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Studies on Variability, Heritability, Correlation and Path Analysis for Yield, Yield Attributes in Rice (*Oryza sativa* L.)

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A B S T R A C T

An investigation was carried out to study the heritability, correlation and path analysis for 15 characters in 40 genotypes of rice during *Kharif*, 2016. Analysis of variance revealed that mean sum of squares due to genotypes showed significant differences for all 15 characters studied. Analysis of variability parameters revealed that the phenotypic coefficient variation were higher than genotypic coefficient variation. The magnitude of PCV and GCV was high for number of grains per panicle. High heritability coupled with high genetic advance as per cent of mean was observed for number of grains per panicle, number of tillers per plant, 1000-grain weight, L/B ratio, plant height, kernel length, grain yield per plant, kernel breadth and days to flowering. In general, magnitudes of genotypic correlation were found to be higher than phenotypic correlations. The results indicated that grain yield per plant showed significant positive association with number of tillers per plant, panicle length and milling percentage. Path coefficient analysis revealed that number of tillers per plant exerted the highest positive direct effect on grain yield per plant followed by kernel breadth, L/B ratio, panicle length, milling percentage, days to flowering and head rice recovery percentage.

Introduction

Rice (*Oryza sativa* L.) is one of the most predominant food crops in India in terms of area, production and consumer preference. India is the second largest producer and consumer of rice in the world.

Rice is the premier food crop in India occupying nearly 43.0 million hectares with annual production of 106.54 million tonnes and productivity of 2424 Kg ha^{-1} per hectare (Indiastat, 2015-2016). Area under rice cultivation Telangana State in nearly 1.65 million hectares while the production is 4.3 million tonnes and productivity in 3162 kg ha^{-1}.

To meet the demands of growing population and to achieve food security in the country the present production levels need to be increased by two million tonnes every year.

It is estimated that 120 million tonnes of rice is required to feed the increasing population

by 2020. The selection criteria may be yield or one or more of the yield component characters. However, breeding for high yield crops require information on nature and magnitude of variation in the available material, relationship of yield with other agronomic characters and the degree of environmental influence on the expression of these component characters. Since grain yield in rice is quantitative in nature and polygenically controlled, effective yield improvement and simultaneous improvement of yield components are imperative. To enhance the yield productivity, genetic parameters and correlation studies between yield and yield components are per requisite to plan a meaningful breeding programme to develop high yielding inbreds and hybrids.

Materials and Methods

All the 40 genotypes were sown separately in the nursery on raised beds. Twenty five days old seedlings of each genotype were transplanted in two rows each in a 4 m length plot by adopting a spacing of 20cm between rows and 15cm between plants in a Randomized Block Design replicated twice during *Kharif,* 2016 at Regional Agricultural Research Station, Polasa, Jagtial, and Telangana State. Five plants of each genotype in each replication were selected are used to record data on plant height (cm), number of tillers per plant, panicle length (cm), number of grains per panicle, kernel length (mm), kernel breadth (mm), L/B ratio, 1000-grain weight (g), hulling percentage, milling percentage, head rice recovery percentage, grain yield per plant (g) and bran oil percentage. The mean values were considered for statistical analysis.

Analysis of variance was done for partitioning the total variation due to treatments and replications according to procedure given by Panse and Sukhatme (1985). Correlation coefficients were determined as described by Singh and Chaudhary (1979).

Results and Discussion

Analysis of variance revealed significant differences for all 15 quantitative traits studied which was presented in Table 1. A perusal of genetic parameters revealed that phenotypic and genotypic coefficients of variation were high for number of grains per panicle, followed by number of tillers per plant, 1000-grain weight, L/B ratio, plant height, kernel breadth, kernel length and grain yield per plant were moderate. The values of genotypic and phenotypic coefficients of variation were low for days to maturity, days to flowering, panicle length, hulling percentage, milling percentage and head rice recovery. These results are in accordance with findings of Nagajyothi (2001) and Tara Satyavathi *et al.,* (2001), Anis *et al.,* (2016) for moderate GCV and PCV, Dhurai *et al.,* (2014) and Ganapathi *et al.,* (2014), Anis *et al.,* (2016), Rukmini Devi *et al.,* (2016) for high heritability and Dhurai *et al.,*(2014), Ganapati *et al.,*(2014) and Sachan (2015**),** Ananth kumar and Verma (2016) and Rukmini Devi *et al.,* (2016).

