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Genetic parameters and correlations among yield, quality and nutritional traits in rice (*Oryza sativa* L.)

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ABSTRACT

This study explores the genetic parameters and variability of yield-attributing traits to enhance the breeding strategies in rice. A high phenotypic coefficient of variation compared to the genotypic coefficient of variation was observed for the traits which indicates the influence of environment in the expression of the trait. High heritability and high genetic advance were observed for number of filled grains per panicle, test weight, protein content, amylose content, iron content and zinc content, and a simple selection procedure could be used for improvement of these traits. The results showed a significant negative correlation of ear-bearing tillers per plant with grain yield per plant. A positive direct effect was exhibited by the traits excluding the iron content. Hence, direct selection for the traits would simultaneously improve the grain yield per plant in rice.

Key words: *Correlation, Genetic advance, Genetic variability, Heritability and Rice*

Rice (*Oryza sativa* L., 2n=24) is the world's most widely consumed staple food, and is rightfully called the "Global Grain". It is the principal source of carbohydrates and a crucial provider of essential micronutrients for approximately half of the global population, underscoring its significance in ensuring food security and nutrition. To meet the needs of a global population of 8 billion by 2030, rice production must rise by 50%, presenting a significant challenge to the plant breeders to increase yields and ensure food security for the world's growing population (Khush and Brar, 2002). Selection is a fundamental process in plant breeding and plays a crucial role in improving crop varieties. Effective selection in breeding programs requires a substantial amount of genetic variation among the breeding materials, enabling breeders to identify and select desirable traits (Sumanth *et al*., 2017). High heritability, in conjunction with significant genetic advance, provides a clear understanding of environmental influences on trait expression, allowing breeders to select stable and consistent genotypes (Nirmaladevi *et al.,* 2015). To develop effective selection and crop improvement strategies, it's essential to understand the complex relationships between yield component traits and their impact on grain yield. Thus, the present study was undertaken with the prime objective of identification of novel varieties of variability and association of yield traits with yield in rice.

MATERIAL AND METHODS

The experiment was conducted at Agricultural College Farm, Bapatla. The experimental material for this investigation included 45 rice genotypes, and check varieties *viz*., BPT 5204, BPT 2782, BPT 2846 and BPT 3082 (Table 1). Twenty-five-days-old seedlings of the genotypes were transplanted in Alpha Lattice Design in 3 rows of about 3m length in two replications by adopting a spacing of 20 × 15 cm between and within the rows. All the recommended packages of practices and need-based plant protection measures were followed to raise a healthy crop. At various stages of plant growth, data was recorded on various yield and yield component traits *viz.,* days to 50% flowering, days to maturity, plant height, number of filled grains per panicle and test weight. The analysis of genetic parameters was performed on the mean data using established statistical methods. Correlation coefficients were estimated according to Johnson *et al*. (1955), while path coefficient analysis was conducted as per Wright (1921) and Dewey and Lu (1959), to quantify the direct and indirect influences of individual characters on yield.

Table: 1 Experimental material used in the present investigation of rice

S. No	Genotype	S. No	Genotype	S. No	Genotype
1	BPT 2808	16	BPT 3082*	31	BPT 3648
2	BPT 3129	17	BPT 2846*	32	BPT 3649
3	BPT 3272	18	BPT 3781	33	BPT 3193
4	BPT 3167	19	BPT 3784	34	BPT 3650
5	BPT 3276	20	BPT 3426	35	BPT 3651
6	BPT 2295	21	BPT 3191	36	BPT 3652
7	BPT 3140	22	BPT 3642	37	BPT 3653
8	BPT 3152	23	BPT 3643	38	BPT 3192
9	BPT 3503	24	BPT 3812	39	BPT 3490
10	BPT 2782*	25	BPT 3644	40	BPT 2840
11	BPT 5204*	26	BPT 3645	41	BPT 3263
12	BPT 3165	27	BPT 3195	42	BPT 3287
13	BPT 3127	28	BPT 3646	43	BPT 3513
14	BPT 2953	29	BPT 3194	44	BPT 3081
15	BPT 3133	30	BPT 3647	45	BPT 3072
*CHECKS					

Table: 2 Variability parameters, heritability and genetic advance as per cent of mean for yield, yield component traits in rice

