fertility and starch showed signs of moderate heritability. All of the characters in the study, with the exception of starch and spikelet fertility, revealed high levels of heritability (i.e., > 60%) during medium submergence stress (7 days). The test weight and character survival percentage had the highest levels of heredity.

In non-stress conditions, the lowest GA was observed in starch content, followed by the number of productive tillers and spikelet fertility. In medium submergence stress conditions, the highest estimate of genetic advance was demonstrated by survival percentage, days to fifty percent flowering, and plant height. The highest genetic advance was found for the character days to fifty percent flowering, followed by survival percentage and grain yield per plant.

Conclusion

From the above experiment, it can be concluded that submergence affected many morphological parameters and that the effect grew stronger with increasing stress levels for variables such as plant height, survival, number of productive tillers, and days to fifty percent flowering. Other morphological traits increased with increasing stress levels, such as plant height and days to fifty percent flowering. Tolerance indices can be used to differentiate between genotypes that are tolerant and sensitive by comparing them to those that were subjected to control conditions.

Similar to past research, this study has demonstrated that additional characteristics, including as survival rate, starch content, and the quantity of productive tillers can be used to aid in the selection of rice genotypes that are tolerant of submergence during the vegetative stage. The results of this study can help choose rice breeding lines that are resistant of submergence for variety development and related studies.

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