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Assessment of genetic variability, correlation and path coefficient analysis for yield & its contributing traits in rice (*Oryza sativa* L.)

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Abstract
The entitled research work "Assessment of genetic variability, correlation and path coefficient analysis for yield & its contributing traits in rice (*Oryza sativa* L.)" was executed Research cum Intractional Farm, Genetics and Plant Breeding department of IGKV Raipur (C.G.) during *kharif* 2021. The research material under research comprised of 50 rice germplasm lines including two checks namely Mahamaya and Rajeshwari, which were tested in RBD with two replications with the objectives v*iz.* (1) To estimate genetic variability for yield and quality traits. (2) To study the association analysis among yield and other traits. (3) To analyse the direct and indirect effects on trait under study on grain yield. The observation of research investigation were recorded for total 24 characters *viz.* Days to 50% flowering, Number of tillers per plant, Panicle length (cm), Plant height (cm), 1000seed weight (g), Grain yield per plant (g), Biological yield per plant(g), Harvest index(%), Paddy length(mm), Paddy breadth(mm), Paddy length breadth ratio, Hulling (%), Milling (%), Alkali spread value, Gel consistency (mm), Amylase content (%), Kernel length (mm), Kernel breadth (mm), Kernel length breadth ratio, Hulled rice length after cooking (mm), Hulled rice breadth after cooking(mm), Cooked rice length (mm), Cooked rice breadth (mm). The analysis of variance showed that there was a highly significant variation in genotypes for all of the studied characters. A small difference between PCV and GCV suggests that the environment has little impact on the concerning traits. The NTPP, TSW, GYPP, BYPP, HI, M, HRR, ASV, GC, AC, KL: B, HRBAC, CRL and CRB had high heritability along with high genetic advance as a percent of mean indicates that the heritability is most likely caused by additive gene action and selection may be effective. Positive significant correlation was showed GYPP with NTPP, TSW, BYPP and HRR with H, M. These characters would be beneficial for increasing yield and choosing superior genotypes among rice cultivars. Positive direct effect on GYPP showed by the HI, BYPP, PLN, DTFF, NTPP, TSW and on HRR showed by PL, M, ASV, GC, KB, KL:B, HRABC, CRL revealed true relationship between them and direct selection for these traits would be beneficial for increasing yield.

Keywords: Correlation, heritability, genetic advance, Direct and indirect effect

Introduction
Rice (*Oryza sativa* L., 2n=24) belongs to family Poaceae and subfamily Oryzoidae. It is believed to be originated in South East Asia. "Rice is Life", the famous motto of the International Rice Year 2004, emphasised the importance of rice as a food and commerce commodity. India has the largest rice-growing area in the world, ranks second in production, with about 127.93 million tonnes in 2021-2022, after China. (Anonymous, 2022) [1]. In rice breeding programmes, yield increase is the primary breeding goal, and recognizing of the type and degree of genetic variation influencing the inheritance of quantitative features like yield and yield components is critical for successful genetic improvement. Plant breeders frequently choose yield components that tangentially increase yield. A trait's heritability (h^2) is crucial in determining how it will react to selection. It has been established that in order to plan a successful breeding programme, genetic improvement of plants for quantitative traits requires accurate estimates of heritability. Correlation coefficient analysis measures the mutual relationship between different plant characteristics and identifies the component characters on which selection can be based for genetic yield improvement. Correlation studies would offer trustworthy information regarding the nature, scope, and direction of the

selection when choosing the best plant type, particularly when the breeder needs to combine high yield potentials with desirable agronomic traits and grain quality characters. According to Dewey and Lu (1959) [2], path analysis is a special type of multivariate statistical analysis, which has a linear correlation with each other and can separate direct and indirect effect towards crop yield.

