Original Research Article

Studies on genetic divergence and character association studies on germplasm accessions of rice (Oryza sativa L.)

Abstract

In this study, fifty-five rice germplasm accessions were used along with five checks, namely IR64, Swarna, Jaya, DRR Dhan 42 and MTU1010, for evaluating genetic variability, heritability and genetic advance during *kharif* 2023. The analysis of variance revealed extremely large genotype differences for each of the 16 traits under investigation. The highest heritability measures were found in number of filled grains per panicle followed by paddy breadth, paddy length:breadth ratio, brown rice length:breadth ratio, 100 seed weight, paddy length, plant height, brown rice breadth, number of effective tillers per plant, brown rice length, number of unfilled grains per panicle, grain yield per plant, panicle length, and harvest index. Grain yield per plant exhibits a positive and highly significant correlation with the days to 50% flowering, number of effective tillers per plant, number of filled grain per panicle and paddy length. In terms of direct effect, paddy length shows the highest impact, followed by brown rice length, number of filled grain per panicle, days to 50% flowering, panicle length, harvest index.

Introduction

Rice is known as the "Grain of Life' because it provides food for more than one-third of the world's population. Furthermore, the United Nations has designated 2004 as the "International Year of Rice" to recognize the importance of rice in human life. Rice is endowed with a wealth of genetic diversity (Akshay *et al.,* 2022). It also occupies around 25% of the world's land used for cereal production. It is one of the most genetically diverse crop species since it is one of the very few with over a million landraces and improved cultivars. When determining the degree of variability present in the germplasm, genetic metrics like genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) are helpful. Heritability in combination with high genetic advance would be a more beneficial tool in predicting the outcome of selecting the optimal genotypes for yield and its attributes. Estimates of heritability aid plant breeders in choosing superior genotypes from a variety of genetic populations (Johnson *et al*., 1955). Crop development efforts could benefit greatly from knowledge of the genetic relationship between breeding materials and the diversity of germplasm. Genetic variety determines the inherent potential of a cross for heterosis and the frequency of desirable recombinants in later generations (Ovung *et al.,* 2012). Heritability also reveals how much a character will be passed down to succeeding generations, which makes understanding it crucial for selection-based improvement (Sabesan *et al*., 2009; Singh *et al*., 2015). A character's heritability tells us how easily it can be passed down to subsequent generations.

Material and Methods

Fifty-five lines of rice germplasm accessions, including five checks IR64, Swarna, Jaya, DRR Dhan 42, and MTU1010 were used in study. The study was set up as a two-replication Randomized Completely Block Design (RCBD) experiment. Seedlings that were 21 days old were planted 20 x 15 cm apart. Every agronomic practice was designed to promote healthy crop growth. For the purpose of recording observations, five plants from each replication were selected. For subsequent study, the average of five plants was utilized. All observations pertaining to yield were documented in order to assess PCV, GCV, GA, heritability, correlation and path analysis.

Result

Analysis of variance.

Analysis of variance was performed on the replication wise mean data for yield and yield attributing traits of rice germplasm accessions. The analysis of variance revealed significant differences in all of the 16 attributes studied, such as days to 50% flowering, plant height, panicle length, number of effective tillers per panicle, number of filled grains per panicle, number of unfilled grains per panicle, spikelet fertility %, 100 seed weight, grain yield per plant, harvest index %, paddy length, paddy breadth, paddy L/B ratio, brown rice length, brown rice breadth, brown rice L/B ratio. Table 1 shows the results of analysis of variance, as well as the significant difference for each of the features studied. This indicates that the material utilized in this investigation have genetic variability among them. The presence of genetic variation (the appearance of variation among the individual in a plant population) is a requirement for every breeding effort; without it, neither improving current lines nor developing distinct lines is conceivable. Similar findings were also reported by Htwe *et al.* (2019) and Saha *et al*. (2019).