S. No	Characters	Mean	Range		GCV (%)	PCV (%)	Heritability (%) (Broad sense)	Genetic advance as % of Mean
			Min	Max				
1	Days to 50 percent flowering	108	98	128	6.27	7.13	77.3	11.3
2	Days to maturity	138	126	158	4.74	5.64	70.69	8.22
3	Plant height (cm)	97.12	61.6	126.6	10.48	16.07	42.51	14.07
4	Ear-bearing tillers per plant	9	7	12	15.54	20	76.7	3.16
5	Test weight (g)	22.55	15.8	28.7	11.71	12.72	84.63	22.18
6	Number of filled grains per panicle	118	73	183	21.4	21.53	98.84	43.84
7	Number of unfilled grains per panicle	50	16	90	37.2	44.39	70.24	64.24
8	Kernel length(mm)	5.46	4.92	5.98	3.01	4.92	60.12	3.79
9	Kernel breadth(mm)	1.84	1.73	2.37	3.54	6.75	62.2	3.83
10	L/B ratio	2.95	2.27	3.34	4.42	7.19	37.77	5.59
11	Head rice recovery (%)	58.69	55.25	63.3	2.41	4.54	28.2	2.63
12	Amylose content (%)	22.63	19.9	25.69	5.4	5.56	94.49	10.82
13	Protein content (%)	8.08	6.22	10.13	22.03	22.28	88.58	20.04
14	Fe content (mg/100g)	0.104	0.067	0.14	18.75	18.95	97.94	38.23
15	Zn content (mg/100g)	0.201	0.139	0.232	19.21	20.2	70.82	45.38
16	Grain yield per plant	40.91	25.45	53.4	15.68	16.72	87.9	30.29

Table 3 Correlation coefficients of yield traits with grain yield per plant in rice

		DFF	DM	PH	EBT	NFGPP	NUFGPP	KL	KB	L/B R	TW	HRR	PC	Fe	Zn	AC	GY
DFF	G	1	0.9922**	0.118	-0.103	-0.155	0.0771	0.8047**	0.0987	0.4702**	-0.1349	0.0397	0.0021	-0.0656	-0.1036	-0.0521	-0.1122
	P	1	0.9829**	0.007	0.029	-0.137	0.0178	0.3531**	0.0545	0.1933	-0.1118	0.0191	-0.0046	-0.0683	-0.0866	-0.0524	-0.0893
DM	G		1	0.111	0.0987	-0.157	0.0516	0.8388**	0.0351	0.5404**	-0.0984	0.0021	0.022	-0.0655	-0.1293	-0.0377	-0.1335
	P		1	0.01	0.0297	-0.127	0.0165	0.3682**	0.0436	0.2047	-0.074	0.023	-0.0075	-0.0724	-0.0989	-0.0382	-0.0997
PH	G			1	0.0779	0.1616	0.302**	0.3571*	0.083	0.1198	-0.0933	0.266	0.2928	-0.0675	0.2391	-0.0728	0.1693
	P			1	0.1759	0.1377	0.2417*	0.1213	0.0842	-0.0075	-0.0704	0.0106	0.1877	-0.0657	-0.018	-0.0506	0.0194
EBT	G				1	0.186	0.295*	-0.1733	0.5685**	-0.39**	0.0178	0.5963**	0.2292	0.2639	0.9309**	-0.1767**	-0.3761*
	P				1	0.0359	0.0997	0.1265	-0.0382	0.1293	-0.0324	0.0875	0.1435	0.0331	-0.1539	-0.1942	-0.071
NFGPP	G					1	0.4843**	0.0882	0.0746	-0.116	-0.1915	-0.3382*	0.0552	-0.1126	-0.1583	-0.0816	0.0947
	P					1	0.4218**	0.0625	0.044	-0.0642	-0.169	-0.1551	0.0504	-0.111	-0.096	-0.0781	0.0734
NUFGPP	G						1	0.1622	0.1304	-0.0925	-0.114	-0.1847	-0.1547	-0.0928	-0.337*	-0.113	0.0259
	P						1	0.1554	0.0637	0.011	-0.1042	-0.0589	-0.142	-0.0774	-0.0825	-0.1015	-0.0744
KL	G							1	0.0017	0.4478**	-0.1157	-0.166	0.1173	-0.3851	-0.7258**	0.0112	-0.0926
	P							1	0.1043	0.5841**	-0.0308	-0.0478	0.0672	-0.2453*	-0.2483*	-0.0183	-0.1299
KB	G								1	-0.9408**	-0.3141*	-0.3899**	-0.3168*	0.265	-0.3734*	0.0902	0.1298
	P								1	-0.677**	-0.1072	-0.0904	-0.205	0.1476	-0.2161*	0.0709	0.0937
L/B R	G									1	0.1122	0.1041	0.303*	-0.4309**	0.003	-0.135	-0.0615
	P									1	0.067	0.0588	0.2161*	-0.2723**	0.0668	-0.1329	-0.1283
TW	G										1	0.0669	0.1095	0.0515	-0.0871	0.025	0.1178
	P										1	0.0446	0.0994	0.0501	-0.0731	0.0305	0.104
HRR	G											1	0.1839	-0.1783	0.3409*	0.1581	0.0249
	P											1	0.0448	-0.1138	-0.1527	0.1026	0.0202
PC	G												1	0.2051	0.2153	0.0274	0.0846
	P												1	0.1853	0.1311	0.0111	0.0864
Fe	G													1	0.4758**	-0.0717	0.1163
	P													1	0.2816**	0.0624	0.116
Zn	G														1	-0.2425	0.2173
	P														1	-0.1349	0.0642
AC	G															1	0.0407
	P															1	0.0511
GY	G																1
	P																1

