International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 17, No. 1, p. 16-25, 2020

INNSPUB

RESEARCH PAPER

OPEN ACCESS

Evaluation of experimental hybrids of fine rice (*Oryza Sativa* L.)

MT Afrose*[1], ML Hakim[2], MA Mahamud[3], MA Rahman[4], F Najmim[5], JK Roy[6], BK Biswas[7]

[1]*Pubali Bank Ltd., Rungpur, Bangladesh*

[2]*Department of Agriculture Extension, Mithapukur, Rungpur, Bangladesh*

[3]*Supreme Seed Company Ltd., Panchagrah, Bangladesh*

[4]*Bangladesh Bank Ltd., Rungpur, Bangladesh*

[5]*Lal Teer Research and Development Center, Gazipur, Bangladesh*

[6]*Seed Certification Agency, Thakurgoan, Bangladesh*

[7]*Department of Genetics and Plant Breeding, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh*

Article published on July 30, 2020

Key words: Genetic variation, Heritability, Genetic diversity, Rice (*Oriza sativa* L.)

Abstract

Seven fine rice genotypes including three aromatic hybrids were evaluated for fifteen quantitative characters to select the most yield enhancing characters as well as the diverged cultivars for hybridization. The mean performances and genetic parameters of the characters were separated through univariate analysis; the most yield promoting characters were selected by bivariate and multivariate analyses and desirable parents were selected by univariate and multivariate analyses. Though high heritability was estimated for most the characters but the highest genetic advance was estimated against total grain/penicle(112.4). Productive tillers/plant, thousand grain wt., days to 50% flowering and days to maturity showed positive and significant, and plant height showed negative and significant correlation coefficients with yield. Upon partitioning the total phenotypic correlation coefficients with yield, 1000-grain weight exerted the highest direct effect (1.05) therefore;these characters appeared as the predominant yield accelerating characters in fine rice. It was initially aimed to develop experimental hybrids through a diallel model. The three hybrids were evaluated and their competence was measured by two criteria of heterosis. The aroma contents in the hybrids and their parents were compared. Out of three hybrids, there were in which the highest aroma was assessed in the F1of Kataribhog ×Begunbichi, hence consideration of yield and aroma content these hybrids may bring to obtain desirable aeromatic rice.

* **Corresponding Author:** MT Afrose ✉ lutfulhstu@yahoo.com

Introduction

Rice (*Oryza sativa* L.) is the most important food crop of Bangladesh with the ranking first both in area and production among the cereal crops. At the current growth of population rice requirement increases dramatically; hence, it is challenging task to ensuring food and nutritional security to the country. Therefore, enhancing productivity of rice through noble genetic approaches like hybrid rice was felt necessary. Hybrid rice is produced when the egg is fertilized by pollen from anthers of a rice plant from a different variety or line. Hybrid vigor or heterosis is a universal phenomenon in which the F_1 shows superiority to both parents in agronomic traits or yield. Exploitation of heterosis is considered to be one of the outstanding achievements of plant breeding. The presence of sufficient hybrid vigour is an important pre-requisite for successful production of hybrid varieties. The hybrids yielded 20-30% higher than conventionally bred varieties.

The increased yield of rice hybrids alone does not ensure profitability to farmers if their grain quality is not acceptable and if they fetch a low price in the market. Rigorous efforts are needed to improve the production of rice in the country by diversifying its uses and by developing rice hybrids for specific traits of economic importance. Identifying high yielding hybrids is expensive and involves testing large number of hybrid combinations in multi environmental trials.

In Bangladesh, there is a wide range of land races with unique flavor and other attractive grain characteristics such as distinct grain texture, endosperm chalkiness, non-stickiness of cooked rice, etc. (Hosan *et al.*, 2010). Thus, there is a wide scope in breeding program to improve fine rice to fulfill divergent demands of farmers and consumers regarding food security, changing palatability, nutrition supply, mitigation of risk due to sudden failure of modern or hybrid varieties, good economic return, uses in socio-cultural programs (Hien *et al.*, 2007.) There is urgent need to improve the yield potential of such rice. However, improvement in yield and its component characters through hybridization with high yielding non-aromatic rice cultivars often becomes difficult due to break-down of aroma and other cooking quality characters. Therefore, generation of variability through all possible ways is of paramount importance for improvement of aromatic rice.