High heritability coupled with high genetic advance as per cent of mean was observed for number of grains per panicle, number of tillers per plant, 1000-grain weight, L/B ratio, plant height, kernel length, grain yield per plant, kernel breadth and days to flowering indicated that these traits were controlled by additive type of gene action in the inheritance of these characters. These characters can be further improved by following simple selection procedure. The high estimates of heritability coupled with low genetic advance as percent of mean for milling percentage and hulling percentage indicated the presence of non-additive gene effects, in addition to influence of environment to some extent (Table 2).

Table.2 Magnitude of variability, heritability and genetic advance for yield and quality traits in rice (*Oryza sativa* L.)

S.no.	Character	General Mean	Range		Phenotypic Coefficient of Variation (PCV)	Genotypic Coefficient of Variation (GCV)	Heritability in broad sense (%) (H_{bs})	GA as per cent of mean (5%) (GAM)
			Maximum	Minimum				
1	Days to flowering	86.20	118.50	74.50	9.99	9.96	99.0	20.44
2	Days to maturity	120.65	149.50	109.50	6.28	6.20	97.0	12.63
3	Plant height (cm)	101.02	151.00	77.60	12.17	12.10	98.0	24.79
4	Number of tillers/plant	12.56	16.70	7.70	17.73	17.32	95.0	34.87
5	Panicle length (cm)	24.30	27.90	17.50	8.07	7.54	87.0	14.52
6	Number of grains / panicle	143.25	333.80	76.50	44.01	43.32	96.0	87.85
7	Kernel length (mm)	6.57	8.25	5.15	10.90	10.85	99.0	22.27
8	Kernel breadth (mm)	1.92	2.70	1.65	11.82	11.21	90.0	21.91
9	L/B Ratio	3.55	4.39	2.06	13.78	13.31	93.0	26.48
10	Grain yield per plant (g)	24.90	29.80	19.00	11.26	10.99	95.0	22.08
11	1000-grain weight (g)	19.67	25.75	12.76	16.42	16.01	95.0	32.15
12	Hulling %	83.62	89.76	75.10	3.81	3.73	95.0	7.54
13	Milling %	75.81	80.89	68.90	4.69	4.60	96.0	9.28
14	Head rice recovery %	64.04	71.88	51.72	7.74	7.51	94.0	15.00
15	Bran oil %	14.95	19.35	11.87	12.15	11.77	93.0	23.48

Table.3 Phenotypic (P) and Genotypic (G) correlation coefficients of yield and quality traits in rice (*Oryza sativa* L.)