Table 1: Analysis of variation for yield and yield attributing traits

ANOVA Summary				
S.No.	**Source**	**Mean Sum of Squares (MSS)**		
		Replication	**Treatment**	**Error**
	Degrees of freedom	**1**	**54**	**54**
1	Days to 50% flowering	15.67	13.19**	6.48
2	Plant height (cm)	47.65	573.18**	52.26
3	Panicle length (cm)	1.37	10.83**	1.94
4	Number of effective tillers per plant	0.32	0.95**	0.08
5	Number of filled grains per panicle	107.10	1252.18**	42.87
6	Number of unfilled grains per panicle	2.40	69.41**	0.80
7	Spikelet fertility %	34.68	74.30**	38.16
8	Hundred seed weight (g)	0.08	0.45**	0.03
9	Grain yield per plant (g)	0.80	11.25**	1.46
10	Harvest index %	11.95	72.56**	14.47
11	Paddy Length (mm)	7.64	154.96**	10.80
12	Paddy breadth (mm)	0.58	14.62**	0.573
13	Paddy L/B Ratio	0.04	0.52**	0.02
14	Brown rice length (mm)	0.22	95.92**	10.78
15	Brown Rice breadth (mm)	0.14	13.14**	1.22
16	Brown rice L/B	0.01	0.45**	0.02

** Significance at 1% level of probability.

Estimation of genetic variability parameters

The nature of genetic variation is the condition of plant breeding. Genetic variation is important for any breeding material, as it not only provides selection, but also valuable information on the selection of different parents for hybridization programs. Landraces are valuable genetic tools because they provide a lot of genetic variation and can be used to supplement and expand the gene pool of developed genotypes. Improving yield requires understanding the genetic variability and demographic composition of germplasm collections.

More diversity in the original breeding material ensures better chances of producing acceptable varieties of a crop plant. Therefore, the primary objective of germplasm conservation is to collect and preserve genetic diversity in a group of indigenous agricultural species for the benefit of current and future generations. Genetic measures such as the genotypic coefficient of variation (GCV) and the phenotypic coefficient of variation (PCV) can be used to assess the level of diversity in the germplasm.

Table 2 showed the values of the genotypic and phenotypic coefficients of variation. The GCV and PCV were shown to have a significant association for all characters. All of the traits had greater phenotypic coefficients of variability than genotypic coefficients of variability, showing that environmental factors as well as genotypes play a role in the apparent variation. Similar findings were given by Iqbal *et al.* (2018), Htwe *et al.* (2019), Saha *et al*. (2019) and Tiwari *et al.* (2019). Among the characters studied, a higher number of the genotypic coefficient of variation was obtained for number of unfilled grains per panicle (37.94%) followed by number of filled grain per panicle. Moderate genotypic coefficient of variation was recorded for 100 seed weight (18.98%), grain yield per plant (16.25%), brown rice (16.14%), number of effective tillers per plant (15.38%), paddy length:breadth ratio (15.23%), plant height (12.30%), brown rice breadth (11.28%), brown rice length (10.57%), paddy breadth (1.50%), harvest index (10.38%) and paddy length (10.36%). The low percentage of genotypic coefficient of variation (less than 10%) in the present analysis has been recorded in panicle length (8.87%) followed by spikelet fertility (4.96%) and days to 50% flowering (1.87%).

Genetic advance as percent of mean and Heritability

Heritability is the ratio of genotypic variance to total or phenotypic variance (Broad sense) and the ratio of additive genetic variance to phenotypic variance (Narrow sense). Genetic advance is the improvement in the mean genotypic value of selected plants over the parental population. It is quite challenging to determine whether or not observed variability is heritable. A character’s heritability tells us how easily it can be passed down to subsequent generations. The reliability of phenotypic value is expressed using heritability estimates as a forecasting tool. High heritability therefore aids in the efficient selection of a particular feature.

The highest heritability measures (>60) were found in number of filled grain per panicle (93.38%), paddy breadth (92.46%), paddy length:breadth (91.97%), brown rice length:breadth (90.53%), 100 seed weight (87.14%), paddy length (86.97%), plant height (83.29%), brown rice breadth (82.96%), number of effective tillers per plant (82.87%), brown rice length (79.78%), number of unfilled grain per panicle (79.46%) grain yield per plant (76.93%), panicle length (69.56%), harvest index (66.74%).

This term "genetic advance" refers to the amount of genetic gain that has occurred as a result of selection. The heritability for which traits was under examination determines the effectiveness of genetic advances under selection. Even when the feature is lesser impacted with environmental influences, selection for enhancement of such characters could not be successful since heredity is based on total genetic variation, which comprises fixable (additive) and non-fixable (dominance and epistatic) variation.

