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Genetic Variability and Association Studies on Grain Yield Components in F_2 Populations of Black Rice (*Oryza sativa* L.) of Manipur

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ABSTRACT

The F_2 segregating populations of two black rice crosses viz., cross I (*Chakhao amubi* ×RCM 23) and cross II (RCM 14×RCM 23) were evaluated during *Kharif* 2014 for assessment of genetic variability, association and path analysis of yield and yield components under transplanted rainfed lowland condition. In both populations, all traits except panicle length and days to first flowering showed moderate to high Phenotypic Coefficient of Variation (PCV) and Genotypic Coefficient of Variation (GCV). Heritability were moderate to high for all the traits coupled with high genetic advance as percent mean except for panicle length and days to first flowering. The correlation studies revealed that in both crosses, productive tillers per plant, filled spikelets, spikelet fertility and 1000 grains weight showed significant positive correlation with grain yield whereas days to first flowering showed significant negative correlation with grain yield in cross I whereas it was negative non-significant in Cross II. Path analysis revealed that productive tillers per plant and filled spikelets per panicle had high positive direct effect on grain yield.

1. Introduction

The scented rice of Manipur, '*Chakhao*', meaning delicious rice is a sacred land race grown by farmers of the state. There are different variants of *Chakhao*, a group of local landraces grown in small scale by the farmers of this region (Roy et al., 2013). The Black rice, *Chakhao amubi* which turns deep purple on cooking is sticky rice used in community feast as well as in ceremonial purpose as delicacy. Rich in anthocyanin content imparting deep purple colour to perisperm, the landrace is a potential source of dietary antioxidants and has great neutraceutical properties (Das et al., 2014). Usually both dehusked and rice with husk intact are sold in the local market at a premium price.

There is high local demand and huge potential for scented black sticky rice in South East and East Asian countries for its elite nutritional properties.However due to low productivity, its area and production is restricted to more of a family consumption. In this regard, systematic breeding work needs to be taken up for improving the yield levels of this important landrace without sacrificing the grain quality for which it is known among the growers and consumers. Existence of variability for quantitative traits like yield, its component traits and their corresponding heritability estimates with genetic advance are required for effective selection (Singh and Narayanan, 2009).

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As Yield is a complex trait, its improvement requires evaluation of segregating generation for various associated traits to select the desirable line. In this direction, correlation studies provide better understanding of Yield component traits which helps in indirect selection for Yield (Robinson et al., 1951, Johnson et al., 1955). Further, association of traits due to direct/ indirect effect on yield may be revealed by Path analysis. Hence the present study was taken up with the objective of gathering information on genetic variability, association of yield attributing traits and path analysis in two F_2 populations of black rice crosses to select the promising plants for higher yield.

2. Materials & Methods

The material for the present study consisted of two crosses of rice, *Chakhao amubi*/RCM 23 (MC-52 series) and RCM 14/RCM 23 (MC-57 series) where RCM 14 is a advanced breeding line of cross, *Chakhao amubi*/Basmati 370 and RCM 23 is a advanced breeding line identified for neck blast resistance and higher yield. The crossing programme was carried out at ICAR RC NEH region, Lamphelpat during *Kharif* 2012 with objective of obtaining useful segregants with quality parameters of *Chakhao amubi* with higher yield traits of RCM 23. The F_1 plants were raised during *Kharif* 2013 along with parents in pots and successful crossed ones were identified based on morphological characters of male parent. The F_2 population of two crosses of black rice viz., *Chakhao amubi* × RCM 23 and RCM 14 × RCM 23 were grown during *kharif 2014* along with parents in the transplanted rainfed lowland condition. A total of 411 and 185 F_2 plants were selected from MC-52 and MC-57 series for recording observation on eight quantitative traits viz., days to first flowering,plant height(cm),number of productive tillers per plant, filled spikelets per panicle, unfilled spikelets per panicle, panicle length(cm), 1000 grain weight (g) and Grain yield per plant(g). Spikelet Fertility percentage was obtained by the ratio of filled spikelets/total spikelets. The Phenotypic and Genotypic Coefficients of Variability (PCV & GCV) were computed as per the methods of Burton and De vane (1953). For the estimation of broad sense heritability (h^2_{bs}) and Genetic advance as percent of mean, the method of Johnson et al., (1955) was followed. The Phenotypic correlation coefficients and Path analysis were performed using the software OPSTAT.