Materials and Methods

The experimental materials included 50 rice genotypes including 48 germplasm and two checks namely Mahamaya and IGKVR1 (Rajeshwari). The experimental materials were received from germplasm section, Department of Genetics and Plant Breeding, IGKV, Raipur (C.G.). **G**enotypes of rice were evaluated at the Research cum Instructional Farm, Department Genetics and Plant Breeding, College of Agriculture, IGKV, Raipur. The plant material of rice direct sowing on June 22, 2021 with 20x15cm spacing. The experimental material was planted in two replication in RBD design. Fertilizer was applied at a rate of 80N: 60P: 40K kg /ha. Half of the nitrogen dose, as well as full dose of phosphate and potassium before of direct sowing. The remaining nitrogen was administrated in 2 stages, the 1st, at the start of tillering and the 2nd at the time of panicle initiation.

Table 1: List of germplasm accessions used as experiment material and during *kharif season* 2021.

S.N.	CGR	Accession No.	Name of accession
1	CGR:5386	M : 63 II	Muni Bhog
2	CGR:5390	M : 804	Muni Bhog
3	CGR:5391	M : 812	Muni Bhog
4	CGR:5392	P : 132	Parsadi Bhog
5	CGR:5393	P : 138	Parsadi Bhog
6	CGR:5396	R : 112 I	Raj Bhog
7	CGR:5398	R : 69 II	Ram Bhog
8	CGR:5399	R : 173 II	Ram Bhog
9	CGR:5407	B : 678 II	Bishun Bhog
10	CGR:5408	B : 1306	Bishun Bhog
11	CGR:5411	B : 2247	Bisun Bhog
12	CGR:5413	V : 15 II	Vishnoo Bhog
13	CGR:5415	V : 15 III	Vishnoo Bhog
14	CGR:5419	V : 34	Vishnu Bhog
15	CGR:5439	B : 1443 II	Bahra Sinki
16	CGR:5443	B : 329 I	Baigani
17	CGR:5447	B : 226 II	Baikuna
18	CGR:5448	B : 304 I	Baikoni
19	CGR:5449	B : 304 II	Baikoni
20	CGR:5451	B : 476	Baikoni
21	CGR:5452	B : 532	Baikoni
22	CGR:5455	B : 580	Bhujanin
23	CGR:5456	B : 1062	Baikoni
24	CGR:5457	B : 1095 I	Baikoni
25	CGR:5459	B : 1095 III	Baikoni
26	CGR:5460	B : 1101 I	Baikoni
27	CGR:5463	B : 1186 VI	Baikoni
28	CGR:5464	B : 1193 I	Baikoni
29	CGR:5466	B : 1227	Baikoni
30	CGR:5472	B : 1590	Baikoni
31	CGR:5474	B : 1914 I	Baikoni
32	CGR:5475	B : 1955	Baikoni
33	CGR:5477	B : 2003	Baikoni
34	CGR:5478	B : 2906	Baikoni
35	CGR:5481	B : 2916	Baikoni
36	CGR:5482	B : 1547	Bade Baikoni
37	CGR:5484	B : 1986	Baiha Baikoni
38	CGR:5485	B : 1988	Baiha Baikoni
39	CGR:5487	B : 1998	Baiha Baikoni
40	CGR:5491	B : 1192	Baikuni
41	CGR:5492	B : 1943	Baikuni
42	CGR:5493	B : 2708	Baikuni
43	CGR:5501	B : 1553 II	Bajrang Bali
44	CGR:5505	B : 2004	Bakai
45	CGR:5506	B : 2263	Bakai
46	CGR:5508	B : 1239	Bakal
47	CGR:5518	B : 435 I	Bal Keshar
48	CGR:5519	B : 1883	Bal Keshar
49	-	-	Mahamaya
50	-	-	Rajeshwari

Results and Discussion

The analysis of variance for different quantitative traits or yield and its contributing traits is shown in the table 1.2. The analysis of variance of all the quantitative characters except panicle length showed that there is highly significant variation found among the genotypes. Panicle length (cm) also showed significant difference. Results of analysis of variance of all physicochemical quality traits also showed highly significant variance (Table 1.3).