The traits grown by high heritability with high genetic advance shown by characters such as number of unfilled grains per panicle, number of filled grain per panicle, paddy breadth, paddy length:breadth ratio, brown rice length:breadth ratio, 100 seed wight. The result are in agreement with Devkota *et al.* (2023) indicating the role of additive gene action in controlling these characters. Also Gupta *et al.* (2021) revealed that for biological yield per plant, harvest index, grain yield per plant, number of effective tillers per plant and number of filled grains per panicle.

Table 2: Genetic parameters for various yield and yield related characters.

S. No.	Characters	Mean	Range Min.	Range Max.	GCV%	PCV%	$h^2_{(bs)}$	GA as % of mean
1.	Days to 50% flowering	98.01	91.50	104.00	1.87	3.20	34.07	2.25
2.	Plant height (cm)	131.21	79.40	155.80	12.30	13.48	83.29	23.12
3.	Panicle length (cm)	24.01	19.97	32.40	8.78	10.53	69.56	15.09
4.	Number of effective tillers per plant	4.28	2.60	6.20	15.38	16.89	82.87	28.84
5.	Number of filled grains per panicle	100.89	44.40	193.30	24.37	25.22	93.38	48.52
6.	No. of unfilled grains per panicle	15.44	2.70	28.40	37.94	38.38	79.46	78.82
7.	Spikelet fertility percent (%)	85.68	67.48	96.39	4.96	8.75	32.13	5.79
8.	100 seed weight (g)	2.41	1.29	3.55	18.98	20.33	87.14	36.49
9.	Grain yield per plant (g)	13.61	8.50	18.90	16.25	18.53	76.93	29.37
10.	Harvest index (%)	52.00	41.00	63.00	10.38	12.71	66.74	17.48
11.	Paddy length (mm)	7.97	5.90	10.05	10.36	11.11	86.97	19.90
12.	Paddy breadth (mm)	2.55	2.00	3.10	10.50	10.92	92.46	20.81
13.	Paddy length breadth ratio	3.29	2.27	5.03	15.23	15.88	91.97	30.08
14	Brown rice length (mm)	6.07	4.40	7.75	10.57	11.83	79.78	19.45
15	Brown rice breadth (mm)	2.25	1.55	2.95	11.28	12.38	82.96	21.15
16	Brown rice length breadth ratio	3.26	2.10	4.43	16.14	16.96	90.53	31.63