The progress in breeding for yield and its contributing characters of any crop is polygenetically controlled, environmentally influenced and determined by the magnitude and nature of their genetic variability. It is very difficult to judge whether observed variability is highly heritable or not Correlation in grouping with path analysis would give a better insight into cause and effect relationship between different pairs of characters (Jayasudha and Sharma, 2010).

Knowledge of correlation between yield and its contributing characters are basic and foremost endeavor to find out guidelines for plant selection. Hence, path analysis is of much importance in any plant breeding program. Genetic variability, character association and path analysis are pre-requisites for improvement of any crop including rice for selection of superior genotypes and improvement of any trait (Krishnaveni *et al.*, 2006). In agriculture, path analysis has been used by plant breeders to assist in identifying traits that are useful as selection criteria to improve crop yield (Surek and Beser, 2003)

The demand for aromatic rice has been increasing in recent years in traditional and non- traditional rice growing countries. Rice breeders have an interest in developing a simple and inexpensive method for distinguishing aromatic from non-aromatic rice. Genetic uniformity could become a problem for the selection of germplasm to develop improved varieties. Keeping eyes on the above facts the present investigation was undertaken to evaluation of experimental hybrid rice with their parental lines, study the genetic variation of some important quantitative characters among the available genotypes, find out the genetic parameters in the selected genotypes, assess the character association and contribution of characters towards grain yield in selected genotypes and finally selection of the most outstanding hybrids.

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, 100Kg, 70Kg, 60Kg and 4000Kg 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. The sources of the experimental genotype used in are given Table 1. 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.

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

Acc. no.	Cultivar name	Place of collection	
		Upazila	District
1	katarivog	Sadar	Dinajpur
2	Begunbichi	Dumki	Patuakhali
3	Ranjit	Fulbari	Dinajpur
4	Salna	Patnitola	Naogaon
Hybrid	Katarivog × begunbichi	Newly develop through crossing	
Hybrid	Ranjit × salna	Department of Genetics and Plant Breeding, Hajee Mohammad Danesh Science & Technology University, Dinajpur-5200.	
Hybrid	Ranjit × katarivog		

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^2e=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 Johnson *et al.* (1955).

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).

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) = $h^2_b K \sigma_p$

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: 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).

Estimation of heterosis

Heterosis expressed as percent increase or decrease of F1 hybrid over mid-parent(average or relative heterosis), better parent (heterobeltiosis) were computed for each character using the following formulae-

a. heterosis over mid parent (relative heterosis)=

F1 - MP /MP × 100

b. heterosis over better parent (heterobeltiosis)=

F1 – BP /BP × 100

Where,

F1 : mean performance of F1

M2 : mean mid-parental value =(P1 + P2) / 2

P1 : mean performance of parent one

P2 : mean performance of parent two

BP : mean performance of better parent

Paired't' test

The paired't' test endowed the hypothesis for the difference between means of a paired samples against a particular character where divergence was approximately under normal distribution .The paired't' is performed when the samples are not independent but they are related.

Assessment of aroma from grain

5-6 grains were collected from each of the cultivars and then dehusked the rice grain. After dehusking the sample were taken in a Vial in which 10ml of 1.7% KOH solution was added and left for 15 minitues at room temperature. A panel of six persons smelled the samples one by one and their respective evaluation was recorded. The average grade was scored from 15% to 35% and only the odd members were included in the functions but the average grades fall within the following ranges-

15% -<20% =Very low aroma, 20%- <25% =Low aroma, 25%- <30% =Medium aroma and 30% -<35% =High aroma

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

Rice breeders can be developed new improved fine rice varieties by applying appropriate breeding strategies. In the present study fine rice cultivars were collected from different parts of Bangladesh and conducted experiments in successive aman seasons; However, after conducting the investigations the data were analyzed in all possible ways and the furnished results along with findings are stated below-

Analysis of variance for different quantitative characters.

Analysis of variance for 15 quantitative characters was accomplished to assess the variability pertained for a particular character among the seven fine rice cultivars. The source of variation included genotype, replication and error are given (Table.2). The mean squares against three replications found nonsignificant 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. Development of high yielding varieties in almost every year by the rice breeders and by different commercial agencies are being culminating pertaining exploitable variability in the popular fine rice land races, that leads to erosion of these valuable rice germplasm.

Table 2. Analysis of variance (MS) on fifteen characters in fine rice.

