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Comparative potential on yield and its related characters in fine rice

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Abstract

A total of twenty fine grain rice cultivars including fifteen land races, three developed (Paijam, BR-49 and BR34) and two exotic (Philippine katari and Ranjit) varieties were collected from different parts of Bangladesh to identify the yield enhancing characters and to select desirable cultivars with high yield potential and high aroma emission from rice grain. The experiments were conducted in Aman season in 2013, in the Plant Breeding Research Field, HSTU, Dinajpur. Genetic variation for yield (t/ha) and other fourteen yield related characters like, plant height (cm), panicle length (cm), panicle weight (gm), total tillers/plant, productive tillers/plant, rachilla/panicle, sterile grain/panicle, total grain/panicle, 1000-grain weight (g), grain length (mm), grain breadth (mm), aroma content (%), days to 50% flowering, days to maturity was estimated. All the characters showed high heritability except sterile grain/panicle, indicated better progress under selection. High heritability (98.65%) was revealed by productive tillers/plant, suggested that the character would be less affected by environment. The cultivar, Ranjit produced the highest yield (4.96 t/h).The highest aroma contents in Kalozira (35%) and Kalosoru (30%) was estimated. The highest yield (4.96 t/h) was obtained from Ranjit and it was statistcally similar with the yields of Bolder (4.68 t/h), Malsira (4.25 t/h), Kalozira (4.33 t/h), BR-49 (4.26 t/h). The simultaneous consideration of yield potential and aroma emission from rice grain, four cultivars *viz*. Kalozira, Radhunipagol, Badshabogh and Chinigura may be advanced for commercial cultivation by the farmers and agriculture entrepreneurs and may be incorporated in further breeding for the development of high yielding fine rice varieties but the highest amount of aroma emission (35%) and yield (4.33 t/h) indicated that Kalozira was the best aromatic rice cultivar.

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Introduction

Rice is the principal food crop that is grown in tropical and temperate countries over a wide range of soil and climatic conditions and more than 90% of the world's rice is produced and consumed in Asia (Virmani, 1996). Among the seventeen Asian countries, the highest rice (202.3 million tons) was produced in China followed by India (154.5 million tons) and Bangladesh occupied the 4th rank (51.9 million tons) in 2011. Rice (*Oryza sativa* L.) is the main staple food and dominant crop in Bangladesh.IRRI (2011) reported that over the last thousand years, rice has been the dominant crop in Bangladesh and it currently accounts for 77% of agricultural land use. There are about 13 million farm families, who grow different types of rice, which includes traditional, modern, or hybrid rice varieties. Over 11.7 million hectares of land in Bangladesh is dedicated to rice production. Ashrafuzzaman *et al.* (2009) reported that aromatic rice in Bangladesh covered 12.5% of total aman rice cultivation. About 75% of the total cropped area and over 80% of the total irrigated area is planted to rice. Bangladesh's rice production is estimated to reach 338.30LMT (lac metric tons) in the current fiscal year 2011-2012, up from about 335.41 LMT in 2010-11. Fine rice may be aromatic or non-aromatic; when the grain is large, the length will exceed the breadth considerably but when the grain is small, it may be any type either small or slender. Independent of the grain type, all rice grains have a high market price and socio-cultural importance in Bangladesh (Biswas *et al.*, 2012).In breeding, development of modern cultivars for the past three decades were bias oriented towards non-aromatic rice for high yield, short stature, erect leaves, high littering, sturdy stems, early maturity and fertilizer responsive. These high yielding improved varieties have replaced many important and popular fine rice cultivars from the farmers' fields. Therefore, the popular landraces of fine rice must be protected through intensive activities both by the breeders and farmers as a whole. Variability proclaims a particular character estimated while diversity refers to exhibited differences for several characters among the genotypes under a species. In plant breeding programs, variability is exploited mainly for improvement through selection and diversity is considered to select parents for hybridization. Therefore, appropriate breeding strategy needs to be applied for improvement of yield potential. The available variability in a population can be partitioned into heritable and non-heritable components with the help of genetic parameters such as genotypic and phenotypic coefficients of variations, heritability and genetic advance (Miller *et al.*, 1958). Moreover, estimation of genetic diversity among different genotypes in a crop of interest is the first and foremost process in any plant breeding program (Rajesh *et al.,* 2010) and genetically diverged parents produce desirable recombination's in segregating generations (Banumathy *et al.*, 2010). Genetic diversity in plant genotypes can be estimated by observing and measuring agro-morphological characters. So the present study was undertaken to identify those characters that are important for improving the yield potential in fine rice and Comparative yield potential of the collected fine rice cultivars.

