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GENETIC ASSOCIATION STUDY OF RICE (*ORYZA SATIVA* L.) GENOTYPES FOR YIELD AND YIELD ATTRIBUTING TRAITS OVER FIVE DIFFERENT LOCATIONS

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Abstract

Yield is a complex polygenic character depends upon several characters. For the effective selection of yield traits correlation and path analysis studies plays a crucial role. In the present investigation genetic association studies of twenty-one genotypes with three replication per location for fourteen characters in five different locations. Correlation studies reported that number of spikelets per panicles, grain weight per panicle and number of grains per panicle had the strongest and high significant positive genotypic correlation with grain yield. Path analysis shows indicate that number of grains per panicle exhibited a maximum positive direct effect on grain yield per plant followed by days to maturity, weight of 1000 seed at the genotypic level and grain weight per panicle having the highest positive direct effect on grain yield per plant at the phenotypic level. The correlation coefficient with grain yield per plant to be negative and the direct effect was positive and high for total effective tiller number. The correlation between grains weight per panicle and grain yield was positive at both genotypic and phenotypic respectively mainly due to positive indirect effect contribution through spikelet fertility percentage at genotypic level but in case of phenotypic level, the correlation was positive due to significant positive indirect effect contribution through the total number of spikelet and grain weight per panicle.

Key words: Correlation, Path analysis, Polygenic, Genetic association

Introduction

Rice (*Oryza sativa* L.), one of the most vital staple crops feeding more than half of the world's population. To meet the food demand and nutritional security of the ever-emerging world population, plant breeders are challenged towards yield improvement and poverty alleviation through new ideas. To meet the demand, the world will have to harvest 60 percent more rice by 2030. Most of the traits of interest to breeders are complex which are the interaction of various components like rice grain yield depends upon days to flowering, panicle number, panicle length, fertile grain number, fertility %, 100-grain weight, grain yield per plant, plot yield and harvest index. Effective parental selection cannot be only dependent upon the final grain yield due to the combined effect of different attributes Kumbhar *et al.,* (2013). Realizing the relation among yield and its attributes is of prime importance for the best utilize for selection. Hence significant association among the yield and its components should be considered as a selection benchmark for rice. Different morphological characters behave in a different way on rice production Yang and Hwa (2008). The relative contribution of different characters on yield can be studied by correlation studies. The correlation can study the presence of the genetic effect of genes or environmental effect or combined effect to make a simultaneous selection for more characters Oad *et al.,* (2002). The information on the association of traits contributing to yield in addition to their direct and indirect effects required for the development of high yielding varieties. Path coefficient analysis distinguishes correlation into genotypic correlation coefficients of yield traits with grain yield into direct and indirect effects reported by Wright (1921). It will give a more worthy interpretation to the cause of the association between the dependent variable like yield and independent variables like yield attributes to avoid misleads due to an over-estimate or under-estimate due to its association with other traits. In agriculture, path analysis has been used by plant breeders to help in recognizing characters to design his selection approaches to bring about an overall enhancement in single plant yield directly. Taking into account the above situation, the present investigation is

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carried out to study the character associations in rice genotypes for yield improvement over different locations.

Materials and Methods

The present investigation is conducted in five different locations with twenty- one genotypes with three replication per location for fourteen characters (Table.1). The experiment is carried out through Randomized complete block design (RBD) during *Kharif* 2017 season. The genotypic and phenotypic correlation coefficients for all the probable comparisons were calculated as per the formulae proposed by Miller *et al.,* (1958). The partitioning of the genotypic correlation coefficient of traits into direct and indirect effects was carried out using the procedure suggested by Dewey and Lu (1959). The experimental data are analyzed through statistical software tool *viz.* Endo-stat over the five locations with proper data arrangement table 2.