Character		DF	DM	PTH	No.TPP	PL	No.GPP	KL	KB	L/B	1000 GW	HUL	MIL	HRR	B O	GYP
DF	**G**	**1.0000**	0.8531	0.2972	0.1666	0.2129	0.1938	0.0788	-0.0402	0.0743	-0.1483	0.1477	-0.2778	-0.0619	-0.0701	0.1767
	P	**1.0000**	0.8451**	0.2951**	0.1608	0.1934	0.1924	0.0788	-0.0317	0.0669	-0.1430	0.1440	-0.2684*	-0.0635	-0.0651	0.1736
DM	**G**		**1.0000**	0.1246	0.0985	0.0076	0.1865	-0.0449	0.0113	-0.0287	-0.1564	0.0887	-0.1719	-0.0690	-0.0280	0.1237
	P		**1.0000**	0.1232	0.0966	0.0028	0.1848	-0.0426	0.0179	-0.0325	-0.1554	0.0779	-0.1601	-0.0639	-0.0210	0.1238
PTH	**G**			**1.0000**	0.2775	0.4546	-0.0231	0.2422	0.2985	-0.0230	0.0823	-0.0793	-0.1485	0.2794	0.3655	0.2357
	P			**1.0000**	0.2653*	0.4355**	0.0239	0.2368*	0.2858*	-0.0267	0.0860	-0.0817	-0.1469	0.2688*	0.3572**	0.2393
No.TPP	**G**				**1.0000**	0.3561	0.0996	0.1835	-0.1770	0.2068	0.0396	0.4170	0.2906	-0.0850	-0.2667	0.9649**
	P				**1.0000**	0.3123**	0.0918	0.1771	-0.1727	0.2013	0.0260	0.3931**	0.2932**	-0.0845	-0.2464*	0.9191**
PL	**G**					**1.0000**	-0.0679	0.3510	-0.0323	0.1881	0.3589	0.2266	0.1030	-0.0702	-0.3284	0.3384**
	P					**1.0000**	-0.0684	0.3196**	-0.0317	0.1688	0.3339**	0.2242*	0.0760	-0.0382	-0.2674*	0.3339**
No.GPP	**G**						**1.0000**	-0.2368	-0.4864	0.1610	-0.6603	0.0282	0.3523	0.1597	0.1976	0.0845
	P						**1.0000**	-0.2283*	-0.4613**	0.1625	0.6381**	0.0299	0.3477**	0.1478	0.1852	0.0805
KL	**G**							**1.0000**	0.0573	0.7232	0.2996	0.0165	-0.0744	-0.0610	-0.0538	0.1385
	P							**1.0000**	0.0606	0.6960**	0.2897**	0.0100	-0.0738	-0.0630	-0.0579	0.1314
KB	**G**								**1.0000**	-0.6296	0.6250	-0.1782	-0.4092	0.0657	0.2154	-0.1847
	P								**1.0000**	-0.6542**	0.5686**	-0.1773	-0.3827**	0.0635	0.1885	-0.1462
L/B	**G**									**1.0000**	-0.2555	0.0887	0.1958	-0.0601	-0.1172	0.1819
	P									**1.0000**	-0.2352*	0.0864	0.1851	-0.0641	-0.1042	0.1481
1000 GW	**G**										**1.0000**	0.0292	-0.1519	-0.2670	-0.3288	0.0324
	P										**1.0000**	0.0308	-0.1564	-0.2573*	-0.3022**	0.0254
HUL	**G**											**1.0000**	0.1053	-0.4396	-0.1180	0.2873**
	P											**1.0000**	0.1020	-0.4062**	-0.1049	0.2707
MIL	**G**												**1.0000**	0.0157	-0.0890	0.3254**
	P												**1.0000**	0.0091	-0.0851	0.3214**
HRR	**G**													**1.0000**	0.3154	-0.0035
	P													**1.0000**	0.3042**	0.0040
B O	**G**														**1.0000**	-0.2867**
	P														**1.0000**	-0.2787**

*** Significant at 5 per cent level; ** Significant at 1 per cent level**

DF: Days to flowering, DM: Days to maturity, PTH: Plant height (cm), No.TPP: Number of tillers per plant, PL: Panicle length (cm), No.GPP: Number of grains per panicle, KL: Kernel length (mm), KB: Kernel breadth (mm), L/B: L/B Ratio, 1000 GW: 1000-grain weight, HUL: Hulling %, MIL: Milling %, HRR: Head rice recovery %, B O: Bran oil % GYP: Grain yield per plant (g).

Table.4 Phenotypic (P) and Genotypic (G) path coefficients of yield and quality traits in rice (*Oryza sativa* L.)