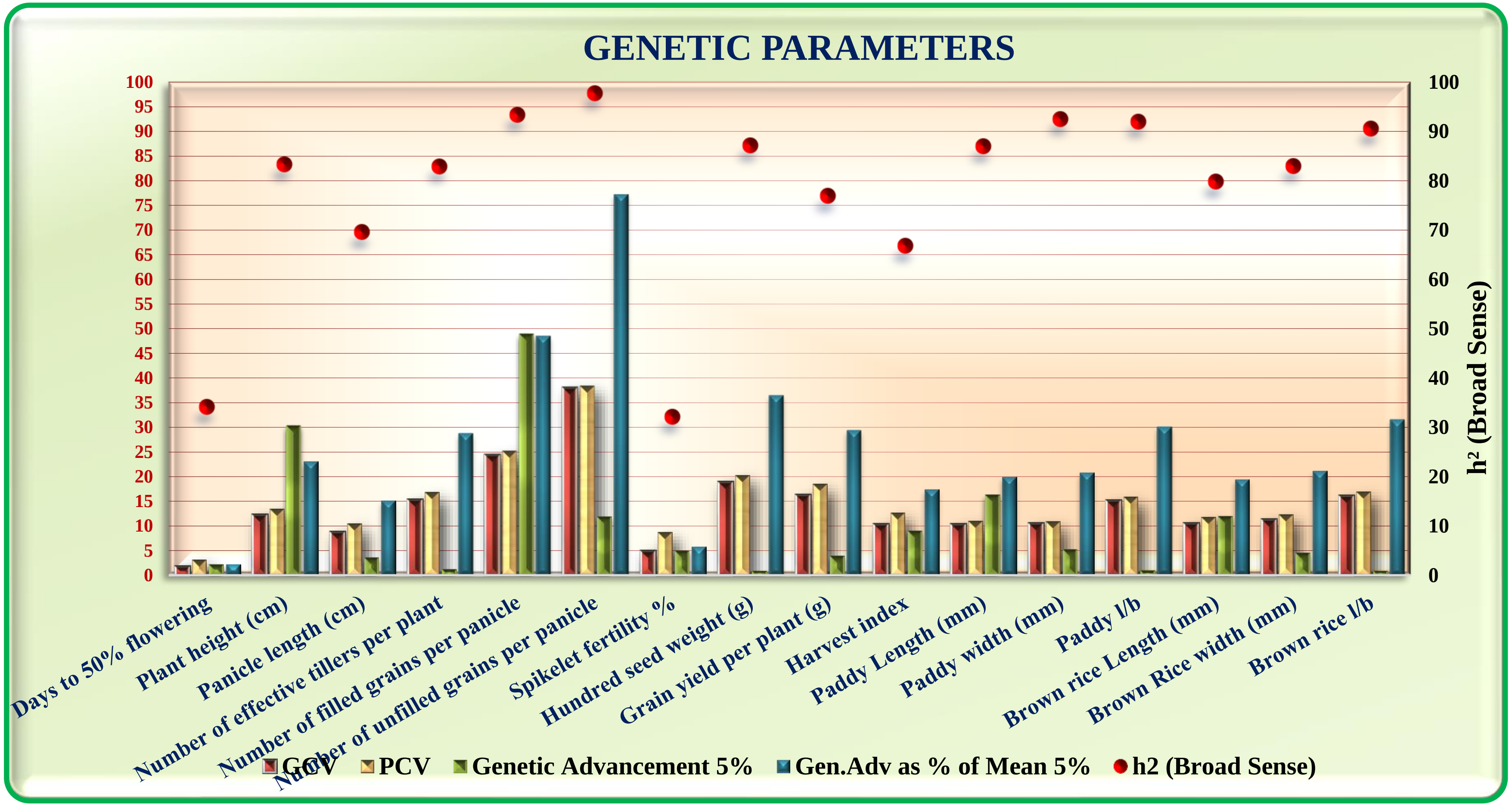

Fig 1- PCV, GCV, Heritability and Genetic advance as percentage of mean for yield and its attributing traits.

Correlation coefficient analysis

Grain yield per plant exhibits a positive and highly significant correlation with the days to 50% flowering (0.383), number of effective tillers per plant (0.315), number of filled grain per panicle (0.219) and paddy length (0.342) in Table 3 and 4. It showed a negative and highly significant correlation with the plant height (-0.327). Similar findings were reported by Patel *et al.* (2017) for biological yield per plant, harvest index, filled spikelets per panicle, number of effective panicles per plant, and total tillers per plant; Bitew *et al*. (2018) and Gupta *et al.* (2021) for filled grains per panicle.

The positive relationship between desired features is advantageous since it aids in the development of both features at the same time. The negative correlation, while, will prevent the simultaneous manifestation of two high-value characters in this case, some form of economic compromise has to be made.

Table 3: Genotypic correlation coefficient for yield and yield attributing traits

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1	-0.295	-0.174	0.136	-0.044	0.123	-0.526**	0.224*	0.188*	0.153	-0.171	0.230*	0.022	0.138	-0.100	0.383**
2		1	0.322**	-0.510**	0.213	0.003	0.571**	0.271*	-0.401**	-0.073	0.204*	-0.201*	-0.038	0.156	-0.214*	-0.327**
3			1	-0.159	0.045	0.345**	-0.155	0.114	-0.237*	0.082	0.386**	-0.190*	0.017	-0.014	-0.005	-0.137
4				1	-0.007	0.001	-0.483**	-0.415**	0.153	-0.028	-0.255*	0.144	-0.064	-0.387**	0.230*	0.315**
5					1	0.286*	0.381**	-0.445**	-0.018	-0.301*	-0.275*	-0.036	-0.323**	-0.404**	0.019	0.219*
6						1	-0.881**	-0.005	0.012	0.217*	0.0724	0.070	0.138	0.053	0.0545	0.197
7							1	-0.148	0.005	-0.518**	-0.218*	-0.182	-0.418**	-0.300*	-0.135	-0.302
8								1	-0.022	0.577**	0.540**	0.017	0.508**	0.435**	0.051	0.165
9									1	0.018	-0.110	0.097	0.060	-0.005	0.036	0.182
10										1	0.013	0.711**	0.913**	0.103	0.569**	0.342**
11											1	-0.687**	-0.091	0.129	-0.157	-0.038
12												1	0.712**	-0.035	0.529**	0.234*
13													1	0.107	0.668**	0.289*
14														1	-0.663**	-0.112
15															1	0.283*
16																1

