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Inheritance and association of yield and its attributing traits in rice *(Oryza sativa* L.)

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ABSTRACT

Rice is the primary food crop of half of the world's population and improving its productivity by the genetic selection is crucial. Fifty genotypes of rice were evaluated during 2011 and 2012 on the basis of eleven yield and its attributing traits following Randomized Block Design with three replications with the objectives to study the different genetic parameters and their association among various yield attributing traits. High estimates of GCV and PCV were obtained for grain yield per plant, harvest index, l: b of rice grain, filled grains per panicle and 1000 grain weight. High heritability coupled with high genetic advance was reported for plant height, days to 50 per cent flowering and filled grains per panicle indicating preponderance of additive gene action and through simple selection on the basis of these characters considerable improvement in rice could be perceived. The correlation coefficient at genotypic level was in general higher than their phenotypic correlations. The characters number of effective tillers per plant, filled grains per panicle, grain breadth and 1000 grain weight exhibited significant positive association with yield per plant. Path coefficient analysis revealed days to 50 per cent flowering, number of effective tillers per plant, filled grains per panicle, grain breadth, grain l: b ratio and harvest index had positive direct effect on yield. Based on overall magnitudes of heritability, genetic advance, correlation and path analysis, number of effective tillers plant^{-1}, filled grains panicle^{-1}, grain breadth and 1000 grain weight should be given emphasised for selecting high yielding genotypes.

Keywords : Additive gene action, genetic advance, heritability, rice

Rice is the second most important food crop in the world. It is the primary staple for half of the world population and for more than 70 per cent of the poor. In the Indian scenario it is estimated that the rice demand will be 140 million tonnes in 2025 (Mishra, 2004). The current world population of 6.1 billion is expected to reach 8.0 billion by 2030 and rice production must increase by 50 per cent in order to meet the growing demand. This projected demand can only be met by maintaining steady increase in production over the years. In the post WTO era, adequate rice is to be produced not only for self-sufficiency, but also for export purposes. The exportable surplus of good quality rice is to be produced at the competitive price. The present investigation attempted to identify high yielding early maturing genotypes. The evaluation of the genotypes was made on the basis of traits related to yield in light of estimated values of genetic parameters of the related traits as well as the correlation coefficient.

MATERIALS AND METHODS

Fifty rice genotypes collected from Rice Research Station, Chinsurah, West Bengal were sown in randomized block design with three replications at Agricultural Instructional Farm, Jaguli, Bidhan Chandra Krishi Viswavidyalaya, during *kharif* season of 2011 and 2012. Sowing of seed was done during June 2011and 2012. The transplanting was done at July for 2011 and 2012 respectively when the seedlings were 21 -25 days old. The size of each plot was 2 x 1.5m with spacing of 15 cm distance from plant to plant and 20cm from row to row and plot to plot distance of 50 cm. The usual recommended doses of N, P and K fertilizers were applied @ 60:40:40 kg ha^{-1}. Intercultural operations (like weeding *etc*.) and plant protection measures were taken from time to time and as when necessary. Harvesting was done after maturity of the crop varieties. It was done during the month of October and November. Five plants were randomly selected from each replication for assessment of various parameters considered for the investigation. Observations were recorded on different yield related morphological and physiological characters like plant height, days to 50 per cent flowering, number of effective tillers per plant, panicle length, number of filled grains per panicle, grain length, grain breadth, grain L/B ratio, 1000 grain weight, harvest index and yield per plant.

Coefficient of variation, Genotypic coefficient of variation and Phenotypic coefficient of variation were estimated as per Burton (1952); heritability (broad sense)

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by Hanson *et al*. (1956), genetic advance as per cent of mean and simple correlations were calculated using the formula suggested by Johnson *et al*. (1955). Path co-efficient analysis was carried out at the genotypic level by Wright (1921) and discussed by Dewey and Lu (1959).