Results and Discussion

Correlation

The mean values were considered for statistical analysis. Genotypic correlations for almost all yield attributes were high as compared to their phenotypic correlations indicating a strong inherent association between the characters which might be due to masking or modifying effects of the environment. Similar results were reported by Bagati *et al.* (2016) and Roy *et al.,* (2015). The correlation analysis indicated (Table.3) that grain yield had positive and significant association with days to 1st flowering (0.3875), days to 50% flowering (0.3879), days to maturity (0.3832), plant height (cm) (0.4357), panicle length(cm) (0.4273), number of spikelet per panicle (0.8423), number of grains per panicle (0.7938) and grain weight per panicle(g) (0.8673) and negative significant association with total effective tiller number (-0.5118) and grain zinc content(ppm) (-0.7212). Similar kind of results was found by (Minnie *et al.,* 2013 and Basavaraja *et al.,* 2013). The strongest and highly significant positive genotypic associations with grain yield were observed for the characters like grain weight per panicle, number of spikelet

Table 1: List of genotypes, character name and locations name.

Entry No.	Entry Name	Character No.	Character Name
V1	IR 95044:8-B-5-22-19-GBS	Chr1	Days to 1st flowering date
V2	IR 84847-RIL 195-1-1-1-1	Chr2	Days to 50% flowering
V3	IR 99704-24-2-1	Chr3	Days to maturity
V4	IR 99647-109-1-1	Chr4	Total effective tiller number
V5	IR 97443-11-2-1-1-1-1 -B	Chr5	Plant height(cm)
V6	IR 97443-11-2-1-1-1-3 -B	Chr6	Panicle Length(cm)
V7	IR 82475-110-2-2-1-2	Chr7	Number of spikelets Per panicles
V8	IR 96248-16-3-3-2-B	Chr8	No of grains/panicle
V9	R-RHZ-7	Chr9	Spikelets fertility percentage (SFP)
V10	CGZR-1	Chr10	Grain weight per panicle(g) (GWPPL)
V11	BRRIdhan 62	Chr11	Weight of 1000 seed(gm)
V12	BRRIdhan 64	Chr12	Grain L/B ratio
V13	BRRIdhan 72	Chr13	Grain zinc content(ppm)
V14	DRR Dhan 45	Chr14	Grain yield/Plant(gm)
V15	DRR Dhan 48	Location No.	Location Name
V16	DRR Dhan 49	L1	BHU Agriculture farm -I
V17	IR 64	L2	BHU Agriculture farm -II
V18	MTU1010	L3	BHIKARIPUR
V19	Sambamahsuri	L4	KARSADA
V20	Swarna	L5	RAMPUR
V21	Local check		

Table 2: Experimental data lay-out over the five locations for Endo stat analysis.

	Chr1	Chr2	Chr3	Chr4	Chr5	Chr6	Chr7	Chr8	Chr9	Chr10	Chr11	Chr12	Chr13	Chr14
V1L1R1	79	83	110	8	99.33	27.57	102.26	69.27	67.74	1.30	18.99	3.75	29.70	10.37
V1L1R2	75	80	106	10	103.17	25.67	77.59	61.95	79.84	1.19	19.55	3.86	29.30	11.94
V1L1R3	76	80	106	9	92.33	22.50	73.00	54.65	75.24	0.99	18.43	3.94	29.40	8.93
V2L1R1	79	84	111	8	113.33	28.50	106.00	78.74	73.82	1.51	19.49	4.05	24.20	12.10
Up to V21L1R3	99	102	132	9	116.90	22.83	131.00	100.78	76.54	1.87	18.85	4.43	25.10	16.84
V1L2R1	86	90	118	7	116.67	24.53	100.65	89.75	89.17	1.82	20.49	3.79	27.60	12.73
Up to V21L2R3	106	111	141	9	76.00	24.67	146.43	103.68	70.80	1.91	18.61	3.99	21.00	17.15
V1L3R1	85	89	116	9	116.40	25.47	98.31	81.81	83.22	1.50	18.89	3.74	29.60	13.48
Up to V21L3R3	104	109	138	8	116.41	24.27	207.94	134.64	64.75	2.53	19.00	4.32	20.50	20.27
V1L4R1	90	94	122	6	89.00	21.57	91.83	72.33	78.76	1.17	15.00	3.92	13.10	7.05
Up to V21L4R3	106	110	140	8	93.80	21.67	108.00	76.34	66.27	1.29	17.07	3.86	11.10	10.33
V1L5R1	85	90	118	7	107.00	25.30	70.08	50.13	74.54	0.71	14.29	3.84	21.10	4.95
Up to V21L5R3	112	105	147	7	101.57	25.69	85.73	60.06	77.43	1.08	18.09	4.21	25.40	7.53