Character		DF	DM	PTH	No.TPP	PL	No.GPP	KL	KB	L/B	1000 GW	HUL	MIL	HRR	B O	GYP
DFF	**G**	**0.1639**	-0.0438	-0.0606	0.1807	0.0319	-0.0191	-0.0426	-0.0151	0.0432	-0.0062	-0.0266	-0.0189	-0.0035	-0.0066	0.1767
	P	**0.0834**	-0.0003	-0.0289	0.1518	0.0236	-0.0121	-0.0117	-0.0052	0.0088	0.0074	-0.0158	-0.0249	-0.0043	0.0017	0.1736
DM	**G**	0.1398	**-0.0514**	-0.0254	0.1068	0.0011	-0.0184	0.0243	0.0042	-0.0167	-0.0065	-0.0160	-0.0117	-0.0039	-0.0026	0.1237
	P	0.0704	**-0.0004**	-0.0121	0.0912	0.0003	-0.0116	0.0063	0.0029	-0.0043	0.0081	-0.0086	-0.0146	-0.0043	0.0006	0.1238
PTH	**G**	0.0487	-0.0064	**-0.2039**	0.3010	0.0682	0.0023	-0.1309	0.1120	-0.0134	0.0034	0.0143	-0.0101	0.0159	0.0346	0.2357
	P	0.0246	0.0000	**-0.0980**	0.2505	0.0532	0.0015	-0.0351	0.0468	-0.0035	-0.0045	0.0090	-0.0136	0.0181	-0.0096	0.2393
No.TPP	**G**	0.0273	-0.0051	-0.0566	**1.0847**	0.0534	-0.0098	-0.0992	-0.0664	0.1203	0.0016	-0.0751	0.0198	-0.0048	-0.0252	0.9649**
	P	0.0134	0.0000	-0.0260	**0.9439**	0.0381	-0.0058	-0.0262	-0.0283	0.0264	-0.0013	-0.0433	0.0272	-0.0057	0.0066	0.9191**
PL	**G**	0.0349	-0.0004	-0.0927	0.3863	**0.1500**	0.0067	-0.1897	-0.0121	0.1095	0.0149	-0.0408	0.0070	-0.0040	-0.0311	0.3384**
	P	0.0161	0.0000	-0.0427	0.2947	**0.1222**	0.0043	-0.0474	-0.0052	0.0222	-0.0173	-0.0247	0.0070	-0.0026	0.0072	0.3339**
No.GPP	**G**	0.0318	-0.0096	0.0047	0.1080	-0.0102	**-0.0987**	0.1280	-0.1825	0.0937	-0.0274	-0.0051	0.0240	0.0091	0.0187	0.0845
	P	0.0160	-0.0001	0.0023	0.0867	-0.0084	**-0.0628**	0.0338	-0.0755	0.0213	0.0331	-0.0033	0.0323	0.0099	-0.0050	0.0805
KL	**G**	0.0129	0.0023	-0.0494	0.1990	0.0526	0.0234	**-0.5405**	0.0215	0.4207	0.0124	-0.0030	-0.0051	-0.0035	-0.0051	0.1385
	P	0.0066	0.0000	-0.0232	0.1672	0.0390	0.0143	**-0.1482**	0.0099	0.0914	-0.0150	-0.0011	-0.0068	-0.0042	0.0016	0.1314
KB	**G**	-0.0066	-0.0006	-0.0609	-0.1920	-0.0048	0.0480	-0.0310	**0.3752**	-0.3663	0.0259	0.0321	-0.0279	0.0037	0.0204	-0.1847
	P	-0.0026	0.0000	-0.0280	-0.1631	-0.0039	0.0290	-0.0090	**0.1636**	-0.0859	-0.0295	0.0195	-0.0355	0.0043	-0.0051	-0.1462
L/B	**G**	0.0122	0.0015	0.0047	0.2243	0.0282	-0.0159	-0.3909	-0.2362	**0.5818**	-0.0106	-0.0160	0.0133	-0.0034	-0.0111	0.1819
	P	0.0056	0.0000	0.0026	0.1900	0.0206	-0.0102	-0.1031	-0.1070	**0.1313**	0.0122	-0.0095	0.0172	-0.0043	0.0028	0.1481
1000 GW	**G**	-0.0243	0.0080	-0.0168	0.0430	0.0538	0.0652	-0.1619	0.2345	-0.1486	**0.0415**	-0.0053	-0.0103	-0.0552	-0.0311	0.0324
	P	-0.0119	0.0001	-0.0084	0.0245	0.0408	0.0401	-0.0429	0.0930	-0.0309	**-0.0519**	-0.0034	-0.0145	-0.0173	0.0081	0.0254
HUL	**G**	0.0242	-0.0046	0.0162	0.4524	0.0340	-0.0028	-0.0089	-0.0669	0.0516	0.0012	**-0.1801**	0.0072	-0.0250	-0.0112	0.2873**
	P	0.0120	0.0000	0.0080	0.3710	0.0274	-0.0019	-0.0015	-0.0290	0.0113	-0.0016	**-0.1101**	0.0095	-0.0273	0.0028	0.2707
MIL	**G**	-0.0455	0.0088	0.0303	0.3152	0.0154	-0.0348	0.0402	-0.1535	0.1139	-0.0063	-0.0190	**0.0681**	0.0009	-0.0084	0.3254**
	P	-0.0224	0.0001	0.0144	0.2768	0.0093	-0.0218	0.0109	-0.0626	0.0243	0.0081	-0.0112	**0.0928**	0.0006	0.0023	0.3214**
HRR	**G**	-0.0101	0.0035	-0.0570	-0.0922	-0.0105	-0.0158	0.0330	0.0246	-0.0349	-0.0111	0.0792	0.0011	**0.0568**	0.0299	-0.0035
	P	-0.0053	0.0000	-0.0263	-0.0797	-0.0047	-0.0093	0.0093	0.0104	-0.0084	0.0133	0.0447	0.0008	**0.0672**	-0.0082	0.0040
B O	**G**	-0.0115	0.0014	-0.0745	-0.2892	-0.0493	-0.0195	0.0291	0.0808	-0.0682	-0.0136	0.0213	-0.0061	0.0179	**0.0947**	-0.2867**
	P	-0.0054	0.0000	-0.0350	-0.2326	-0.0327	-0.0116	0.0086	0.0308	-0.0137	0.0157	0.0115	-0.0079	0.0204	**-0.0269**	-0.2787**
Genotypic Residual effect = 0.1739 Phenotypic Residual effect = 0.3510 Bold values are direct effects																