***DFF** -Days to 50 per cent flowering, **DM**- Days to maturity, **PH** -Plant height (cm), **EBT** -Ear bearing tillers per plant, **TW** -Test weight (g), **NFGP**-Number of filled grains per panicle, **NUFGPP**- Number of unfilled grains per panicle, **KL**- Kernel length(mm), **KB**- Kernel breadth (mm), **L/B R**-L/B ratio, **HRR**- Head rice recovery (%), **AC** -Amylose content (%), **PC**- Protein content, **Zn**-Zn content (mg/100g), **Fe**-Fe content(mg/100g), **AC** – Amylose content (%), **GY** -Grain yield/pla

Table. 4 Direct and indirect effects of yield component traits at genotypic level on grain yield per plant in rice

	DFF	DM	PH	EBT	NFGP	NUGPP	KL	KB	LB R	TW	HRR	PC	Fe	Zn	AC
DFF	**1.3382**	-0.9427	0.0348	0.014	-0.0162	-0.0039	-0.2658	-0.0184	-0.2103	-0.032	-0.0097	0.0004	0.0156	-0.0156	-0.0005
DM	1.3489	**-0.9353**	0.0329	-0.0115	-0.0164	-0.0026	-0.2771	-0.0065	-0.2418	-0.0234	-0.0005	0.0041	0.0155	-0.0195	-0.0004
PH	0.1572	-0.104	**0.2959**	-0.0136	0.0168	-0.0153	-0.118	-0.0155	-0.0536	-0.0221	-0.0648	0.0551	0.016	0.036	-0.0007
EBT	-0.1109	-0.0636	0.0238	-0.1689	0.019	-0.0122	0.0436	-0.0795	0.1249	0.0212	-0.0893	0.0401	-0.0405	0.1037	-0.0057
NGPP	-0.2075	0.1471	0.0478	-0.0308	**0.1042**	-0.0246	-0.0291	-0.0139	0.0519	-0.0454	0.0825	0.0104	0.0267	-0.0238	-0.0008
NUGP	0.1032	-0.0483	0.0894	-0.0407	0.0505	-0.0507	-0.0536	-0.0243	0.0414	-0.027	0.045	-0.0291	0.022	-0.0507	-0.0011
KL	1.0768	-0.7846	0.1057	0.0223	0.0092	-0.0082	-0.3303	-0.0003	-0.2004	-0.0274	0.0405	0.0221	0.0913	-0.1092	0.0001
KB	0.1322	-0.0328	0.0246	-0.072	0.0078	-0.0066	-0.0006	-0.1864	0.421	-0.0745	0.0951	-0.0596	-0.0629	-0.0562	0.0009
LB	0.6292	-0.5054	0.0355	0.0472	-0.0121	0.0047	-0.1479	0.1753	**-0.4474**	0.0266	-0.0254	0.057	0.1022	0.0004	-0.0013
TW	-0.1805	0.092	-0.0276	-0.0151	-0.02	0.0058	0.0382	0.0585	-0.0502	**0.2373**	-0.0163	0.0206	-0.0122	-0.0131	0.0002
HRR	0.0532	-0.002	0.0787	-0.0619	-0.0353	0.0094	0.0548	0.0727	-0.0466	0.0159	-0.2438	0.0346	0.0423	0.0513	0.0016
PC	0.0029	-0.0206	0.0866	-0.036	0.0058	0.0078	-0.0388	0.059	-0.1355	0.026	-0.0448	**0.1881**	-0.0487	0.0324	0.0003
Fe	-0.0877	0.0613	-0.02	-0.0288	-0.0117	0.0047	0.1272	-0.494	0.1928	0.0122	0.0435	0.0386	**-0.2372**	0.0716	-0.0007
Zn	-0.1387	0.1209	0.0707	-0.1163	-0.0165	0.0171	0.2398	0.0696	-0.0013	-0.0207	-0.0831	0.0405	-0.1129	**0.1505**	-0.0024
AC	-0.0698	0.0352	-0.0215	0.0969	-0.0085	0.0056	-0.0037	-0.0168	0.0604	0.0059	-0.0385	0.0052	0.017	-0.0365	**0.0099**
GYP	-0.1122	-0.1335	0.1693	-0.1944	0.0947	0.0259	-0.0926	0.1298	-0.615	0.1178	0.0249	0.0846	0.1163	0.2173	0.0407
Partial R2	-0.1501	0.1248	0.0501	0.0328	0.0099	-0.0013	0.0306	-0.0242	0.0275	0.0279	-0.0061	0.0159	-0.0276	0.0327	0.0004