Materials and methods

The experiment was conducted in the Plant Breeding Research Field, Department of Genetics and Plant Breeding, Hajee Mohammad Danesh Science and Technology University, Dinajpur. The experimental plots were laid out in Randomized Complete Block Design with three replications. Each replication contained 150 hills of each cultivar having 20cm×20cm spacing. The unit plot size was 3m in length and 2m in breadth. The cultivars were randomly distributed to each of the plots within a block. Fertilizer was applied at the rate of 150kg, 100 Kg, 70Kg, 60 Kg and 4000 Kg Urea, TSP, MP, Gypsum and Cowdung respectively. The cow dung was applied at the beginning of land preparation and all the fertilizers except urea were applied as basal dose at the time of final land preparation. Urea (150 kg/ha) was applied in equal three splits. The first dose of urea was applied at 21 days after transplanting (DAT), the second dose of urea was added as top dressing at 45 days (active vegetative stage) after transplanting and third dose was applied at 60 days (panicle initiation stage) after transplanting as recommended by BRRI. Data on different yield and yield contributing characters were recorded on plot and hill basis at different dates as per experimental requirement. Data were recorded on the following plant characters- Plant height (cm) ,Panicle length (cm), Panicle wt. (gm) Rachilla/panicle (no. ,Sterile grain/panicle (no.), Total grain/panicle (no.), 1000-grain weight (g), Grain length (mm), Grain breadth (mm , Productive tillers/plant (no. , Total tillers/plant , Days to 50% flowering (day), Days to maturity (day, Yield (t/h.

Estimation of Genotypic and Phenotypic Variances

Genotypic and Phenotypic Variances are to be estimated according to the formulae given by Johnson *et al.* (1955).

Genotypic variances (σ^2 g)=$\frac{MSg-MSe}{r}$

Where,

MSg = Mean sum of squares for genotypes;

MSe = Mean sum of squares for error, and

r = Number of replications.

Phenotypic Variances (σ^2 p)= σ^2 g + σ^2 e

Where,

σ^2 g = Genotypic variances; and

σ^2 e = Error mean of square or environmental covariance.

Estimation of Genotypic and Phenotypic Coefficient of Variations

Genotypic and Phenotypic Coefficient of Variations are to be calculated according to the formulae given by Burton (1952).

Genotypic Co-efficient of Variations (GCV) =$\frac{\sqrt{\sigma^2 g}}{x}$

Where,

σ^2 g = Genotypic covariance; and

$\bar{x}$= Population mean

Phenotypic Co-efficient of Variations (PCV) =$\frac{\sqrt{\sigma^2 p}}{x}$

Where,

σ^2 p = Phenotypic covariance; and

$\bar{x}$ = Population mean.

Estimation of heritability

Broad sense heritability of all characters was estimated by the formula used by Johnson *et al.* (1955) and Hanson *et al.* (1956).

$$\text{Heritability (\%)} = \frac{\sigma_g^2 \times 100}{\sigma_p^2}$$

Where,

σ_g^2 = genotypic variance

σ_p^2 = phenotypic variance.