per panicles and number of grains per panicle could be considered as criteria for selection for yield enhancement as these were mutually and directly linked with grain yield (Table.3). The positive association between all possible pairs of traits suggested that the possibility of correlated response to selection so that with the improvement of one trait, there will be an improvement in the other positively correlated trait. The observed positive correlation of grain yield with various traits was supported by earlier workers *viz.,* Rao and Srivastava (1999) and Chandra *et al.* (2009) for the number of filled grains per panicle; Chandra *et al.* (2009) and Kumar and Ravindra babu (2016) for panicle length; Reddy and Suresh, (2013) for plant height; Rao and Srivastava (1999) and Ekka *et al.* (2015) for days to 50% flowering (Table.3). The days to 1st flowering date, days to 50% flowering and days to maturity had a positive association with the number of spikelets per panicles and the number of grains per panicle and negative association with grain zinc content and weight of 1000 seeds. Total effective tiller number had showed a positive association with grain L/B ratio and spikelet fertility percentage and had negative significant association with most of the characters *viz.* plant height, panicle length, number of spikelet per panicle, number of grains per panicle, grain weight per panicle and weight of 1000 seeds (Table.3).

Plant height had a significant positive association with grain weight per panicle and weight of 1000 seeds and negative association with Spikelet fertility percentage and grain L/B ratio. Panicle length had a significant positive association with grain weight per panicle and negative association with grain zinc content. The number of spikelets per panicle had a significant positive association with the grain weight per panicle and number of grains per panicle and negative association with grain zinc content. The number of grains per panicle had a significant positive association with grain weight per panicle and negative significant association with grain zinc content and weight of 1000 seeds. Spikelet fertility percentage negatively associated with weight of 1000 seeds and grain weight per panicle. Grain weight per panicle had negatively associated with grain zinc content and grain L/B ratio. Weight of 1000 seeds had negatively associated with grain L/B ratio and positively associated with grain zinc content. Grain L/B ratio had negatively associated with grain zinc content (Table.3).

Path coefficient analysis

Path coefficient analysis was used to estimate the direct and indirect effects of thirteen characters on grain yield. Path coefficient analysis is focused to examine and determine the traits having greater and factual interrelationship with grain yield through splitting of the correlation coefficient into indirect and direct effects. As a result of this, traits that exerted positive direct effect and positive and significant correlation with grain yield need much attention in the selection program. In addition to this, traits that showed considerable positive indirect effects via other traits should be considered simultaneously as indirect selection criteria for grain yield improvement.

The correlation coefficient between characters like days to maturity, number of grains per panicle, total effective tiller number, weight of 1000 seed (gm), grain L/B ratio and grain zinc content (ppm) with grain yield per plant (gm) exhibited more or less similar positive direct effect indicating that direct selection through these traits would be rewarding (Table.4). Similar findings were reported by Karad and Pol (2008) for total effective tiller number, Chandra *et al.* (2009) for number of grains per panicle, The results of path analysis at genotypic level indicate that number of grains per panicle (2.2695) exhibited a maximum positive direct effect on grain yield per plant followed by days to maturity (2.1644), weight of 1000 seed (1.6203), total effective tiller number (0.9759) and grain zinc content (0.2772) and at phenotypic level grain weight per panicle (0.7505) having the maximum positive direct effect on grain yield per plant followed by total effective tiller number (0.6914), number of grains per panicle (0.4755) and weight of 1000 seed (0.3368) (Table.4). Similar findings were reported by Chandra *et al.,* (2009), Yadav *et al.,* (2011), Padmaja *et al.,* (2011) and Rahman *et al.,* (2014) for 1000 seed weight and by Seyoum *et al.,* (2012), Nagaraju *et al.,* (2013) and Rao *et al.,* (2014) for the number of filled grains per panicle.