SL	Characters	Source of variation			Co-efficient of variation%
		Replication	Genotype	Error	
1	Plant height(cm)	14.99	849.07**	55.38	5.71
2	Panicle length(cm)	7.13	9.18*	3.06	6.89
3	Panicle wt.(gm)	0.99	3.77**	0.38	20.55
4	Rachillae/panicle(no.)	0.15	13.33**	1.58	10.96
5	Sterile grain/panicle(no.)	170.28	3034.09**	257.79	32.82
6	Total grain/panicle(no.)	234.36	9738.25**	207.69	6.09
7	1000 grain wt.(gm)	1.03	35.45**	0.51	5.11
8	Grain length(mm)	0.01	2.80**	0.01	1.62
9	Grain breadth(mm)	1.09	1.63	1	51.13
10	Aroma content%	2.71	66.87**	1.32	4.97
11	Productive tiller/plant(no.)	0.51	7.56**	0.57	6.09
12	Total tiller/plant(no.)	1.47	57.35**	0.92	4.78
13	Days to 50% flowering(day)	1.67	11.17**	0.79	0.96
14	Days to maturity(day)	0.14	10.43**	0.97	0.8
15	Yield(t/ha)	0.01	1.99**	0.02	4.18

Performances of the genotypes for yield and its related characters

The mean performances of 15 characters in seven fine rice cultivars were separated by DMRT test at 5% level of provability presented in Table 3. The characters were plant height (cm), tillers/hill, effective tillers/hill, days to 50% flowering, days to maturity, panicle length (cm),rachillae/panicle, 1000-grain weight (g) and yield (t/ha). The plant height of the cultivars observed in general towering and ranged from 119.5-135.5cm; contemporary the plant height of modern rice varieties is around 110-120cm, therefore, the height of fine rice cultivars need to reduce by appropriate breeding methods so as to check the cultivars from unwanted lodging at pre-mature stage, which drastically reduces yield potential of the cultivars. The highest effective tillers/hill was observed from the cultivar kataribhog (15.83). As an important yield contributing character, the highest panicle length was measured in Kataribhog (28.0). The days to maturity of the cultivars was counted from the transplanting date and 25 days old seedlings were transplanted in the experimental field. Likewise, plant height, days to maturity was too much higher as compared to our traditional modern rice varieties and the range for days to maturity of the investigated cultivars was from 121-125.3days. Another important yield contributing character rachilla/panicle was highest in Salna (12.33) and the lowest was in the cultivar kataribhog (9.7). Among the cultivars katari (19.04) showed highest 1000-grain weight and Begunbichi showed lowest 1000-grain weight. However the most economically important character, yield (t/ha) obtained low where the range was 3.97-4.7 t/ha.The highest yield (t/ha) was recorded from the cultivar, Ranjit (4.7t/ha) followed by Salna (4.45t/ha) and katari.

Genetic parameters for different morph-physiological characters

Different parameters such as mean range, genotypic variance (σ^2g), phenotypic variance (σ^2p), genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), genetic advance (GA) and genetic advance as percent mean (GAM) of 15 characters were estimated to levy the variability exited among the characters. The results are presented in (Table 4 and Table 5) revealed that very close relation was observed between each of the pairs of parameters against each of the selected characters. Most of the characters showed high heritability couple with low genetic advance, except total grain/penicle (h^2b=93. 86%) but high genetic advance (112.4%) indicated that the character may response well under favorable growing conditions. The highest heritability value (h^2b=98.73%) was estimated for grain length but the character had only 1.97% genetic progress, therefore, amenable of grain lengthby modifying cultural environment is very difficult in fine rice. Nonetheless, the magnitude of heritability for yield (t/ha) was also high ((h2b=97.05%) but genetic progress under direct selection would offer only 1.64%, consequently direct selection on yield alone would not be effective for improving yield potential; others approaches of plant breeding need to be applied for sustainable improvement of fine rice. Rokonuzzaman *et al.* (2008) estimated the highest heritability (%) in broad sense for plant height and followed by days to 50% flowering and it was lowest for yield and followed by panicle length.

Table 3. Mean performance of different quantitative characters in fine rice.