Estimation of genetic advance

The expected genetic advance for different characters was estimated by the formula as suggested by Johnson *et al.* (1955).

Genetic advance (GA) = h^2_b K σ_p

Where,

h^2_b = Heritability in broad sense;

K = Selection intensity which is equal to 2.06 at 5%; and

σ_p = Phenotypic standard deviation.

Estimation of genetic advance in percentage of mean, GA (%)

Genetic advance in percentage of mean was calculated by the formulae of Comstock and Robinson (1952) as follows.

$$\text{GA (\%)} = \frac{GA}{\bar{x}} \times 100$$

Where,

GA = Genetic advance; and

$\bar{x}$ = Population mean.

Genotypic and phenotypic correlation coefficients

The genotypic and phenotypic correlation coefficients of yield and its different contributing characters were estimated by the following formulae given by Johnson *et al.* (1955) and Singh and Chaudhary (2010).

Statistical analysis

The collected data were compiled and tabulated in form for statistical analysis. Analysis of variance was done following Randomized Complete Block Design (RCBD) with the help of a computer package (MSTAT-C) and the mean differences among the varieties were adjusted by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Results and discussions

Analysis of variance for different quantitative characters

Analysis of variance for 14 quantitative characters was accomplished to assess the variability pertained for a particular character among the twenty fine rice cultivars.

Table 1. The sources of the experimental genotype used in are listed below.

Acc. No.	Cultivar name	Place of collection	
		Upazila	District
FR 1	Kataribogh	Sadar	Dinajpur
FR 2	Radhunipagol	Birol	Dinajpur
FR 3	Begunbichi	Dumki	Patuakhali
FR 4	Malsira	Fulbari	Dinajpur
FR 5	Kalosoru	Sadar	Dinajpur
FR 6	Shalna	Patnitola	Naogaon
FR 7	Kalozira	Sadar	Narail
FR 8	Bolder	Sadar	Thakurgoan
FR 9	Ronjit	Fulbari	Dinajpur
FR 10	Jaistakatari	Birol	Dinajpur
FR 11	Chinigura	Ulipur	Kurigram
FR 12	Sadakatari	Chirirbondar	Dinajpur
FR 13	Uknimodhu	Chilmari	Kurigram
FR 14	Paijam	Fulbari	Dinajpur
FR 15	Binnipakri	Chirirbondar	Dinajpur
FR 16	Badshabogh	Chirirbondar	Dinajpur
FR 17	BR-34	BRRI, Joydebpur	Gazipur
FR 18	Philipinekatari	Birol	Dinajpur
FR 19	BR-49	BRRI, Joydebpur	Gazipur
FR 20	Sorna	Raninagar	Naogaon

Table 2. Analysis of variance (MS) on fourteen characters of twenty fine rice variety.

SL No	Characters	Source of variation with mean sum of square			
		Replication (2df)	Genotypes (19 df)	Error (38df)	Coefficient of variation (%)
1	Plant height (cm)	697.423	693.571**	51.499	5.78
2	Panicle length (cm)	14.287	8.088**	1.283	4.82
3	Panicle weight (gm)	1.851	1.277*	0.189	18.40
4	Rachilla / panicle (no)	0.86	4.281**	0.788	8.43
5	Sterile grain / panicle (no)	611.711	486.544**	137.914	40.36
6	Total grain / panicle (no)	2028.041	5728.962**	515.762	12.97
7	1000 grain weight (gm)	0.203	36.572**	0.541	4.93
8	Grain length (mm)	0.195	2.396*	0.326	8.37
9	Grain breadth (mm)	0.024	0.05*	0.032	10.72
10	Productive tiller/hill (no)	0.236	3.761**	2.917	14.10
11	Total tillers/hill (no)	0.301	6.083**	4.549	12.47
12	Days to 50% flowering (day)	2.769	72.349**	0.838	0.99
13	Days to maturity (day)	3.699	63.369**	0.806	0.74
14	Yield/ hectare (t/h)	0.184	1.956*	0.009	2.75