Table 2: Analysis of Variance (ANOVA) for yield and its contributing traits

S. No.	Source of variance	Mean Sum of Squares		
		Replication	Treatment	Error
		D. F. (1)	D. F. (49)	D. F. (49)
1.	Days to 50% flowering	13.69	61.62**	4.20
2.	Number of tillers per plant	0.04	0.79**	0.12
3.	Plant height (cm)	4.51	314.13**	61.24
4.	Panicle length (cm)	0.50	4.80*	2.64
5.	1000 seed weight (g)	2.23	28.72**	1.68
6.	Grain yield per plant (g)	1.29	11.72**	0.68
7.	Biological yield per plant(g)	5.98	31.79**	2.62
8.	Harvest index (%)	0.06	161.79**	4.14

** Significant at 1 % level, * Significant at 5 % level, d. f. Degree of freedom

Table 3: Analysis of Variance (ANOVA) for physicochemical quality traits

S. No.	Source of variance	Mean Sum of Squares		
		Replication	Treatment	Error
		D. F. (1)	D. F. (49)	D. F. (49)
1	Paddy length (mm)	0.69	1.02**	0.23
2	Paddy breadth (mm)	0.03	0.18**	0.02
3	Paddy L:B ratio	0.01	0.26**	0.05
4	Hulling (%)	16.88	85.46**	19.96
5	Milling (%)	42.22	174.92**	10.47
6	Head rice recovery (%)	20.24	405.08**	6.70
7	Alkali spread value	0.16	2.37**	0.09
8	Gel consistency	14.44	502.90**	13.11
9	Amylose content (%)	5.74	18.11**	1.63
10	Kernel length(mm)	0.42	0.67**	0.10
11	Kernel breadth (mm)	0.07	0.09**	0.01
12	Kernel L:B ratio	0.001	0.30**	0.04
13	Hulled rice length after cooking (mm)	0.21	0.85**	0.17
14	Hulled rice breadth after cooking (mm)	0.01	0.29**	0.03
15	Cooked rice length (mm)	0.30	2.36**	0.08
16	Cooked rice breadth (mm)	0.02	0.31**	0.03

**Significant at 1% level, * Significant at 5% level, d. f. Degree of freedom

Estimation of genotypic and phenotypic coefficient of variation:

Yield & yield contributing traits:

The high value of GCV and PCV was recorded only for grain yield per plant 24.49 and 25.96, respectively. These results are in agreement with the findings of Dhanwani *et al.* (2013) [3], Chamar *et al.* (2021) [4], Noatia *et al.* (2021) [5] and Singh *et al.* (2021) [13].

Moderate genotypic coefficient of variation and phenotypic variation were recorded in number of tillers per plant (GCV 16.22, PCV 18.95), 1000 seed weight (GCV 15.38, PCV 16.31), biological yield per plant (GCV 18.93, PCV 20.57) and harvest index (GCV 18.59, PCV 19.07). Similar findings were also reported by Sonwani (2021) [7].

The low estimates of GCV and PCV were reported in days to 50 % flowering (GCV 4.89, PCV 5.23), plant height (GCV 7.19, PCV 8.76) and panicle length (GCV 4.17, PCV 7.74). Similar findings have been reported by Noatia *et al.* (2021) [5] and Sudeepthi *et al.* (2020) [8] for the panicle length, days to 50 % flowering, by Donkor *et al.* (2020) [9] for days to 50 % flowering and plant height.

Physicochemical quality traits

The high genotypic and phenotypic coefficient of variation were recorded for physicochemical quality traits namely head rice recovery (GCV 35.98, PCV 36.58), alkali spread value (GCV 31.70, PCV 33.05), gel consistency (GCV36.58, PCV 37.55). Dhanwani *et al.* (2013) [3] and Singh *et al.* (2021) [13] also reported similar findings for alkali spread value and gel consistency.

The moderate genotypic and phenotypic coefficient of variation were recorded for physicochemical quality traits namely paddy breadth (GCV 10.18, PCV 11.32), paddy L: B ratio (GCV 11.26, PCV 13.55), Milling (%) (GCV 15.02, PCV 15.95), amylose content (GCV 15.32, PCV 16.77), kernel L: B ratio (GCV 12.55, PCV 14.83), hulled rice breadth after cooking (GCV 11.21, PCV 12.79), cooked rice length (GCV 12.35, PCV 12.80), cooked rice breadth (GCV 11.03, PCV 12.25).