At genotypic level days to 1st flowering date (-1.8744) exhibited a maximum negative direct effect on grain yield per plant followed by panicle length (-0.1444) and plant height (-0.1158) and at phenotypic level days to 1st flowering date (-0.1839) had the highest negative direct effect on grain yield per plant and remaining had a negligible effect. Similar negative direct effect reported by Gupta *et al.* (1998) for plant height and first flowering date and by Abarshahr *et al.* (2011) for days to 50% flowering and Seyoum *et al.,* (2012) for plant height and panicle length (Table.4). Thus, signifying the importance of such traits as standards for selection in that order for the realization of higher productivity. The genotypic correlation coefficient between the grain weight per panicle and the grain yield per plant was found to be positive (0.8673) & the direct effect was negative or negligible (-0.0273) and similar for panicle length (r= 0.4273 & direct effect = -0.1444), plant height (r= 0.4357 & direct effect = -0.1158) and days to 1st flowering date (r= 0.3875 & direct effect = (-1.8744). At the phenotypic level, the correlation coefficient of days to 1st flowering date with grain yield per plant was observed positive and negative direct effect (Table.4). The genotypic correlation

Table 3: Genotypic (G) and phenotypic (P) correlation for Yield and its attributes.

		Chr1	Chr2	Chr3	Chr4	Chr5	Chr6	Chr7	Chr8	Chr9	Chr10	Chr11	Chr12	Chr13	Chr14
Chr1	G	1	0.9985	0.9984	0.1489	-0.0472	0.0512	0.3515	0.3685	0.0104	0.1172	-0.4711	0.1592	-0.5942	0.3875
	P	1	0.9613***	0.9857***	0.0976	-0.0108	0.0246	0.2564***	0.2793	0.0287	0.0841	-0.3836***	0.0887	-0.4489***	0.2476
Chr2	G		1.00	1.0024	0.1299	-0.0408	0.0875	0.3451	0.3598	0.0009	0.1291	-0.4439	0.1295	-0.6038	0.3879
	P		1.00	0.9514***	0.0878	0.0139	0.0216	0.2505***	0.2713	0.0077	0.084	-0.3632***	0.0418	-0.4198***	0.2444
Chr3	G			1.00	0.1407	-0.049	0.0583	0.3426	0.3549	-0.0137	0.1178	-0.448	0.1362	-0.5971	0.3832
	P			1.00	0.0812	0.0075	0.0341	0.2658***	0.2824	0.0057	0.0989	-0.3606***	0.0472	-0.4596***	0.2585
Chr4	G				1.00	-0.6333	-0.5179	-0.5624	-0.514	0.3472	-0.8476	-0.4017	0.4657	0.1512	-0.5118
	P				1.00	-0.2347***	-0.2718***	-0.5289***	-0.5107	0.1441*	-0.7012***	-0.2678***	0.3361***	0.0516	-0.1667
Chr5	G					1.00	0.2164	0.274	0.1853	-0.5164	0.6557	0.5546	-0.2391	-0.0311	0.4357
	P					1.00	0.1371*	0.149**	0.1313*	-0.0875	0.353***	0.3368***	-0.1185*	0.031	0.2771
Chr6	G						1.00	0.3079	0.3301	0.084	0.5414	0.2321	-0.083	-0.1709	0.4273
	P						1.00	0.2108***	0.2241	0.0111	0.3198***	0.1518**	0.0169	-0.0451	0.212
Chr7	G							1.00	0.9804	-0.2215	0.8285	-0.3872	-0.1568	-0.7387	0.8423
	P							1.00	0.9598	-0.2382***	0.8205***	-0.2706***	-0.1496**	-0.4438***	0.6884
Chr8	G								1.00	-0.0196	0.7704	-0.4908	-0.1211	-0.732	0.7938
	P								1.00	-0.0141	0.8177***	-0.3275***	-0.1359*	-0.4559***	0.7038
Chr9	G									1.00	-0.3794	-0.4709	0.1542	0.1667	-0.316
	P									1.00	-0.0919	-0.0792	0.0703	-0.0146	0.0094
Chr10	G										1.00	0.1716	-0.3171	-0.5124	0.8673
	P										1.00	0.2303***	-0.2349***	-0.3056***	0.7744
Chr11	G											1.00	-0.2163	0.4454	-0.0598
	P											1.00	-0.1312	0.2838***	0.106
Chr12	G												1.00	-0.1648	0.0513
	P												1.00	-0.0785	-0.0053
Chr13	G													1.00	-0.7212
	P													1.00	-0.4093
Chr14	G														1.00
	P														1.00

Significance 0.05 0.01 0.005 0.001 level 0.1105279 0.1449365 0.157792 0.1845253.