** Indicates significant at 1% level of probability, * indicates significant at 5% level of probability.

The source of variation included genotype, replication and error (Table 2). The mean squares against three replications found non-significant for all the characters studied, visualized justification of blocking in the field. The mean squares for the cultivars exhibited strong and significant differences in each of the selected characters, superimposed ample variability for the characters and therefore, breeders could drive the breeding methods either selection or hybridization for the improvement of present yield status of the collected fine rice cultivars Analysis of variance for fourteen characters under study exhibited significant variability. The genotypic and phenotypic coefficients of variations, heritability and genetic advance are the important tools to estimate the nature and extent of variabilities for the characters (Ifftikhar *et al.,* 2009).

Table 3. Estimation of genetic variability parameters on 14 characters in 20 aromatic rice variety.

Sl. No.	Characters	Genotypic variance (σ^2g)	Phenotypic variance (σ^2p)	Environmental variance (σ^2e)	GCV (%)	PCV (%)
1	Plant height	214.024	265.523	51.499	11.780	13.121
2	Panicle length	2.264	3.551	1.287	6.406	8.016
3	Panicle weight	0.363	0.552	0.189	25.508	31.456
4	Rachilla/panicle	1.164	1.953	0.789	10.246	13.272
5	Sterile grain/panicle	116.212	254.125	137.913	37.047	54.784
6	Total grain/panicle	1737.733	2253.49	515.757	23.815	27.120
7	1000 grain weight	12.011	12.551	0.54	24.307	24.848
8	Grain length	0.69	1.016	0.326	12.162	14.758
9	Grain breadth	0.006	0.038	0.032	4.638	11.67
10	Total tillers/plant	1.978	2.127	0.149	8.221	8.524
11	Productive tillers/plant	1.248	1.265	0.017	10.302	10.443
12	Days to 50% flowering	23.837	24.675	0.838	5.291	5.384
13	Days to maturity	20.854	21.660	0.806	3.740	3.811
14	Yield / hectare	0.649	0.658	0.009	0.658	23.504

Table 4. Estimation of Heritability and genetic advance of different characters in fine rice.

Sl. No.	Characters	Heritability (%)	Genetic advance	Genetic advance in 1% mean
1	Plant height	80.604	27.054	21.294
2	Panicle length	63.869	2.478	10.541
3	Panicle weight	65.760	1.004	42.508
4	Rachilla/panicle	59.600	1.715	16.326
5	Sterile grain/panicle	45.730	15.016	51.604
6	Total grain/panicle	77.112	75.407	43.080
7	1000 grain weight	95.697	6.984	48.984
8	Grain length	67.913	1.409	9.882
9	Grain breadth	15.789	0.063	3.772
10	Total tillers/plant	92.99	4.071	21.075
11	Productive tillers/plant	98.65	2.553	2.666
12	Days to 50% flowering	96.603	9.885	10.714
13	Days to maturity	96.278	9.230	7.559
14	Yield/hectare	98.632	1.647	47.722

Genetic parameters for different morph-physiological characters

The different parameters for the assessment of variability in terms of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were estimated (Table 3). The PCV was higher than corresponding GCV for each of the characters and difference between PCV and GCV was in general low for maximum characters. The small difference between GCV and PCV indicated the additive fashion of transmission of such polygenic characters. Moreover, a considerable difference (10.01%) was measured between GCV and PCV against yield (t/h), indicated that the ultimate complicated interacted character, yield was affected by environment. Heritability provided the information regarding the magnitude of transmissible genetic variation among the generations out of total variation and determined the degree of response to selection. In the investigation, heritability in broad sense was estimated for all the characters. High heritability values were obtained for all the characters except sterial grain per panicle (h^2_b=54.784%) (Table 5).

Table 5. Genotypic correlation of 14 characters of 20 aromatic rice varieties.