The low genotypic and phenotypic coefficient of variation were recorded for physicochemical quality traits namely paddy length (GCV 7.59, PCV 9.63), Hulling (%) (GCV 7.68, PCV 9.75), kernel length (GCV 8.58, PCV 10.07), kernel breadth (GCV 8.47, PCV 10.44) and hulled rice length after cooking (GCV 7.55, PCV 9.28). Low GCV and PCV for the Hulling (%) were reported by Noatia *et al.* (2021) [5] and Paikra *et al.* (2021) [10].

4.2.3. Estimation of heritability and genetic advance as % of mean

Yield & yield contributing traits

High heritability estimates was recorded for days to 50 % flowering (87.24 %), number of tillers per plant (73.27 %), plant height (67.37 %), 1000 seed weight (88.92 %), grain yield per plant (88.99 %), biological yield per plant (84.75 %) and harvest index (95.00 %). Low heritability estimate was recorded panicle length (29.04 %) only. High genetic advance as % of mean was recorded for number of tillers per plant (28.60), 1000 seed weight (29.88), grain yield per plant (47.60), biological yield per plant (35.90), harvest index (37.31). Moderate genetic advance as % of mean was recorded for plant height only, while low genetic advance as % of mean was recorded for days to 50 % flowering (9.40) and panicle length (4.63).

Physicochemical quality traits

High heritability was recorded for physicochemical quality traits namely paddy length (62.11 %), paddy breadth (80.80 %), paddy L: B ratio (69.00 %), hulling (%) (62.13 %), milling (%) (88.70 %), head rice recovery (%) (96.74 %), alkali spread value (91.99 %), gel consistency (94.92 %), amylose content (%) (83.46 %), kernel length (72.60 %), kernel breadth (65.80 %), kernel L:B ratio (71.63 %), hulled rice length after cooking (66.19 %), hulled rice breadth after cooking (76.79 %), cooked rice length (93.14 %) and cooked rice breadth (81.02 %). Similar results were reported by Paikra *et al.* (2021) [10] for Hulling (%) and amylase content. High genetic advance as a % of mean was recorded for physicochemical quality traits milling (29.15), head rice recovery (72.90), alkali spread value (62.64), gel consistency (73.42), amylase content (28.82), kernel L:B ratio (21.89), hulled rice breadth after cooking (20.23), cooked rice length (24.56) and cooked rice breadth (20.45). Moderate genetic advance as a % of mean was recorded for physicochemical traits namely paddy length (12.32), paddy breadth (18.85), paddy L: B ratio (19.27), hulling (12.48), kernel length (15.05), kernel breadth (14.15) and hulled rice length after cooking (12.65). Similar findings were reported by Paikra *et al.* (2021) [10] for paddy breadth and Hulling (%).

Table 4: Estimates genetic variability of various yield and its contributing traits

S. N.	Characters	Mean	Range		PCV (%)	GCV (%)	h^2 (bs)	GA as % of mean
			Min.	Max.				
1	DTFF	109.65	96.50	120.00	5.23	4.89	87.24	9.40
2	NTPP	3.56	2.50	5.00	18.95	16.22	73.27	28.60
3	PH	156.39	128.89	176.75	8.76	7.19	67.37	12.16
4	PLN	24.91	21.79	28.35	7.74	4.17	29.04	4.63
5	TSW	23.90	11.33	32.05	16.31	15.38	88.92	29.88
6	GYPP	9.59	3.19	15.65	25.96	24.49	88.99	47.60
7	BYPP	20.17	10.59	26.56	20.57	18.93	84.75	35.90
8	HI	47.76	27.08	64.31	19.07	18.59	95.00	37.31

DTFF- Days to50% flowering, NTPP- Number of tillers per plant, PLN- Panicle length, PH - Plant height, TSW-1000 seed weight, - GYPP Grain yield per plant, BYPP- Biological yield per plant, HI- Harvest index.