RESULTS AND DISCUSSION

The mean performances of fifty genotypes for eleven characters are presented in table 1. Analysis of variance (Table 2) revealed significant variation within the genotypes for the eleven different characters studied over two years which provided enough scope for improvement on the traits through selection. Umadevi *et al*. (2009), Praveen *et al*. (2010) and Nandan *et al*. (2010) also observed the high magnitude of genetic variability for yield and many of its component traits and suggested that high mean value of the traits coupled with high variability may be considered as a better index of selection.

Pankaj recorded the highest yield (24.85g) followed by Patnai-23(22.79) and Swarna sub 1(21.81) (Table 1) and also exhibited desirable performance for number of effective tillers per plant(13.31), number of filled grains per panicle (203.91) and 1000 grain weight(22.40 g). Satabdi was superior for characters like days to 50 per cent flowering (87.16 days), filled grains per panicle (200.98), grain l:b ratio (4.43), harvest index(56.32) and good performance with respect to panicle length(23.36). IR 64 was superior with respect to panicle length (23.37cm), grain length (9.65cm), 1000 grain weight (25.22 g) and also days to 50 per cent flowering (102.16) and harvest index (44.57). These high yielding genotypes may be considered as an important parent in hybridization programme for rice improvement with respect to yield and its associated traits and some other quality aspects. From the above results it could be suggested that the genotypes differed significantly for all the studied characters as observed by Karim *et al.* (2007), Umadevi *et al.* (2009) and Praveen *et al.* (2010).

The genotypic coefficient of variation provides a measure to compare the genetic variability present in various traits. PCV which measures total variation was found to be marginally higher than GCV for plant height and days to 50 per cent flowering indicating least environmental influence on the expression of these characters. High estimates of GCV and PCV were obtained for grain yield per plant, harvest index, l: b of rice grain, filled grains per panicle and 1000 grain weight (Table: 3). Sharma and Bhuyan (2004) and Bose *et al.* (2005) reported high GCV and PCV values for grain yield per plant and filled grains per panicle. High heritability estimates has been found to be helpful in selection of superior genotypes on the basis of phenotypic performance. In the present investigation high heritability coupled with high genetic advance were reported for plant height, days to 50 per cent flowering and filled grains per panicle indicating preponderance of additive gene action and through simple selection on the basis of these characters considerable improvement in rice could be perceived. Bharadwaj *et al.* (2007) reported high heritability and high genetic advance for plant height, days to 50 per cent flowering, seed yield per plant and 1000 grain weight. Due to high heritability estimate the traits are expected to remain stable under varied environmental conditions and could easily be improved through selection. The importance of correlation and path coefficient analysis is particularly appreciable when highly heritable characters associated with complex yield traits are identified and successfully used as criteria for selection to achieve high yield. On the other hand the characters such as number of effective tillers per plant, panicle length, grain length, grain breadth, grain l:b ratio, 1000 grain weight and yield per plant had shown lower genetic advance which suggested that the clusters of characters are governed predominantly by non-additive gene action. So, a complex breeding may be advocated to improve these characters. Correlation studies among the eleven characters indicated different degree of association between characters at genotypic and phenotypic levels (Table 4). The correlation coefficient at genotypic level was in general higher than their phenotypic correlations. The characters like number of effective tillers per plant, filled grains per panicle, grain breadth and 1000 grain weight exhibited significant and positive association with yield at both genotypic and phenotypic level. Hijam *et al*. (2011) have also found significant positive association of 1000 grain weight with yield. So, the genotypes possessing these characteristics may be used in breeding programme for bringing yield improvement in rice.

Path coefficient analysis revealed that days to 50 per cent flowering, number of effective tillers plant^{-1}, filled grains panicle^{-1}, grain breadth, grain l: b ratio and harvest index had positive direct effect on yield. Highest direct effect on yield was shown by grain l:b ratio followed by grain breadth, 1000 grain weight, days to 50 per cent flowering and filled grains panicle^{-1}. All these characters except grain l:b showed significant positive

Table 1: Mean performance of fifty genotypes of rice for yield and its attributing traits over two years (2011and 2012)