	PH	PL	PW	RPP	SGPP	TGPP	TGW	GL	GB	TTPP	PTPP	DF	DM	YTH
PH	1	0.267	0.758**	-0.262	-0.189	0.059	-0.633**	-0.594**	-0.579**	0.031	0.602**	0.524*	0.466*	-0.382
PL		1	0.207	0.557**	0.447*	0.471*	-0.312	-0.489*	-0.146	-0.692**	-0.991**	0.151	0.254	0.087
PW			1	0.303	0.349	-0.649**	0.406	0.417	0.407	-0.214	-0.319	-0.295	-0.192	0.503*
RPP				1	0.338	0.217	0.204	0.032	0.323	-0.448*	0.578**	0.308	-0.299	0.347
SGPP					1	0.852**	-0.196	-0.077	-0.281	-0.787**	-0.979**	-0.349	-0.295	0.024
TGPP						1	-0.476*	-0.398	-0.552**	-0.681**	-0.297	0.062	0.1	0.145
TGW							1	0.907**	0.912**	0.408	0.213	-0.539*	-0.503*	0.646**
GL								1	0.808**	0.409	0.476*	-0.386	-0.353	0.226
GB									1	0.469*	0.292	-0.571**	-0.515*	0.513*
TTPH										1	0.902**	0.387	0.385	0.227
PTPH											1	0.519*	0.342	0.635**
DF												1	0.989**	-0.415
DM													1	-0.432
YTH														1

PH= Plant height (cm), PL=Panicle Length (cm), PW=Panicle wt. (gm), RPP=Rachilla/panicle, SGPP=Sterile grain/panicle, TGPP=Total grain/panicle, TGW=1000-grain wt. (g), GL=Grain length (mm), GB=Grain breadth (mm), TTPP=Total tillers/plant,
PTPP=Productive tillers/plant, DF=Days to 50% flowering, DM=Days to maturity, YTH=Yield (t/h).

Table 6. Phenotypic correlation of 14 characters of 20 aromatic rice varieties.

	PH	PL	PW	RPP	SGPP	TGPP	TGW	GL	GB	TTPP	PTPP	DF	DM	YTH
PH	1	0.361	0.658**	0.012	-0.068	0.193	-0.547*	-0.457*	-0.162	0.079	0.229	0.465*	0.422	-0.337
PL		1	0.305	0.617**	0.268	0.532*	-0.239	-0.389	0.008	-0.245	-0.369	0.149	0.22	0.075
PW			1	0.402	0.314	0.537*	0.349	0.204	0.152	-0.163	-0.318	-0.214	-0.131	0.403
RPP				1	0.952**	0.356	0.159	0.062	0.154	-0.013	0.19	0.276	-0.216	0.266
SGPP					1	0.576**	-0.142	-0.004	-0.141	-0.203	-0.278	-0.207	-0.212	0.024
TGPP						1	-0.407	-0.37	-0.165	-0.277	-0.385	0.062	0.095	0.132
TGW							1	0.746**	0.403	0.115	0.045	-0.516*	-0.479*	0.544*
GL								1	0.3	0.353	0.333	-0.315	-0.296	0.183
GB									1	0.089	0.034	-0.225	-0.191	0.202
TTPH										1	0.837**	0.119	0.109	-0.067
PTPH											1	0.133	0.392	0.497*
DF												1	0.956**	-0.406
DM													1	-0.418
YTH														1

PH= Plant height (cm), PL=Panicle Length (cm), PW=Panicle wt. (gm), RPP=Rachilla/panicle, SGPP=Sterile grain/panicle, TGPP=Total grain/panicle, TGW=1000-grain wt. (g), GL=Grain length (mm), GB=Grain breadth (mm), TTPP=Total tillers/plant, PTPP=Productive tillers/plant, DF=Days to 50% flowering, DM=Days to maturity, YTH=Yield (t/h).