Table 5: Estimates of genetic variability of various physicochemical quality traits

S. No.	Characters	Mean	Range		PCV (%)	GCV (%)	h^2 (Bs)	GA as % of mean
			Min.	Max.				
1.	PL	8.24	6.40	10.50	9.63	7.59	62.11	12.32
2.	PB	2.82	2.30	3.65	11.32	10.18	80.80	18.85
3.	P L:B	2.95	2.30	3.85	13.55	11.26	69.00	19.27
4.	H	74.47	59.55	85.76	9.75	7.68	62.13	12.48
5.	M	60.36	34.65	74.94	15.95	15.02	88.70	29.15
6.	HRR	39.23	11.84	66.46	36.58	35.98	96.74	72.90
7.	ASV	3.36	2.00	6.00	33.05	31.70	91.99	62.64
8.	GC	42.78	27.50	94.50	37.55	36.58	94.92	73.42
9.	AC	18.74	12.62	25.59	16.77	15.32	83.46	28.82
10.	KL	6.20	4.50	7.35	10.07	8.58	72.60	15.05
11.	KB	2.24	1.85	2.80	10.44	8.47	65.80	14.15
12.	KL: B	2.8	2.0	3.7	14.83	12.55	71.63	21.89
13.	HRLAC	7.70	6.25	9.00	9.28	7.55	66.19	12.65
14.	HRBAC	3.17	2.65	4.70	12.79	11.21	76.79	20.23
15.	CRL	8.64	7.25	14.00	12.80	12.35	93.14	24.56
16.	CRB	3.37	2.90	4.85	12.25	11.03	81.02	20.45

PL-Paddy length, PB- Paddy breadth, P.L: B- Paddy length breadth ratio, H- Hulling (%), M- Milling (%), ASV- Alkali spread value, GC- Gel consistency, AC-Amylase content, KL- Kernel length, KB- Kernel breadth, K.L: B- Kernel length breadth ratio, HRLAC- Hulled rice length after cooking, HRBAC- Hulled rice breadth after cooking, CRL-Cooked rice length, CRB-Cooked rice breadth

Correlation coefficient analysis

Grain yield per plant is positive significant correlated with number of tillers per plant, 1000 seed weight, biological yield per plant, harvest index and negative significant correlated with plant height at both genotypic and phenotypic level. At only genotypic level grain yield is positive significant correlated with panicle length whereas negative significant with days to 50 % flowering. Similar results were reported by Prasad *et al.* (2017) [12]. Head rice recovery (%) is positive significant correlated with Hulling (%), Milling (%) at both genotypic and phenotypic level. Similar results were reported by Vyas *et al.* (2021) [11] for milling (%).

Table 6: Genotypic and phenotypic correlation coefficient of various yield and its contributing traits

Characters		Days to 50 % flowering	Number of tillers per plant	Plant height	Panicle length	1000 seed weight	Biological yield per plant	Harvest index
Number of tillers per plant	G	-0.149						
	P	0.131						
Plant height	G	0.652**	-0.384**					
	P	0.519**	-0.247*					
Panicle length	G	0.085	0.175	0.190				
	P	0.026	0.103	0.285**				
1000 seed weight	G	0.086	0.013	0.184	0.261**			
	P	0.056	-0.004	0.116	0.053			
Biological yield per plant	G	0.074	0.520**	0.094	0.493**	0.224*		
	P	0.084	0.400**	0.073	0.210*	0.210*		
Harvest index	G	-0.352**	0.231*	-0.473**	-0.207*	0.162	-0.121	
	P	-0.330**	0.192	-0.345**	-0.044	0.130	-0.122	
Grain yield per plant	G	-0.199*	0.593**	-0.315**	0.269**	0.285**	0.669**	0.648**
	P	-0.163	0.465**	-0.226*	0.151	0.254*	0.697**	0.607**

Path coefficient analysis

Path Coefficient analysis revealed that the highest positive direct effects on grain yield per plant were observed through harvest index (0.7114) followed by biological yield per plant (0.7102). Both of these characters showed high positive direct effects on grain yield and hence these traits should be taken into consideration in selecting for yield among the genotypes studied. The direct effects of days to 50 % flowering, numbers of tillers per plant, plant height, panicle length and 1000 seed weight were observed to be negligible, but the characters plant height, panicle length and 1000 seed weight showed significant positive correlation with grain yield per plant via indirect effects. The maximum direct effect on head rice recovery was observed for kernel breadth (0.998) and kernel L:B ratio (0.998) followed by paddy length (0.9220) milling % (0.792) and hulled rice after cooking (0.726). The trait milling (%) showed significant positive correlation with head rice recovery as shown in table 4.30. The physicochemical trait hulling (%) also showed significant positive correlation with head rice recovery via indirect effects of kernel breadth, milling (%), hulled rice after cooking and kernel length although its direct effect was observed negatively low (-0.165). The results which are given in table are in accordance with Vyas (2021) [11].