Characters / Genotypes	Plant height (cm)	Days to 50% flowering	No. of effective tillers plt^{-1}	Panicle length (cm)	Filled grains panicle^{-1}	Grain length (mm)	Grain breadth (mm)	L:B ratio	1000 grain weight (g)	Harvest index (%)	Yield plant^{-1} (g)
Satabdi	108.64	87.16	13.89	23.36	200.98	9.96	2.40	4.43	19.35	56.32	20.74
IR 36	88.64	94.16	13.11	22.20	108.17	8.91	2.09	4.25	18.19	48.43	15.89
Triguna	100.04	91.16	12.09	21.97	116.71	9.15	2.10	4.34	19.13	53.19	17.46
Khitish	88.65	91.83	14.30	22.93	113.24	8.93	1.95	4.56	16.29	45.15	17.85
MTU 1010	108.58	114.16	14.92	22.79	177.83	9.05	2.12	4.25	21.10	51.05	18.62
IR 64	103.03	102.16	13.06	23.37	190.58	9.65	2.95	3.26	25.22	44.57	21.18
Sabita	130.83	122.50	11.77	22.39	124.01	10.61	2.38	4.45	21.63	67.50	15.77
Mahsuri	118.03	120.16	12.57	22.41	133.29	7.81	2.22	3.51	17.55	32.97	14.08
Ranjit	114.23	114.50	11.48	22.68	158.97	8.26	2.30	3.58	27.85	32.65	18.77
Pratikshya	113.31	116.83	13.10	23.54	177.25	8.10	1.98	4.08	20.27	38.25	21.16
Kaushalya	124.77	113.66	12.80	22.92	149.40	9.49	1.83	5.22	20.69	39.60	18.04
Giri	113.22	111.16	14.83	20.22	135.22	8.97	2.17	4.13	21.45	33.86	16.55
Sashi	115.21	118.83	12.46	22.42	128.31	9.22	2.36	3.91	20.54	36.01	15.52
Pankaj	124.70	114.66	13.31	22.82	203.91	6.74	2.26	2.97	22.40	31.86	24.85
Swarna sub 1	102.98	117.83	13.26	21.76	188.97	7.52	2.13	3.52	19.12	40.79	21.81
Swarnadhan	108.55	121.66	13.40	22.39	178.87	7.99	2.70	2.96	21.00	42.95	21.23
Seetasail	149.84	113.16	10.74	26.05	145.92	8.11	2.32	3.53	19.92	67.58	11.91
Kalma 222	138.27	118.83	10.84	22.32	157.39	9.16	2.53	3.63	25.09	38.55	16.20
Patnai 23	145.83	131.50	16.07	22.43	145.79	10.69	2.25	4.78	29.82	37.47	22.79
Bhasamanik 23	150.90	129.83	11.96	21.51	170.41	8.54	2.17	3.85	24.33	34.96	11.88
NC 678	154.32	135.20	12.62	22.53	159.31	8.57	2.63	3.25	27.17	40.17	14.99
Nizersail	157.81	135.33	11.43	23.68	179.81	7.87	2.17	3.62	19.68	35.51	12.74
Rupsail	150.77	129.00	10.72	21.18	136.02	8.36	2.35	3.56	21.16	30.92	11.70
Jayasilet	142.72	123.33	10.84	23.31	130.09	9.07	2.53	3.58	25.65	36.40	17.33
Chapakhushi	146.34	109.16	12.84	24.62	121.81	9.04	3.12	2.91	29.68	38.68	20.76
Seetabhog	152.61	136.00	13.89	24.32	180.98	6.59	2.00	3.30	12.52	44.67	11.86
IR 68144-2B-2-2-2-3-1-120	92.64	108.00	11.66	22.31	158.85	9.18	2.18	4.21	22.12	46.11	15.99

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Table 1 (contd) : Mean performance of fifty genotypes of rice for yield and its attributing traits over two years (2011and 2012)