Table 4: Genotypic & Phenotypic path coefficient analysis of Yield and its attributes.

		Chr1	Chr2	Chr3	Chr4	Chr5	Chr6	Chr7	Chr8	Chr9	Chr10	Chr11	Chr12	Chr13	Chr14
Chr1	G	-1.8744	-1.8716	-1.8713	-0.279	0.0884	-0.096	-0.6589	-0.6907	-0.0195	-0.2197	0.883	-0.2985	1.1138	0.3875
	P	-0.1839	-0.1768	-0.1813	-0.0179	0.002	-0.0045	-0.0472	-0.0514	-0.0053	-0.0155	0.0706	-0.0163	0.0826	0.2476
Chr2	G	-0.0083	-0.0083	-0.0083	-0.0011	0.0003	-0.0007	-0.0029	-0.003	0	-0.0011	0.0037	-0.0011	0.005	0.3879
	P	0.0929	0.0966	0.0919	0.0085	0.0013	0.0021	0.0242	0.0262	0.0007	0.0081	-0.0351	0.004	-0.0406	0.2444
Chr3	G	2.1609	2.1696	2.1644	0.3046	-0.106	0.1261	0.7414	0.7681	-0.0296	0.255	-0.9698	0.2948	-1.2924	0.3832
	P	0.1728	0.1668	0.1753	0.0142	0.0013	0.006	0.0466	0.0495	0.001	0.0173	-0.0632	0.0083	-0.0806	0.2585
Chr4	G	0.1453	0.1268	0.1373	0.9759	-0.618	-0.5054	-0.5488	-0.5016	0.3388	-0.8272	-0.392	0.4545	0.1476	-0.5118
	P	0.0675	0.0607	0.0561	0.6914	-0.1623	-0.1879	-0.3656	-0.3531	0.0996	-0.4848	-0.1851	0.2323	0.0357	-0.1667
Chr5	G	0.0055	0.0047	0.0057	0.0734	-0.1158	-0.0251	-0.0317	-0.0215	0.0598	-0.076	-0.0642	0.0277	0.0036	0.4357
	P	0	0	0	0.0006	-0.0025	-0.0003	-0.0004	-0.0003	0.0002	-0.0009	-0.0009	0.0003	-0.0001	0.2771
Chr6	G	-0.0074	-0.0126	-0.0084	0.0748	-0.0313	-0.1444	-0.0445	-0.0477	-0.0121	-0.0782	-0.0335	0.012	0.0247	0.4273
	P	-0.0004	-0.0003	-0.0005	0.0041	-0.0021	-0.015	-0.0032	-0.0034	-0.0002	-0.0048	-0.0023	-0.0003	0.0007	0.212
Chr7	G	0.0245	0.0241	0.0239	-0.0392	0.0191	0.0215	0.0697	0.0683	-0.0154	0.0577	-0.027	-0.0109	-0.0515	0.8423
	P	0.0141	0.0138	0.0146	-0.029	0.0082	0.0116	0.0549	0.0527	-0.0131	0.0451	-0.0149	-0.0082	-0.0244	0.6884
Chr8	G	0.8363	0.8165	0.8054	-1.1665	0.4206	0.7493	2.2251	2.2695	-0.0445	1.7485	-1.1139	-0.2748	-1.6613	0.7938
	P	0.1328	0.129	0.1343	-0.2428	0.0625	0.1066	0.4564	0.4755	-0.0067	0.3889	-0.1557	-0.0646	-0.2168	0.7038
Chr9	G	0.0008	0.0001	-0.0011	0.0273	-0.0405	0.0066	-0.0174	-0.0015	0.0785	-0.0298	-0.037	0.0121	0.0131	-0.316
	P	0.0007	0.0002	0.0001	0.0035	-0.0021	0.0003	-0.0058	-0.0003	0.0244	-0.0022	-0.0019	0.0017	-0.0004	0.0094
Chr10	G	-0.0032	-0.0035	-0.0032	0.0231	-0.0179	-0.0148	-0.0226	-0.021	0.0103	-0.0273	-0.0047	0.0086	0.014	0.8673
	P	0.0631	0.063	0.0742	-0.5263	0.2649	0.24	0.6157	0.6137	-0.0689	0.7505	0.1729	-0.1763	-0.2294	0.7744
Chr11	G	-0.7633	-0.7193	-0.726	-0.6508	0.8987	0.3762	-0.6274	-0.7953	-0.7629	0.278	1.6203	-0.3504	0.7217	-0.0598
	P	-0.1292	-0.1223	-0.1214	-0.0902	0.1134	0.0511	-0.0911	-0.1103	-0.0267	0.0776	0.3368	-0.0442	0.0956	0.106
Chr12	G	0.0355	0.0289	0.0304	0.1039	-0.0533	-0.0185	-0.035	-0.027	0.0344	-0.0707	-0.0482	0.223	-0.0368	0.0513
	P	0.0049	0.0023	0.0026	0.0187	-0.0066	0.0009	-0.0083	-0.0076	0.0039	-0.0131	-0.0073	0.0558	-0.0044	-0.0053
Chr13	G	-0.1647	-0.1674	-0.1655	0.0419	-0.0086	-0.0474	-0.2048	-0.2029	0.0462	-0.1421	0.1235	-0.0457	0.2772	-0.7212
	P	0.0123	0.0115	0.0126	-0.0014	-0.0008	0.0012	0.0121	0.0125	0.0004	0.0084	-0.0078	0.0021	-0.0273	-0.4093