Table 7: Genotypic and phenotypic correlation coefficient of various physicochemical quality traits

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2	G	0.359**														
	P	0.261**														
3	G	0.405**	-0.705**													
	P	0.517**	-0.680**													
4	G	0.028	0.042	-0.019												
	P	-0.087	0.01	-0.061												
5	G	0.335**	0.048	0.213*	0.378**											
	P	0.253*	0.026	0.183	0.346**											
6	G	0.316	0.086	0.171	0.249*	0.037										
	P	0.196	0.107	0.079	0.216*	0.014										
7	G	0.227*	0.103	0.069	-0.367**	-0.056	-0.072									
	P	0.168	0.092	0.049	-0.255*	-0.035	-0.072									
8	G	0.018	-0.136	0.159	-0.159	0.097	-0.113	0.038								
	P	-0.049	-0.12	0.081	-0.093	0.082	-0.1	0.022								
9	G	0.837**	0.152	0.467**	-0.219*	0.154	0.184	0.019	0.018							
	P	0.49**	0.127	0.259**	-0.095	0.143	0.165	0.007	0.009							
10	G	0.019	0.358**	-0.303**	0.385**	0.064	0.083	-0.04	-0.17	-0.135						
	P	-0.045	0.296**	-0.279**	0.230*	0.062	0.116	-0.08	-0.07	-0.055						
11	G	0.571**	-0.143	0.539**	-0.407**	0.064	0.078	0.024	0.134	0.759**	-0.741**					
	P	0.357**	-0.11	0.361**	-0.224*	0.062	0.04	0.046	0.058	0.718**	-0.724**					
12	G	0.750**	0.086	0.463**	-0.113	0.044	0.239*	0.061	0.105	0.596**	0.082	0.332**				
	P	0.365**	0.025	0.273**	-0.054	0.014	0.186	0.091	0.097	0.411**	0.071	0.207*				
13	G	-0.119	0.300**	-0.366**	0.222*	0.026	0.112	-0.13	0.084	-0.244*	0.314**	-0.384**	0.177			
	P	-0.105	0.219*	-0.268**	0.189	0.027	0.084	-0.1	0.089	-0.225*	0.241*	-0.327**	0.162			
14	G	0.203*	0.181	-0.029	0.122	-0.087	0.268**	-0.09	0.103	0.184	-0.108	0.208*	0.353**	0.135		
	P	0.132	0.149	-0.03	0.104	-0.093	0.254*	-0.07	0.098	0.171	-0.074	0.176	0.377**	0.104		
15	G	-0.136	0.273**	-0.336**	0.194	0.048	0.171	-0.18	0.196	-0.255*	0.278**	-0.354**	0.131	0.955**	0.223*	
	P	-0.107	0.207*	-0.250*	0.178	0.062	0.152	-0.15	0.166	-0.195	0.194	-0.260**	0.108	0.915**	0.200*	
16	G	0.089	-0.056	0.131	0.324**	0.699**	0.081	0.054	-0.13	0.034	0.184	-0.087	-0.149	0.006	-0.13	-0.02
	P	0.046	-0.076	0.116	0.262**	0.658**	0.072	0.051	-0.11	0.038	0.161	-0.075	-0.111	-0.002	-0.12	-0.03

1-Paddy length, 2-Paddy breadth, 3-Paddy L:B ratio, 4-Hulling (%), 5-Milling (%), 6-Alkali spread value,7-Gel consistency, 8-Amylose content, 9-Kernel length, 10-Kernel breadth, 11-Kernel L:B ratio, 12-Hulled rice length after cooking, 13-Hulled rice after cooking, 14- Cooked rice length, 15-Cooked rice breadth, 16-Head rice recovery

Summary and Conclusions

According to the analysis of variance, there were highly significant differences for all traits under study. Analysis manifested that the mean sum of squares is highly significant for all the traits.