Genotypes	Plant height (cm)	Days to 50% flowering	No. of effective tillers plant^{-1}	Panicle length (cm)	Filled grains panicle^{-1}	Grain length (mm)	Grain breadth (mm)	Grain L:B ratio	1000 grain weight (g)	Harvest index (%)	Yield plant^{-1} (g)
IR 72046-B-R-3-2-2-1	122.43	105.00	12.03	26.23	172.70	9.44	2.21	4.26	24.39	43.55	20.18
Basmati 370	147.44	112.50	11.41	21.78	112.76	9.71	2.09	4.63	21.99	36.32	16.22
Pusa Basmati 1	114.50	94.05	11.89	24.11	151.98	11.02	2.19	5.02	20.81	33.89	17.73
Taraori Basmati	141.91	110.16	11.48	27.25	125.81	10.96	1.99	5.52	20.08	38.89	13.88
Type 3	141.11	99.83	11.17	23.96	174.93	8.69	2.09	4.15	19.03	39.66	11.88
PNR 546	100.61	98.50	11.65	25.19	159.91	10.78	2.17	4.95	20.23	32.89	12.00
Pakistan Basmati	132.75	114.16	11.72	26.53	133.05	11.21	2.16	5.20	22.88	37.95	12.90
CN 1719-4	132.33	96.00	17.71	23.24	190.49	10.49	2.08	5.04	20.57	43.25	13.61
CN 1646-6-11-9	113.17	103.33	13.17	21.24	123.68	10.93	2.17	5.03	18.38	43.10	12.47
CN 1794-2	121.77	111.83	17.60	27.32	174.18	10.35	2.28	4.60	23.90	48.62	20.25
CN1722-2	162.60	96.50	19.48	27.98	178.65	11.08	1.86	5.96	21.77	35.98	14.43
Mahisugandha	93.37	103.33	14.22	26.80	166.45	8.70	2.25	3.88	19.29	36.47	14.97
Vasumoti	145.98	112.00	13.43	23.20	149.28	10.61	2.12	5.01	21.82	38.18	12.35
Tulaipangi	125.89	113.66	11.72	28.03	129.94	8.42	1.94	4.33	19.36	39.86	12.43
Badshahbhog	136.08	116.83	12.28	24.94	198.85	6.67	2.37	2.82	14.24	38.57	12.83
Randhunipagal	139.21	120.33	12.04	24.97	111.64	5.92	2.26	2.64	12.74	39.82	11.89
Kataribhog	133.85	125.50	11.14	26.09	165.90	8.36	2.33	3.60	24.25	43.56	11.09
Kalonunia	118.77	105.66	12.25	23.86	118.95	7.83	2.06	3.82	18.48	39.83	16.32
Dadsail	149.95	123.50	12.00	23.52	174.18	7.32	2.56	2.85	19.22	36.81	12.62
Kanakchur	139.32	116.83	14.79	26.10	143.05	6.67	2.46	2.71	23.04	38.67	17.44
Danaguri	130.02	124.50	12.34	23.90	130.18	6.24	2.07	3.02	18.23	37.80	11.05
NC 365	120.09	124.83	12.55	22.61	93.32	7.40	2.17	3.41	15.94	39.55	11.66
Kalozira	135.50	113.00	13.95	26.74	139.88	7.03	1.92	3.65	22.48	40.22	13.08
Mean	**126.88**	**113.27**	**12.92**	**23.80**	**151.84**	**8.83**	**2.24**	**3.99**	**21.04**	**40.99**	**16.02**
C.V	**2.84**	**1.66**	**7.29**	**5.42**	**8.12**	**4.31**	**6.12**	**7.36**	**7.40**	**5.10**	**8.32**
S.E(±).	**1.47**	**0.77**	**0.38**	**0.52**	**5.03**	**0.15**	**0.05**	**0.12**	**0.63**	**0.85**	**0.54**
LSD(0,05)	**4.10**	**2.14**	**1.07**	**1.46**	**14.03**	**0.43**	**0.15**	**0.33**	**1.77**	**2.38**	**1.51**

Table 2: Analysis of variance for yield and its attributing traits over two years (2011and 2012).