***DFF** -Days to 50 per cent flowering, **DM**- Days to maturity, **PH** -Plant height (cm), **EBT** -Ear bearing tillers per plant, **TW** -Test weight (g), **NFGP**-Number of filled grains per panicle, **NUFGPP**- Number of unfilled grains per panicle, **KL**- Kernel length(mm), **KB**- Kernel breadth (mm), **L/B R**-L/B ratio, **HRR**- Head rice recovery (%), **AC** -Amylose content (%), **PC**- Protein content, **Zn**-Zn content (mg/100g), **Fe**-Fe content(mg/100g), **AC** – Amylose content (%), **GY** -Grain yield/plant

RESULTS AND DISCUSSION

The analysis of variance for the traits revealed significant variation indicating the existence of sufficient amount of variation among the genotypes included in the study. The genotypic and phenotypic coefficients of variation (GCV and PCV), heritability and genetic advance as per cent of mean values were obtained for various yield components and were presented in Table 2. The highest phenotypic and genotypic coefficients of variation was observed for the protein content followed by number of unfilled grains per panicle and zinc content while the least was recorded by head rice recovery. High heritability coupled with moderate to low genetic advance was exhibited by days to 50% flowering, days to maturity, ear-bearing tillers per plant, kernel length, kernel breadth and amylose content indicating that these characters were governed by non- additive gene action. These findings are in agreement with the findings of Sridevi (2018), Nath and Kole (2021) and Devi *et al*. (2022).

The results obtained from statistical analysis under the association studies between yield and yield-component traits (Table 3) revealed that a significant positive association was observed for days to maturity, kernel length with days to 50 percent flowering; kernel length with days to maturity; number of unfilled grains per panicle with plant height; L/B ratio with kernel length; zinc content with iron content at both phenotypic and genotypic levels. A significant negative association was observed for L/B ratio with kernel breadth; and iron content with L/B ratio at both genotypic and phenotypic levels.

A significant negative association was recorded for ear-bearing tillers per plant (- 0.376*) with grain yield per plant at the genotypic level indicating that the genotypes with smaller number of ear-bearing tillers manifested more number of filled grains. These findings are in agreement with Archana *et al*. (2018), Santhipriya *et al*. (2017) and Shivani *et al.* (2018). The results from path analysis (Table 4) revealed that positive direct effects were observed for days to 50% flowering, plant height, number of filled grains per panicle, test weight, protein content, zinc content and amylose content with grain yield per plant.

Negative direct effects were observed for days to maturity, ear-bearing tillers per plant, head rice recovery, number of unfilled grains per panicle, kernel length, kernel breadth, L/B ratio and zinc content with grain yield per plant at the genotypic level. The above findings were found similar by Singh *et al.* (2020), Deepthi *et al*. (2022), Heera *et al*. (2023), Kulsum *et al*. (2022), Archana *et al*. (2018), Thuy *et al*. (2023), Singh *et al*. (2020) and Edukondalu *et al*. (2017).

CONCLUSION

The phenotypic coefficient of variation estimates for the traits were higher than the genotypic coefficient of variation. Higher phenotypic and genotypic coefficients of variation were recorded by number of filled grains per panicle. The high heritability and genetic advance of few traits suggest that the influence of additive gene action and simple selection is advocated for the improvement of the traits. The correlation and path coefficient analysis results indicate good significant positive association of yield traits and positive direct effects revealed that direct selection for the traits will simultaneously improve grain yield per plant in rice.

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