The high PCV and GCV was estimated for grain yield per plant among all yield and its contributing traits and head rice recovery, alkali spread value, and gel consistency among all physicochemical quality traits.

High heritability was recorded for harvest index, grain yield per plant, 1000 seed weight, days to 50 % flowering, biological yield per plant, number of tillers per plant, plant height among all yield and its contributing traits and for head rice recovery%, gel consistency, cooked rice length, alkali spread value, milling (%), amylose content, cooked rice breadth, panicle breadth, hulled rice breadth after cooking, kernel length, kernel L:B ratio, paddy L:B ratio, hulled rice length after cooking, kernel breadth, hulling%, panicle length among all physicochemical traits.

Maximum genetic advance as % of mean was estimated for grain yield per plant, harvest index, biological yield per plant, 1000 seed weight, number of tillers per plant among all yield and its contributing traits and for gel consistency, head rice recovery (%), alkali spread value, milling %, amylose content, cooked rice length, kernel L: B ratio, cooked rice breadth, hulled rice breadth after cooking among all physicochemical quality traits.

Number of tillers per plant, 1000 seed weight, biological yield per plant, harvest index are positive significantly correlated with grain yield per plant at both phenotypic and genotypic level among yield and its contributing traits, while hulling (%) and milling (%) are positive as well and are significantly correlated with head rice recovery among physiochemical quality traits.

Path analysis revealed that positive direct effect on grain yield per plant showed by the harvest index, biological yield per plant, panicle length, days to 50 % flowering, number of tillers per plant and 1000 seed weight among yield and its contributing traits while the positive direct effect on head rice recovery showed by paddy length, milling (%), alkali spread value, gel consistency, kernel breadth, kernel L: B ratio, hulled rice breadth after cooking, cooked rice length.

Table 8: Path analysis (Direct and indirect effect) of various yield and its contributing traits of 50 genotypes

	1	2	3	4	5	6	7	GCC of GYPP
1	0.0490	-0.0034	-0.0534	0.0061	0.0002	0.0528	-0.2502	-0.199*
2	-0.0072	0.0232	0.0314	0.0126	0.00003	0.3692	0.1640	0.593**
3	0.0319	-0.0089	-0.0819	0.0137	0.0004	0.0664	-0.3365	-0.315**
4	0.0041	0.0040	-0.0155	0.0724	0.0006	0.3502	-0.1470	0.269**
5	0.0042	0.0003	-0.0151	0.0189	0.0024	0.1591	0.1149	0.285**
6	0.0036	0.0120	-0.0077	0.0357	0.0005	0.7102	-0.0858	0.669**
7	-0.0172	0.0053	0.0387	-0.0149	0.0003	-0.0856	0.7114	0.648**

Residual effect 0.0213

1-Days to 50 % flowering, 2-Number of tillers per plant, 3-Plant height, 4-Panicle length,5-1000 seed weight, 6-Biological yield per plant,7-Harvest index, GCC of GNPP-Genotypic correlation coefficient of grain yield per plant

Table 9: Path analysis (Direct and indirect effects) of various physicochemical quality traits of 50 genotypes

