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Assessment of genetic variability, heritability and genetic advance for yield and quality traits in advanced breeding lines of rice (*Oryza sativa* L.)

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Abstract
In this investigation genetic variability, heritability and genetic advance was studied in fifty advanced breeding lines along with five checks for eleven yield and nineteen quality traits during *kharif* 2020. Variance studies showed extremely significant variations among all the advanced breeding lines for all the yield and quality traits, suggesting presence of significant amount of variance. Number of unfilled grains/panicle (49.20), alkali spreading value (32.24), amylose% (30.36), gel consistency (27.05), number of filled grains/panicle (24.48), grain yield/plant (g) (22.40), head rice recovery % (22.20), biological yield per plant (g) (20.53) and harvest index % (19.16) showed high values of GCV and PCV. This indicates that considering these traits for direct selection will result in genetic improvement. The yield and quality traits which showed high estimates for genetic advance as % of mean along with high heritability were number of filled grain/panicle, biological yield/plant (g), number of unfilled grain/panicle, 100 seed weight (g), grain yield/plant (g), paddy L/B ratio, amylose %, kernel breadth after cooking (mm), brown rice L/B ratio, gel consistency, cooked rice L/B ratio, alkali spreading value and head rice recovery %. This implied that additive gene activity influenced the inheritance of these traits. Revealing a prevalence of additive gene action, thus providing scope for further improvement through selection.

Keywords: Rice, genetic variability, heritability, genetic advance, yield traits, quality traits

Introduction

Rice (*Oryza sativa* L.) (2n=24) is a major cereal crop that belongs to the Poaceae family and the Oryzoidea subfamily. It is known as the "Global Grain" because it is a staple food in over 100 countries. Approximately 90% of the world's rice is grown and consumed in Asia, with rice providing food for 50% of the population (Yugandhar *et al*., 2018) [18]. Rice is responsible for 20% of the world's nutritional energy supply. Rice is mostly a starchy food with amylose and amylopectin fractions (78-79 percent starch). It also provides significant protein and vitamin content. Rice is high in vitamin B (thiamin and nicotinamide), as well as iron (Fe), phosphorus (P), and magnesium (Mg). Rice yield needs to be urgently increase to meet the food demand, due to rapid expansion of population. By 2050, the world's population is anticipated to reach 9.1 billion, necessitating a 70 percent increase in food production (Godfray *et al*., 2010; Hodges *et al*., 2011; Parfitt *et al*., 2010) [6, 7, 13]. Grain quality traits are very crucial in rice breeding as it is predominantly consumed as a whole grain. The milling percentage, hulling percentage, grain dimensions, cooking quality constitute the quality traits (Babu *et al*., 2012) [1].

The primary aspect to consider when making a selection is variability in genotypes for yield and its component traits. Any successful hybridization programme for varietal development relies heavily on the selection of parents with high variability, allowing for the selection of desirable character combinations to increase grain quality and yield. When selection is made based on yield contributing characteristics, heritability and genetic advance are essential selection parameters. Heritability estimates combined with genetic improvement are typically more effective in predicting selection benefit than heritability estimates alone (Paul *et al*., 2006) [14].

Materials and Methods

The present experiment was carried out at Research cum Instructional farm Department of Genetics and Plant Breeding, College of Agriculture, IGKV, Raipur (C.G.) and the laboratory work was performed at Quality laboratory, Department of Genetics and Plant breeding, RRL, IGKV, Raipur (C.G.) during *kharif* 2020. The experimental material comprises of total 50 advanced breeding lines of rice along with 5 checks namely IR 64, IGKV R1, IGKV R 2, Karma Mahsuri and IGKV R 1244. During *kharif* 2020, the experiment was set up in a Randomized Block Design of two replications maintaining inter and intra row spacing 20 x 20 cm. The observations during the investigation were recorded on the basis of five random plants selected at optimum stage of plant growth from each line in both the replications for the evaluation of yield and quality traits.

Results and Discussion

The present investigation was performed upon fifty advanced breeding lines of rice and five checks. Experimental material was planted in RBD (randomized block design) with two replications. The genetic parameters of variability were explored in order to get a clear picture of genotype variability. Eleven yield characters and nineteen quality characters were taken in account for the various analysis. From each replication randomly five plants were selected for taking observation.

Analysis of variance

Analysis of variance was used to determine the degree of variation of observed characters among advanced breeding lines of rice and the results are presented in tables 1 and 2. For all of the characters, the study of variance showed extremely significant variations among the 55 advanced breeding lines, suggesting significant genetic variation in the material. For all yield and quality characters tested, an F-test revealed that the values of mean sum of squares were significant (at 1% level of significance). High genetic variability for different yield traits in rice was also reported by Khan *et al*., (2009) [8] and Devi *et al*., (2017) [4].