* Significant at 5 per cent level; ** Significant at 1 per cent level

DF: Days to flowering, DM: Days to maturity, PTH: Plant height (cm), No.TPP: Number of tillers per plant, PL: Panicle length (cm), No.GPP: Number of grains per panicle, KL: Kernel length (mm), KB: Kernel breadth (mm), L/B: L/B Ratio, 1000 GW: 1000-grain weight, HUL: Hulling %, MIL: Milling %, HRR: Head rice recovery %, B O: Bran oil % GYP: Grain yield per plant (g).

Table.1 Analysis of variance for yield and quality traits in rice (*Oryza sativa* L.)

S. No.	Character	Mean sum of squares		
		Replications (d.f.=1)	Treatments (d.f.=39)	Error (d.f.=39)
1	Days to flowering	0.05	148.04**	0.53
2	Days to maturity	3.20	113.59**	1.40
3	Plant height (cm)	0.02	300.81**	1.69
4	Number of tillers per plant	7.32**	9.70**	0.22
5	Panicle length(cm)	0.68	7.21**	0.48
6	Number of grains per panicle	101.29	7828.56**	123.48
7	Kernel length (mm)	0.04*	1.08**	0.04
8	Kernel breadth (mm)	0.08	0.09**	0.05
9	L/B ratio	0.17	0.46**	0.01
10	Grain yield per plant (g)	1.18	15.36**	0.38
11	1000-grain weight (g)	0.90	20.37**	0.51
12	Hulling %	11.08**	19.95**	0.41
13	Milling %	0.06	24.82**	0.50
14	Head rice recovery	14.93*	47.72**	1.45
15	Bran oil %	0.93*	6.40**	0.20
** Significant at 1 per cent level * Significant at 5 per cent level				

Character association studies revealed that the characters grain yield per plant showed significant and positive association with number of tillers per plant, panicle length and milling percentage. This indicated that simultaneous selection of all these characters was important for yield improvement. Similar kind of association was revealed by Satish Chandra *et al.*, (2009), Nandan and Sweta Singh (2010) for days to flowering, Madhavilatha (2002) for days to maturity, Nandan and Sweta Singh (2010) and Ratna *et al.*, (2015) for plant height, Idris and Mohamed (2013) for number of tillers per plant, Eswara reddy *et al.*, (2013), Rahman *et al.*,(2014) for panicle length, Yadav *et al.*, (2010) for number of grains per panicle, Reddy *et al.*, (1997), Madhavilatha *et al.*, (2005) for kernel length and L/B ratio (Table 3).

Path coefficient analysis revealed that number of tillers per plant exerted the highest positive direct effect on grain yield per plant followed by kernel breadth, L/B ratio, panicle length, milling percentage, days to flowering and head rice recovery percentage indicating that the selection for these characters was likely to bring about an overall improvement in grain yield per plant directly (Table 4). The similar results were reported by Ravindra Babu *et al.*, (2012), Mulugeta Seyoum *et al.*, (2012) and Imad Naseem *et al.*, (2014).

Keeping in view of the facts, by considering all factors like *per se* performance, bran oil content the most promising genotypes may be utilized as parents in hybridization programme as they were expected to produce high heterotic crosses.

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