3. Results and Discussion

Genetic variability in both F_2 Populations (Table 1) indicated that, range of variation, a simple measure of variability was quite high for all the characters. Values of Phenotypic Coefficient of Variation (PCV) in both F_2 generations were higher than the Genotypic Coefficient of Variation (GCV) for the traits studied. The narrow difference between PCV and GCV observed for most traits was an indication of low environmental influence for traits under study. GCV and PCV estimates were classified as low (0-10%), moderate (10-20%) and high (>20%) as per Johnson et al., (1955). Accordingly, Productive tillers and filled spikelets per panicle showed high PCV & GCV in both crosses. Plant height, spikelet fertility and 1000 grains weight showed moderate PCV & GCV whereas, panicle length showed low GCV and PCV in both the crosses. Days to first flowering showed low PCV, GCV in Cross I but moderate in Cross II. These results are in agreement with Shet *et al*. (2012). As per Robinson et al.(1949), broad sense heritability estimates were categorized into low (0- 30%), moderate (30-60%) and High (>60%).In both crosses, Days to first flowering, plant height, spikelet fertility(%) and 1000 grains weight showed high heritability whereas filled spikelets per panicle and Panicle length showed moderate heritability in both populations. However, productive tillers showed high heritability in cross II population but moderate heritability in Cross I population. The estimates of Genetic advance as per cent of mean were classified as low (<10%), moderate (10-20%) & high (>20%) as suggested by Johnson et al., (1955). Except panicle length, days to first flowering (Cross I) all the remaining traits viz., plant height, productive tillers, filled spikelets, spikelet fertility, 1000 grains weight and grain yield per plant depicted high genetic advance as per cent mean. Grain yield improvement being the primary concern in the present study, presence of high variability for the trait in both crosses is an indication of scope for selection. Also, high heritability coupled with highest genetic advance as per cent mean was shown by the trait suggests additive gene effect of the trait and effectiveness of selection. The results of the present study closely agree with the earlier reports in rice by Ramalingam et al (1994), Suman et al (2005), Panwar et al., (2007) and Shet et al (2012).In order to understand the nature and magnitude of association between different quantitative traits, phenotypic correlation was studied in both F_2 populations (Table 2). In both crosses, association of productive tillers per plant, filled spikelets, spikelet fertility and 1000 grains weight showed significant positive correlation with grain yield suggesting to use these traits as criterion for yield improvement. Grain yield showed significant positive correlation with panicle length in cross I, positive non-significant correlation in Cross II, significant positive correlation with plant height in cross I and negative correlation in cross II. Days to first flowering showed significant negative correlation with grain yield in cross I whereas it was negative non-significant in Cross II.

Among the yield attributing traits, significant positive correlation was shown by filled spikelets with spikelet fertility and with panicle length in both crosses.

This is in agreement with the results of Shet et al (2012), Kiran et al (2014), Shailaja Hittalamani (1999), Rajeshwari & Nadarajan (1996), Krishna veni and Shobha Rani (2005).

Table 1. Genetic Variability Parameters for yield traits in F_2 generation of two crosses

Characters	Mean± SE		Range		PCV (%)		GCV (%)		h^2 in broad sense (%)		GA (% mean)	
	Cross I	Cross II	Cross I	Cross II	Cross I	Cross II	Cross I	Cross II	Cross I	Cross II	Cross I	Cross II
Days to first flowering	117.53 ± 0.68	106.01± 1.18	94 to 130	88 to 125	6.25	11.46	6.20	11.43	0.98	0.99	12.64	23.49
Plant height(cm)	148.47± 2.19	141.72 ±1.62	66 to199	95 to182	17.98	13.57	17.64	13.24	0.96	0.95	35.66	26.61
Productive tillers	4.17 ± 0.9	9.49 ± 1.38	1 to 13	2 to 26	44.08	44.80	31.50	41.45	0.51	0.86	46.36	79.02
Filled grains	132.78± 3.43	149.71±3.50	36.83 to 265.5	68.9 to 248.66	29.74	28.63	19.54	21.46	0.43	0.56	26.45	33.15
Spikelet fertility (%)	79.98± 1.53	75.061± 1.32	33.74 to 97.37	29.4 to 92.9	17.16	15.28	16.42	13.22	0.92	0.75	32.36	23.55
Panicle length(cm)	24.82 ±0.52	25.899± 0.37	15.5 to31.85	16.72 to 28.62	10.48	7.29	7.74	4.54	0.55	0.39	11.80	5.83
1000 grain weight(g)	27.62 ± 0.82	28.20± 0.82	11.2 to 44.2	15.4 to 41	15.50	15.43	15.44	15.39	0.99	1.00	31.68	31.62
Grain yield per plant(g)	19.06± 2.84	48.43± 3.93	1.53 to127.22	8.16 to 188.62	65.08	56.51	56.17	55.06	0.74	0.95	99.86	110.50

Table 2. Phenotypic Correlation coefficients among grain yield and its components in F_2 generation of the Cross I (*Chakhao amubi*/RCM 23) and Cross II (RCM 14/RCM 23)