Genotypic and phenotypic coefficient of variance

For both yield and quality traits the value for GCV and PCV ranged from low to high. For all characters, the genotypic variance was smaller than phenotypic variance, this indicates that environment had masking effect on the expression of genetic variability (Table 3 and 4). Among yield traits, number of unfilled grains/panicle (58.88) had highest GCV and PCV value followed by grain yield (26.17) and number of filled grains/panicle (26.123). And among quality traits highest GCV and PCV value observed for trait alkali spreading value (35.17) followed by amylose% (34.46) and gel consistency (30.23). This indicates the existence of wide genetic base among the advanced breeding lines taken under study and possibility of genetic improvement through direct selection for these traits. These results are in conformity with the findings of Rathi *et al.*, (2019) [15], Longjam and Singh (2019) [11] and Chakrabarty *et al.*, (2020) [3].

Table 1: Analysis of variance for yield characters in advanced breeding lines of rice

S. No.	Sources of variance	Mean sum of squares		
		Replication (df=1)	Advanced breeding lines (df=54)	Error (df=54)
1.	Days to 50% flowering	4.81	27.624**	1.402
2.	Plant height (cm)	25.34	91.529**	7.004
3.	Number of effective tillers per plant	0.22	2.307**	0.765
4.	Panicle length (cm)	0.02	3.721**	0.94
5.	Number of filled grains per panicle	281.6	2,566.94**	166.026
6.	Number of unfilled grains per panicle	281.6	910.541**	161.878
7.	Spikelet fertility %	64.298	103.072**	23.277
8.	100 seed weight (g)	0.011	0.356**	0.003
9.	Biological yield per plant (g)	26.118	194.946**	39.71
10.	Harvest index %	101.953	225.902**	67.088
11.	Grain yield per plant (g)	2.658	44.324**	6.835

Table 2: Analysis of variance for quality characters in advanced breeding lines of rice

S. No.	Sources of variance	Mean sum of squares		
		Replication (df=1)	Advanced breeding lines (df=54)	Error (df=54)
1.	Hulling %	10.172	18.202**	3.517
2.	Milling %	7.384	34.616**	1.926
3.	Paddy length (mm)	0.052	0.969**	0.08
4.	Paddy breadth (mm)	0.052	0.124**	0.016
5.	Paddy L/B ratio	0.105	0.365**	0.048
6.	Brown rice length (mm)	0.029	0.603**	0.007
7.	Brown rice breadth (mm)	0.006	0.083**	0.002
8.	Brown rice L/B ratio	0.02	0.24**	0.006
9.	Kernel length (mm)	0.001	0.41**	0.025
10.	Kernel breadth (mm)	0.009	0.07**	0.003
11.	Kernel L/B ratio	0.029	0.179**	0.01
12.	Kernel length after cooking (mm)	0.015	0.809**	0.15
13.	Kernel breadth after cooking (mm)	0.013	0.191**	0.006
14.	Cooked rice L/B ratio	0.002	0.21**	0.022
15.	Elongation ratio	0.003	0.016**	0.005
16.	Gel consistency	73.636	395.037**	43.673
17.	Alkali spreading value	0.909	5.364**	0.465
18.	Amylose %	0.611	148.221**	18.686
19.	Head rice recovery %	11.913	200.538**	3.143

Table 3: Genetic parameter of variation for yield and yield contributing characters in advanced breeding lines of rice

S. No	Characters	Mean	Range		CD at 5%	CV%	Coefficient of variance		h^2%	GA	GA% mean
			Max.	Min.			PCV	GCV			
1.	Days to 50% flowering	91.79	103.00	86.50	2.37	1.29	4.15	3.95	90.34	7.09	7.72
2.	Plant height (cm)	108.10	126.33	93.49	5.30	2.45	6.49	6.01	85.78	12.40	11.47
3.	Number of effective tillers per plant	7.18	10.30	4.90	1.75	12.18	17.27	12.24	50.21	1.28	17.86
4.	Panicle length (cm)	24.67	27.38	21.43	1.94	3.92	6.19	4.78	59.66	1.88	7.60
5.	Number of filled grains per panicle	141.51	256.00	90.00	25.83	9.11	26.12	24.48	87.85	66.90	47.27
6.	Number of unfilled grains per panicle	39.33	126.50	14.00	25.39	32.27	58.88	49.20	69.81	33.30	84.68
7.	Spikelet fertility %	78.79	89.62	54.58	9.68	6.13	10.09	8.02	63.15	10.34	13.12
8.	100 seed weight (g)	2.35	2.89	1.47	0.01	2.10	18.01	17.87	98.41	0.86	36.52
9.	Biological yield per plant (g)	42.91	67.56	27.55	19.44	22.60	25.25	20.53	66.15	14.76	34.40
10.	Harvest index %	46.51	82.41	25.74	20.63	21.80	26.02	19.16	54.21	13.52	29.06
11.	Grain yield per plant (g)	19.33	31.58	11.13	5.24	13.52	26.17	22.40	73.28	7.64	39.50

Table 4: Genetic parameter of variation for quality characters in advanced breeding lines of rice