Partial R^2 (G) -0.7 (P) 0.9048 Rasidual (G) 0.3456 (P) 0.4587

coefficient with grain yield per plant to be negative & the direct effect was positive respectively for total effective tiller number(-0.5118 & 0.9759) and grain zinc content (-0.7212 & 0.2772) representing that under such circumstances, a restricted simultaneous selection model to be followed to neutralize the objectionable indirect effects to take advantage of the direct effects. The correlation coefficient with grain yield per plant to be negative & the direct effect was positive and high for total effective tiller number suggests that direct selection for those traits should be taken to minimize the unfavorable indirect effect. The correlation was negative and non-significant for total effective tiller number mainly due to negative indirect effect through most of the character *viz.* panicle length (-0.5054), plant height (-0.618), total number of spikelet (-0.5488), grain weight per panicle (-0.8272), number of grains per panicle (-0.5016) and weight of 1000 seeds (-0.392) and for grain zinc content negative indirect effect through grain weight per panicle (-0.1421), number of grains per panicle (-0.2029), total number of spikelet(-0.2048) and date of 50% flowering(-0.1674) (Table.4). The correlation between grains weight per panicle and grain yield (0.0.8673, 0.7744) was positive at both genotypic and phenotypic respectively followed by the total number of spikelet (0.8423, 0.6884) and number of grains per panicle (0.7938, 0.7038) mainly due to positive indirect effect contribution through spikelet fertility percentage (0.0103) at genotypic level but in case of phenotypic level, the correlation was positive due to significant positive indirect effect contribution through total number of spikelet(0.4564) and grain weight per panicle (0.3889) (Table.4). Similar types of conclusions were reported by Chandra *et al.,* (2009), Padmaja *et al.,* (2011) and Mohanty *et al.,* (2012).

Conclusion

Among the yield attributes, grain weight per panicle, number of spikelet per panicles and number of grains per panicle had the strongest and highly significant positive genotypic correlation with grain yield. These attributes could be considered as standard for selection for improvement of yield as these were reciprocally and directly associated with grain yield. The results of path analysis at the genotypic level indicate that number of grains per panicle exhibited a maximum positive direct effect on grain yield per plant followed by days to maturity, weight of 1000 seed and at phenotypic level grain weight per panicle having the maximum positive direct effect on grain yield per plant. The correlation coefficient with grain yield per plant to be negative and the direct effect was positive and high for total effective tiller number. The correlation between grains weight per panicle and grain yield was positive at both genotypic and phenotypic respectively mainly due to positive indirect effect contribution through spikelet fertility percentage at genotypic level but in case of phenotypic level, the correlation was positive due to significant positive indirect effect contribution through the total number of spikelet and grain weight per panicle.

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