Raisheed *et al.* (2002) observed high heritability for most of the yield contributing characters in rice. Whatever, the maximum heritability was estimated for 1000-grain weight (95.69%), productive tillers per plant (98.78%), days to 50% flowering (96.61%), days to maturity (96.27%). Therefore, there is a scope of improving the character through selection in rice (Das *et al.,* 2005 ; Mall *et al.* 2005). The high heritability along with high genetic advance as percentage of mean was also registered for 1000-grain weight (48.98%), indicated that 1000-grain weight was the most vital character for improving yield in fine rice.

Correlation coefficients and path coefficients analysis on yield and its related characters

Genotypic and phenotypic correlation coefficients of yield and eleven yield contributing characters were estimated (Table 5 and 6). Genotypic and phenotypic correlation coefficients showed a similar trend but genotypic correlation coefficients were higher in magnitudes than the corresponding phenotypic correlation coefficients in most of the associations. In very few associations where phenotypic correlation coefficients were higher than corresponding genotypic correlation coefficients.

Table 7. Genotypic path analysis showing direct and indirect effects on yield.

	PH	PW	RPP	TGPP	TGW	GL	GB	PTPP	DF	DM	Genotypic correlation yield
PH	-0.068	0.295	-0.096	0.033	0.562	-0.127	-0.788	-0.266	-0.196	0.270	-0.382
PW	-0.051	0.389	0.111	-0.369	-0.361	0.089	0.554	0.141	0.110	-0.111	0.502*
RPP	0.017	0.118	0.367	0.123	-0.181	0.006	0.439	-0.256	-0.115	-0.173	0.347
TGPP	-0.004	-0.252	0.079	0.569	0.423	-0.085	-0.751	0.131	-0.023	0.058	0.144
TGW	0.043	0.058	0.074	-0.271	0.889	0.094	0.142	-0.094	0.002	-0.291	0.646**
GL	0.0404	0.162	0.011	-0.226	-0.806	0.214	1.1004	-0.210	0.144	-0.204	0.226
GB	0.039	0.158	0.118	-0.314	-0.810	0.173	1.361	-0.129	0.214	-0.298	0.513*
PTPH	-0.041	-0.124	0.212	-0.169	-0.189	0.102	0.397	0.443	-0.194	0.198	0.635**
DF	-0.035	-0.114	0.113	0.035	0.479	-0.082	-0.777	-0.229	-0.375	0.574	-0.415
DM	-0.031	-0.074	-0.109	0.056	0.447	-0.075	-0.701	-0.151	-0.371	0.5804	-0.432

These results might be due to the masking or modifying effects of the environment on the development of such character associations at the genotypic level (Zahid *et al.,* 2006 ; Agahi *et al.,* 2007). It is noted that yield and its influencing characters are poly genetically controlled, so, these characters were subjective to environmental fluctuation during phenotypically expressed which eventually abridged the correlation coefficients at phenotypic level. Grain length exerted maximum positive indirect effect (1.1) through grain breadth; days to 50% flowering paid a considerable indirect effect (0.479) via 1000-grain weight; again days to maturity given a considerable indirect effect (0.447) via 1000-grain weight. On the contrary, the highest negative direct effect on the development of a genotypic correlation with yield was resulted by days to 50% flowering (-0.375) followed by plant height (-0.068). Each and every character had both positive and negative indirect effects but through which these effect were exerted should be considered. Therefore, the primary characters like, 1000-grain weight, productive tillers per plant, panicle weight, grain breadth and the days to 50% flowering, days to maturity might have prime importance in the selection to increase grain yield.

Conclusion

Out of the fourteen traits the panicle weight, 1000-grain weight, effective tillers per plant, plant height, days to 50% flowering, and days to maturity are important traits for improving the yield potential in fine rice. Among the 20 fine rice cultivars seemed to be highly potential Ranjit and Bolder were outstanding against yield/ha.

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