S. No	Characters	Mean	Range		CD	CV%	Coefficient of variance		h^2%	GA	GA% mean
			Max.	Min.			PCV	GCV			
1.	Hulling %	77.03	82.23	71.29	1.59	4.85	4.28	3.52	67.61	4.59	5.96
2.	Milling %	68.41	78.56	57.45	2.09	6.50	6.25	5.91	89.46	7.88	11.51
3.	Paddy length (mm)	8.82	10.35	7.40	2.92	8.71	8.21	7.57	84.82	1.27	14.35
4.	Paddy breadth (mm)	2.51	3.15	2.10	1.50	4.26	10.52	9.25	77.28	0.42	16.75
5.	Paddy L/B ratio	3.56	4.94	2.50	5.67	16.78	12.77	11.19	76.84	0.72	20.21
6.	Brown rice length (mm)	6.70	7.90	5.60	2.37	7.19	8.26	8.16	97.57	1.11	16.59
7.	Brown rice breadth (mm)	2.14	2.55	1.80	2.85	8.92	9.64	9.42	95.47	0.41	18.96
8.	Brown rice L/B ratio	3.17	3.92	2.43	3.38	9.82	11.06	10.77	94.97	0.69	21.63
9.	Kernel length (mm)	6.02	7.15	4.95	3.13	9.18	7.74	7.29	88.59	0.85	14.13
10.	Kernel breadth (mm)	2.06	2.50	1.73	2.40	7.32	9.24	8.90	92.78	0.36	17.67
11.	Kernel L/B ratio	2.99	3.57	2.28	3.03	8.05	10.29	9.73	89.39	0.57	18.94
12.	Kernel length after cooking (mm)	8.44	10.35	7.15	2.96	8.58	8.21	6.81	68.76	0.98	11.62
13.	Kernel breadth after cooking (mm)	3.01	3.55	2.15	2.78	7.22	10.44	10.09	93.49	0.61	20.11
14.	Cooked rice L/B ratio	2.84	3.79	2.13	2.31	6.58	12.00	10.83	81.41	0.57	20.13
15.	Elongation ratio	1.40	1.60	1.27	2.11	5.82	7.43	5.32	51.21	0.11	7.84
16.	Gel consistency	49.00	97.5	31.00	6.12	17.07	30.23	27.05	80.09	24.44	49.87
17.	Alkali spreading value	4.86	6.50	2.00	6.34	17.60	35.17	32.24	84.06	2.96	60.89
18.	Amylose %	26.51	44.80	12.65	3.24	9.83	34.46	30.36	77.61	14.61	55.09
19.	Head rice recovery %	44.74	62.52	22.12	4.17	12.94	22.56	22.20	96.91	20.15	45.03

Heritability and Genetic Advance

Estimating heritability helps breeders manage the resources needed to successfully select for desirable characteristics and achieve maximum genetic gain with minimal effort and resources. Heritability is a good index of the transmission of characters to the offsprings from their parents. Heritability was classified as low (<30%), medium (30-60%) and high (>60%) as suggested by Johnson *et al*., (1955). In present investigation, highest heritability was obtained for 100 seed weight (98.41%) followed by brown rice length (mm) (97.57%), head rice recovery% (96.91%), brown rice L/B ratio (94.97%), brown rice breadth (mm) (95.47%), kernel breadth after cooking (mm) (93.49) and so on. All yield and quality traits showed high heritability except panicle length (cm), harvest index, number of effective tillers/plant and elongation ratio which showed moderate heritability. Similar results were obtained by Saha *et al.*, (2019) [16] and Parimala and Devi (2019) [12].

The degree of gain achieved in a character under a certain selection pressure is referred to as genetic advance. High estimates of genetic advance as % of mean obtained from characters were number of filled grain/panicle (47.27%), biological yield per plant (34.40%), number of unfilled grains/panicle (84.68%), alkali spreading value (60.89%), amylose % (55.09%), gel consistency (49.87%), head rice recovery % (45.08%), grain yield/plant (39.50%), 100 seed weight (36.52%), harvest index (29.06%), brown rice L/B ratio (21.63%), paddy L/B ratio (20.21%), cooked rice L/B ratio (20.13%) and kernel breadth after cooking (20.11%). Similar results were obtained by Rathi *et al.*, (2019) [15], Ganpati *et al.*, (2020) [5] and Behera *et al.*, (2018) [2].

High heritability does not always indicate high genetic gain, therefore the best conditions for selection are high genetic advance combined with high heritability estimates (Larik *et al.*, 2000) [10]. The yield and quality traits which showed high values for genetic advance as % of mean along with high heritability were number of filled grain/panicle, biological yield per plant (g), number of unfilled grain/panicle, 100 seed weight (g), grain yield/plant (g), paddy L/B ratio, amylose %, kernel breadth after cooking (mm), brown rice L/B ratio, gel consistency, cooked rice L/B ratio, alkali spreading value and head rice recovery %. This implied that additive gene activity influenced the inheritance of these features. Following a simple selection method, these traits can be improved. Similar results were observed in recent studies by Singh *et al.*, (2021) [17] and Kumar *et al.*, (2020) [9].

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