Sources of variation	d.f.	Mean sum of squares										
		Plant height (cm)	Days to 50% flowering	No. of effective tillers Plant^{-1}	Panicle length (cm)	Filled grains panicle^{-1}	Grain length (mm)	Grain breadth (mm)	Grain L:B ratio	1000 grain weight (g)	Harvest index (%)	Yield plant^{-1} (g)
Replications	2	11.561	4.742	0.012	0.614	126.755	0.451	0.028	0.072	4.729	12.764	0.139
Environments	1	66.684*	16.595**	0.556	28.188***	738.183***	0.141*	0.011*	0.005	18.830***	28.681***	1.575
Interaction	2	10.475	1.838	0.160	1.364	11.013	0.029	0.002	0.009	0.797	0.340	0.422
Overall sum	5	22.151	5.951	0.180	6.429**	202.744	0.220	0.014	0.033	5.977*	10.978	0.539
Genotypes	49	2304.716***	879.815***	20.046***	22.158**	4654.965***	11.806***	0.379***	3.808***	80.048***	351.771***	92.065***
Error	245	13.037	3.561	0.889	1.668	152.243	0.145	0.018	0.086	2.425	4.383	1.780

*Significant at 5% level ** Significant at 1% level *** Significant at 0.1% level

Table 3: Genetic parameters of different yield attributing traits over two years (2011and 2012)

Parameters	Mean	Range	GCV	PCV	Heritability (bs)h^2	Genetic advance	Genetic advance as % of mean
Plant height(cm)	126.88	88.64-162.60	15.40	15.66	0.967	50.73	39.98
Days to 50% flowering	113.27	87.16-136.00	10.66	10.79	0.976	31.52	27.82
No. of effective tillers plt-^{1}	12.92	10.72-19.48	13.82	15.63	0.782	4.17	32.27
Panicle length(cm)	23.80	20.22-28.03	7.76	9.47	0.672	3.99	16.79
Filled grains panicle^{-1}	151.84	93.32-203.91	18.04	19.78	0.831	65.94	43.42
Grain length (mm)	8.83	5.92-11.21	15.78	16.36	0.930	3.55	40.20
Grain breadth (mm)	2.24	1.83-3.12	10.91	12.51	0.761	0.56	40.20
Grain L:B ratio	3.99	2.64-5.96	19.69	21.02	0.877	1.94	25.13
1000 grain weight (g)	21.04	12.52-29.82	17.09	18.62	0.842	8.71	48.70
Harvest index (%)	40.99	30.92-67.58	18.56	19.25	0.930	19.36	41.40
Yield plant^{-1}	16.02	11.05-26.32	24.20	25.60	0.894	9.68	60.43

Table 4: Genotypic and phenotypic correlation coefficients between yield and its attributing traits over two years (2011and 2012).

		Days to 50% flowering	No. of effective tillers plant^{-1}	Panicle length (cm)	Filled grains panicle^{-1}	Grain length (mm)	Grain breadth (mm)	Grain L:B ratio	1000 grain weight (g)	Harvest index (%)	Yield plant^{-1} (g)
Plant height(cm)	G	0.558***	-0.043	0.223***	0.056	-0.097	0.087	-0.106	0.197***	-0.174**	-0.372***
	P	0.542***	-0.041	0.177**	0.060	-0.101	0.065	-0.099	0.164**	-0.161**	-0.343***
Days to 50%	G		-0.257***	-0.152**	0.012	-0.455***	0.183**	-0.500***	0.118*	-0.219***	-0.225***
flowering	P		-0.222**	-0.118*	0.005	-0.433***	0.158**	-0.460***	0.110*	-0.208***	-0.219***
No. of effective	G			0.187**	0.293***	0.225***	-0.193***	0.321***	0.049	0.030	0.251***
tillers plant^{-1}	P			0.141*	0.213***	0.193***	-0.156**	0.269***	0.054	0.032	0.226***
Panicle	G				0.118	0.031	-0.168**	0.148*	-0.029	0.054	-0.191*
length (cm)	P				0.074	0.064	-0.068	0.115*	-0.012	0.048	-0.139*
Filled grains	G					-0.049	0.137*	-0.096	0.109	-0.023	0.208**
panicle^{-1}	P					-0.059	0.103	-0.095	0.087	-0.023	0.185**
Grain length	G						-0.075	0.866*	0.389***	0.135*	0.080
(mm)	P						-0.035	0.823***	0.351***	0.135*	0.081
Grain breadth	G							-0.554***	0.475***	0.059	0.236***
(mm)	P							-0.568***	0.399***	0.057	0.215***
L:B ratio	G								0.081	0.080	-0.032
	P								0.067	0.074	-0.040
1000 grain weight	G									-0.124*	0.377***
(g)	P									-0.114*	0.332***
Harvest index (%)	G										0.057
	P										0.033