*:- Significance level at 0.05 % **:- Significance level at 0.01 %

Note:- 1= Days to 50% flowering, 2= Plant height, 3= Panicle length, 4= Number of effective tiller per plant, 5= Number of filled grain per panicle 6= Number of unfilled grain per panicle, 7= Spikelet fertility, 8= 100 seed weight, 9= Harvest index, 10= Paddy length, 11= Paddy breadth, 12= Paddy length:breadth ratio, 13= Brown rice length, 14= Brown rice breadth, 15= Brown rice length:breadth ratio, 16= Grain yield per plant

Table 4: Phenotypic correlation coefficients for yield and yield contributing traits

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
1	1	-0.195*	-0.161	0.118	-0.046	0.059	-0.224*	0.154	0.155	0.123	-0.117	0.158	-0.040	0.132	-0.1145	0.199*
2		1	0.308*	-0.426**	0.213*	0.006	0.310**	0.201*	-0.351**	-0.094	0.190*	-0.194*	-0.056	0.162	-0.218*	-0.180
3			1	-0.193*	0.024	0.283*	-0.153	0.094	-0.161	0.046	0.328**	-0.171	-0.011	-0.046	-0.001	-0.088
4				1	0.013	-0.003	-0.216*	-0.358**	0.113	-0.033	-0.220*	0.122	-0.073	-0.334**	0.201*	0.271*
5					1	0.277*	0.279*	-0.406**	-0.020	-0.280*	-0.245*	-0.046	-0.279*	-0.350**	0.012	0.221*
6						1	-0.525**	0.004	0.019	0.216*	0.063	0.079	0.126	0.051	0.051	0.166
7							1	-0.128	-0.074	-0.296*	-0.099	-0.123	-0.209*	-0.109	-0.098	-0.145
8								1	-0.005	0.522**	0.459**	0.043	0.444**	0.363**	0.057	0.114
9									1	0.052	-0.104	0.106	0.009	0.023	0.002	0.100
10										1	0.013	0.700**	0.812**	0.102	0.522**	0.237*
11											1	-0.692**	-0.108	0.098	-0.152	-0.023
12												1	0.662**	-0.013	0.500**	0.170
13													1	0.096	0.654**	0.167
14														1	-0.667**	-0.076
15															1	0.197*
16																1

*:- Significance level at 0.05 % **:- Significance level at 0.01 %

Note:- 1= Days to 50% flowering, 2= Plant height, 3= Panicle length, 4= Number of effective tiller per plant, 5= Number of filled grain per panicle 6= Number of unfilled grain per panicle, 7= Spikelet fertility, 8= 100 seed weight, 9= Harvest index, 10= Paddy length, 11= Paddy breadth, 12= Paddy length:breadth ratio, 13= Brown rice length, 14= Brown rice breadth, 15= Brown rice length:breadth ratio, 16= Grain yield per plant

Path coefficient analysis

In terms of direct effect, paddy length shows the highest impact (4.735), followed by brown rice length (1.183), number of filled grain per panicle (0.578), days to 50% flowering (0.347), panicle length (0.135), harvest index (0.082), Conversely, paddy length:breadth ratio had the highest negative direct effect (-6.147), followed by paddy breadth (-3.908), brown rice length:breadth ratio (-1.204), brown rice breadth (-0.946), number of unfilled grain per panicle (-0.606), plant height (-0.364), 100 seed weight (-0.298), spikelet fertility (-0.217), number of effective tiller per plant (-0.119).

According to the magnitude of the direct effect, days to 50% flowering, panicle length, number of filled grains per panicle, harvest index, paddy length, brown rice length had a highly significant and positive correlation with grain yield per plant along with a positive direct effect on grain yield per plant. These points indicate true relationships among these traits, and for yield improvement, direct selection for these characters will be rewarding. Similar findings were concluded by Devi *et al.* (2017), Rasel *et al.* (2018) and Sivasankar *et al.* (2018).