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	r_g HRR
1	0.922	-0.547	-0.495	-0.005	0.265	0.046	0.035	-0.002	-0.385	0.019	0.569	-0.365	-0.086	0.038	0.078	0.088
2	0.331	-1.523	0.861	-0.007	0.038	0.013	0.016	0.017	-0.070	0.358	-0.143	-0.042	0.218	0.034	-0.157	-0.056
3	0.373	1.073	-1.222	0.003	0.169	0.025	0.011	-0.020	-0.215	-0.302	0.538	-0.225	-0.266	-0.006	0.193	0.131
4	0.026	-0.065	0.024	-0.165	0.299	0.036	-0.057	0.020	0.101	0.384	-0.407	0.055	0.161	0.023	-0.112	0.324**
5	0.309	-0.074	-0.260	-0.062	0.792	0.005	-0.009	-0.012	-0.071	0.064	0.064	-0.021	0.019	-0.016	-0.028	0.699**
6	0.291	-0.131	-0.209	-0.041	0.029	0.146	-0.011	0.014	-0.085	0.082	0.078	-0.116	0.081	0.050	-0.099	0.081
7	0.209	-0.158	-0.085	0.061	-0.044	-0.011	0.155	-0.005	-0.009	-0.044	0.024	-0.030	-0.098	-0.016	0.104	0.054
8	0.016	0.207	-0.194	0.026	0.077	-0.017	0.006	-0.127	-0.008	-0.170	0.134	-0.051	0.061	0.019	-0.113	-0.134
9	0.771	-0.231	-0.570	0.036	0.122	0.027	0.003	-0.002	-0.460	-0.134	0.758	-0.290	-0.177	0.034	0.147	0.034
10	0.018	-0.546	0.370	-0.064	0.051	0.012	-0.007	0.022	0.062	0.998	-0.740	-0.040	0.228	-0.020	-0.160	0.184
11	0.526	0.218	-0.658	0.067	0.051	0.011	0.004	-0.017	-0.349	-0.740	0.998	-0.162	-0.278	0.039	0.203	-0.087
12	0.692	-0.131	-0.565	0.019	0.035	0.035	0.010	-0.013	-0.274	0.082	0.331	-0.487	0.129	0.066	-0.075	-0.149
13	-0.109	-0.457	0.447	-0.037	0.021	0.016	-0.021	-0.011	0.112	0.313	-0.383	-0.086	0.726	0.025	-0.549	0.006
14	0.187	-0.276	0.036	-0.020	-0.069	0.039	-0.013	-0.013	-0.084	-0.108	0.207	-0.172	0.098	0.187	-0.128	-0.129
15	-0.125	-0.416	0.410	-0.032	0.038	0.025	-0.028	-0.025	0.117	0.277	-0.353	-0.064	0.693	0.042	-0.575	-0.016

Residual effect 0.3131,

1-Paddy length, 2-Paddy breadth, 3-Paddy L:B ratio,4-Hulling (%),5-Milling (%), 6-Alkali spread value,7-Gel consistency, 8-Amylose content, 9-Kernel length,10- Kernel breadth,11- Kernel L: B ratio,12- Hulled rice length after cooking,13-Hulled rice after cooking,14- Cooked rice length, 15- Cooked rice breadth, r_g HRR-Genotypic correlation coefficient of head rice recovery

Conclusion

- For all of the characters studied, analysis of variance revealed that highly significant variation among genotypes. The available genetic variability present in the material can be used for improvement of rice cultivars.
- Low difference between PCV and GCV indicate the low influence of the environment on the concerning traits.
- Yield and its contributing traits namely number of tillers per plant, 1000 seed weight, grain yield per plant, biological yield per plant, harvest index and physicochemical quality traits namely milling (%), head rice recovery (%), alkali spread value, gel consistency, amylose content, hulled rice breadth after cooking, cooked rice length, kernel L:B ratio, cooked rice breadth had high heritability accompanied with high genetic advance as a % of mean indicates that the most

likely the heritability is due to additive gene action and selection may be effective.

- If the correlation value is significant, the association between the two characters is high. Grain yield per plant is positive significantly correlated with number of tillers per plant, 1000 seed weight, biological yield per plant and harvest index while head rice recovery is positive significantly correlated with hulling (%), milling (%). These characters would be rewarding for grain yield improvement and selection of superior genotypes from the rice cultivars.
- Positive direct effect on grain yield per plant showed by the harvest index, biological yield per plant, panicle length, days to 50% flowering, number of tillers per plant, 1000 seed weight and positive direct effect on head rice recovery showed by paddy length, milling (%), alkali spread value, gel consistency, kernel breadth, kernel L:B ratio, hulled rice breadth after cooking, cooked rice length revealed true relationship between them and direct selection for these characters would be rewarding for yield improvement.

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