*Significant at 5% level ** Significant at 1% level *** Significant at 0.1% level

Table 5: Path analysis of yield attributing characters on yield in rice over two years (2011and 2012).

	Plant height (cm)	Days to 50% flowering	No. of effective tillers plant^{-1}	Panicle length (cm)	Filled grains panicle^{-1}	Grain length (mm)	Grain breadth (mm)	Grain L:B ratio	1000 grain weight (g)	Harvest index (%)	Yield plant^{-1} (g)
Plant height(cm)	**-0.612**	-0.341	0.026	-0.136	-0.034	0.059	-0.053	0.064	-0.120	0.10	-0.372***
Days to 50% flowering	0.084	**0.151**	-0.038	-0.023	0.001	-0.069	0.027	-0.075	0.018	0.018	-0.225***
Effective tillers plant^{-1}	-0.000	-0.010	**0.032**	0.006	0.009	0.007	-0.006	0.010	0.001	0.001	0.251***
Panicle length(cm)	-0.062	0.042	-0.052	**-0.279**	-0.033	-0.008	0.047	-0.041	0.008	0.008	-0.191*
Filled grains panicle^{-1}	0.017	0.000	0.039	-0.016	**0.136**	-0.006	0.018	-0.013	0.014	0.014	0.208*
Grain length (mm)	0.470	2.200	-1.087	-0.152	0.237	**-4.827**	0.364	-4.183	-1.878	-1.878	0.080
Grain breadth (mm)	0.231	0.485	-0.509	-0.444	0.363	-0.199	**2.363**	-1.464	1.255	1.255	0.236***
L:B ratio	-0.594	-2.804	1.805	0.833	-0.539	4.860	-3.111	**5.608**	0.456	0.456	-0.032
1000 grain weight (g)	0.125	0.075	0.031	-0.018	0.069	0.247	0.303	0.051	**0.637**	0.637	0.377***
Harvest index (%)	-0.022	-0.027	0.003	0.006	-0.00	0.017	0.007	0.010	-0.015	**-0.015**	0.057

Residual effect: 0.4454

association with yield. Days to 50 per cent flowering showing negative correlation with yield will help to develop high yielding early lines. Though l: b ratio showed non significant negative effect on yield with highest direct effect and which may be indirectly influenced by grain length. So, improvement in grain length will help to obtain desirable grain size maintaining effective l:b ratio as a result of which all these characters including grain length should be given due consideration for development of high yielding rice with good quality grain. The characters number of effective tillers per plant, filled grains per panicle, grain breadth and 1000 grain weight had also shown significant positive correlations with grain yield accompanied by positive direct effect and these traits could effectively be employed for yield improvement in rice. Sawant *et al*. (1995), Santhakumar *et al.* (1998), Singh *et al.* (1998) Khedikar *et al*., (2003) observed positive association of 1000 grain weight with yield. Nandan *et al*. (2010) also reported that the maximum direct effect on yield was contributed by number of filled grains per panicle.

From this study, it can be concluded that sufficient variability exists in most of the components and would offer a good scope for selection of promising desirable varieties. The characters like number of filled grains per panicle, number of effective tillers per plant, grain breadth and 1000 grain weight were found to have high heritability and also had exhibited significant positive correlation with yield at both genotypic and phenotypic level. These characters may be considered as an important selection criteria in rice and it will enhance selection and subsequent breeding work towards development of improved rice varieties.

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