Table 5 Estimation of path coefficient (direct and indirect effects) for various yield attributing traits on grain yield per plant

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	**0.347**	-0.102	-0.060	0.047	-0.015	0.042	-0.182	0.077	0.065	0.053	-0.059	0.079	0.007	0.048	-0.034	0.383**
2	0.107	**-0.364**	-0.117	0.186	-0.077	-0.001	-0.208	-0.098	0.146	0.027	-0.074	0.073	0.013	-0.056	0.078	-0.327**
3	-0.023	0.043	**0.135**	-0.021	0.006	0.046	-0.021	0.015	-0.032	0.011	0.052	-0.025	0.002	-0.002	-0.008	-0.137
4	-0.016	0.060	0.018	**-0.119**	0.009	-0.002	0.057	0.049	-0.018	0.003	0.030	-0.017	0.007	0.046	-0.027	0.315**
5	-0.025	0.123	0.026	-0.004	**0.578**	0.165	0.220	-0.257	-0.010	-0.174	-0.159	-0.021	-0.186	-0.233	0.011	0.219*
6	-0.074	-0.002	-0.209	-0.008	-0.173	**-0.606**	0.533	0.003	-0.007	-0.131	-0.043	-0.042	-0.083	-0.032	-0.033	0.197
7	0.114	-0.124	0.033	0.105	-0.083	0.191	**-0.217**	0.032	-0.001	0.112	0.047	0.039	0.091	0.065	0.029	-0.302
8	-0.066	-0.080	-0.034	0.123	0.132	0.001	0.044	**-0.298**	0.006	-0.171	-0.160	-0.005	-0.151	-0.129	-0.015	0.165
9	0.015	-0.032	-0.019	0.012	-0.001	0.001	0.004	-0.001	**0.082**	0.001	-0.009	0.008	0.005	-0.004	0.003	0.182
10	0.729	-0.350	0.388	-0.135	-1.424	1.026	-2.454	2.730	0.088	**4.735**	0.062	3.367	4.322	0.491	2.692	0.342**
11	0.670	-0.798	-1.507	0.998	1.074	-0.282	0.851	-2.10	0.432	-0.051	**-3.908**	2.685	0.358	-0.505	0.616	-0.038
12	-1.410	1.235	1.165	-0.889	0.222	-0.435	1.121	-0.10	-0.600	-4.371	4.224	**-6.147**	-4.375	0.217	-3.250	0.234*
13	0.026	-0.045	0.020	-0.076	-0.381	0.163	-0.494	0.600	0.071	1.079	-0.108	0.842	**1.183**	0.127	0.789	0.289*
14	-0.130	-0.147	0.014	0.366	0.382	-0.050	0.284	-0.411	0.004	-0.098	-0.122	0.033	-0.102	**-0.946**	0.627	-0.112
15	0.120	0.257	0.007	-0.277	-0.023	-0.065	0.163	-0.061	-0.043	-0.684	0.190	-0.636	-0.803	0.798	**-1.204**	0.283*

Residual effect = 0.369

Note:- 1= Days to 50% flowering, 2= Plant height, 3= Panicle length, 4= Number of effective tiller per plant, 5= Number of filled grain per panicle 6= Number of unfilled grain per panicle, 7= Spikelet fertility, 8= 100 seed weight, 9= Harvest index, 10= Paddy length, 11= Paddy breadth, 12= Paddy length:breadth, 13= Brown rice length, 14= Brown rice length, 15= Brown rice length:breadth.

CONCLUSIONS

The results of the analysis of variance showed that there were extremely significant genotype differences for each of the quantitative traits. The traits showed high heritability with high genetic advance by characters such as number of unfilled grains per panicle, number of filled grain per panicle, paddy breadth, paddy length:breadth ratio, brown rice length:breadth ratio, 100 seed weight indicated that these traits were controlled by additive type of gene action. Grain yield per plant exhibits a positive and highly significant correlation with the days to 50% flowering, number of effective tillers per plant, number of filled grain per panicle and paddy length. It showed a negative and highly significant correlation with the plant height. Days to 50% flowering, panicle length, number of filled grains per panicle, harvest index, paddy length, brown rice length had a highly significant and positive correlation with grain yield per plant along with a positive direct effect on grain yield per plant.

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