Characters	Cross	X2	X3	X4	X5	X6	X7	X8
X1	I II	0.172* 0.003	-0.024 -0.04	0.186** -0.134	0.269** 0.087	0.168** 0.009	-0.055 -0.01	-0.103 -0.058
X2	I II		0.054 -0.098	0.467** 0.103	0.374** 0.197	0.400** 0.067	0.296** 0.034	0.234** -0.008
X3	I II			0.156** 0.108	0.031 0.062	0.097* -0.023	0.059 0.165	0.781** 0.880**
X4	I II				0.547** 0.527**	0.429** 0.326**	0.330** 0.19	0.523** 0.493**
X5	I II					0.123* -0.137	-0.039 -0.111	0.229** 0.261*
X6	I II						0.454** 0.211	0.289** 0.131
X7	I II							0.312** 0.297**

*, **, Significant at P=0.05 and P=0.01

X1: Days to first flowering, X2: Plant height (cm), X3: Productive tillers, X4: filled Spikelets/panicle, X5: Spikelet fertility (%),

X6: Panicle length (cm), X7:1000 grain weight (g), X8: Grain yield/plant (g)

Table 3. Direct (Diagonal) and Indirect effects of yield component traits on grain yield in F_2 generation of cross I (*Chakhao amubi*/RCM-23) of rice

Characters	X1	X2	X3	X4	X5	X6	X7	Yield correlation
X1	**-0.0080**	0.0052	-0.0170	-0.0659	-0.0078	-0.0002	-0.0090	-0.103*
X2	0.0014	**-0.0303**	0.0385	0.1653	0.0108	0.0004	0.0479	0.234**
X3	0.0002	-0.0016	**0.7168**	0.0553	0.0009	0.0001	0.0096	0.781**
X4	0.0015	-0.0142	0.1120	**0.3541**	0.0158	0.0004	0.0534	0.523**
X5	0.0022	-0.0113	0.0219	0.1938	**0.0289**	0.0001	-0.0064	0.229**
X6	0.0013	-0.0121	0.0698	0.1519	0.0036	**0.0010**	0.0734	0.289**
X7	0.0004	-0.0090	0.0424	0.1169	-0.0011	0.0005	**0.1617**	0.312**

Residual 0.20377
*, **, significant at P=0.05, P=0.01
X_1: Days to first flowering, X_2 : Plant height(cm), X_3: Productive tillers, X_4: filled Spikelets/panicle, X_5: Spikelet fertility(%), X_6: Panicle length (cm), X_7: 1000 grain weight (g), X_8: Grain yield/plant (g)

Table 4. Direct (Diagonal) and Indirect effects of yield component traits on grain yield in F_2 generation of cross II (RCM 14/RCM-23) of rice

Characters	X1	X2	X3	X4	X5	X6	X7	Yield correlation
X1	0.0252	0.0001	-0.0329	-0.0507	0.0012	0.0001	-0.0009	-0.0580
X2	0.0001	0.0283	-0.0812	0.0389	0.0027	0.0005	0.0030	-0.0080
X3	-0.0010	-0.0028	0.8283	0.0407	0.0009	-0.0002	0.0145	0.880**
X4	-0.0034	0.0029	0.0891	0.3783	0.0073	0.0026	0.0166	0.493**
X5	0.0022	0.0056	0.0511	0.1995	0.0137	-0.0011	-0.0097	0.261*
X6	0.0002	0.0019	-0.0189	0.1234	-0.0019	0.0079	0.0185	0.1310
X7	-0.0003	0.0010	0.1369	0.0718	-0.0015	0.0017	0.0874	0.297**

Residual = 0.05524
*, **, significant at P=0.05, P=0.01
X_1: Days to first flowering, X_2 : Plant height(cm), X_3: Productive tillers, X_4: filled Spikelets/panicle, X_5: Spikelet fertility(%), X_6: Panicle length (cm), X_7: 1000 grain weight (g), X_8: Grain yield/plant (g)

Path analysis (Table 3 & 4) indicated that in both F_2 populations of crosses *Chakhao amubi* / RCM 23 & RCM 14 / RCM 23, productive tillers per plant and filled grains had high positive direct effect on grain yield per plant. This is in accordance with the report of Rajeshwari and Nadarajan (2004), Suman et al (2004), Shet et al (2012), Nandeshwar et al (2010) about high positive direct effect of productive tillers on grain yield. However in cross I, 1000 grain weight showed high direct positive effect on grain yield. The indirect effect of spikelet fertility and 1000 grain weight via filled spikelets per panicle and productive tillers resulted in significant positive correlation with grain yield in both F_2 populations. Hence selection based on productive tillers per plant and filled grains would be most effective for grain yield improvement in these two populations of black rice as these two traits exerted highest direct effect and also indirect effects on grain yield.

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