SL	variety	Plant height (cm)	Paniclelen gth (cm)	Panicle wt.(gm.)	Rachillae/pa nicle (no.)	Sterile grain/panicle (no.)	Total grain/panicle (no.)	1000 grain wt.(gm)
1	kataribhog	119.5c	28a	4.18a	9.7c	19.37c	156.8e	19.04a
2	Begunbichi	127.2b	25c	1.77c	11.33bc	34.9bc	221.1cd	17.12c
3	Ranjit	127.2b	25c	2.47b	10.4bc	41.8bc	241.8c	17.12c
4	Salna	135.5a	27.07b	2.96b	12.33b	43b	224.3cd	17.13c
5	Katari ×begunbichi	126.6b	27b	2.96b	11.07bc	55.93a	290.4b	18b
6	ranjit×salna	120.6bc	28a	1.96c	9.7c	31.07bc	195.7d	18.5b
7	ranjit×katari	119.5c	28.6a	4.81a	15.77a	19.37c	326.8a	19.04a
	Mean	125.2	26.95	3.01	11.47	35.06	236.7	17.99
	Range	119.5-135.5	25-28.6	1.77-4.81	9.7-15.77	19.37-55.93	156.8-326.8	17.12-19.04

Mean values having common letters are statistically identical; those having different letters are significantly different from each other.

Table 3. Mean performance of different characters in fine rice (cont'd).

SL	variety	Grain length (mm)	Grain breadth (mm)	Aroma content %	Productive tiller/plant (no.)	Total tiller/plant (no.)	Days to 50% flowering (day)	Days to maturity (day)	Yield (t/ha)
1	kataribhog	7.82a	3.61a	30a	15.83a	17.27cd	92.77a	125.3a	4.7a
2	Begunbichi	5.98c	1.74b	25b	12c	16.13d	91.37b	121d	3.97c
3	Ranjit	5.98c	1.57c	25b	12c	15.87d	91.67b	121d	3.97c
4	Salna	5.99c	1.74b	21c	12.25c	25.5a	90.12c	122c	3.98c
5	Katari×begunbichi	6.98bc	1.6bc	25b	14.23b	18c	91.9b	124.3b	4.5b
6	ranjit×salna	7.24b	1.67bc	15d	14.7b	21.6b	91.99b	124.5b	4.6ab
7	ranjit×katari	7.82a	3.61a	30a	15.83a	26.2a	92.15a	125.3a	4.7a
	Mean	6.83	2.22	24.42	13.83	20.08	91.71	123.3	4.34
	Range	5.98-7.82	1.57-3.61	15-30	12-15.83	15.87-26.2	90.12-92.77	121-125.3	3.97-4.7

Mean values having common letters are statistically identical; those having different letters are significantly different from each other.

Table 4. Estimation of variability of fifteen characters in fine rice.

SL	Character	Genotypic Variance (σ^2g)	Phenotypic Variance(σ^2p)	Environmental variance (σ^2e)	GCV (%)	PCV (%)
1	Plant height(cm)	264.56	319.94	55.38	12.47	13.72
2	Panicle length(cm)	2.04	5.10	3.06	0.62	8.89
3	Panicle wt.(gm)	1.13	1.51	0.38	35.31	40.88
4	Rachillae/panicle(no.)	3.91	5.49	1.58	17.22	20.42
5	Sterile grain/panicle(no.)	925.43	1183.22	257.79	62.19	70.33
6	Total grain/panicle(no.)	3176.85	3384.55	207.69	23.81	24.58
7	1000 grain wt.(gm)	11.65	12.16	0.51	24.39	24.93
8	Grain length(mm)	0.93	0.94	0.01	14.59	14.69
9	Grain breadth(mm)	0.21	1.21	1	23.44	6.27
10	Aroma content%	21.85	23.17	1.32	20.32	20.93
11	Productive tiller/plant(no.)	2.33	2.91	0.57	12.22	13.66
12	Total tiller/plant(no.)	18.81	19.73	0.92	21.59	22.12

13	Days to 50% flowering(day)	3.46	4.25	0.79	2	2.22
14	Days to maturity(day)	3.15	4.13	0.97	1.44	1.65
15	Yield(t/ha)	0.657	0.67	0.02	23.91	24.27

Table 5. Estimation of Heritability and genetic advance of different characters in fine rice.

SL	Character	Heritability (%)	Genetic Advance (at 5% selection intensity)	Genetic Advance (as% of mean)
1	Plant height(cm)	82.69	30.47	23.37
2	Panicle length(cm)	39.96	1.86	7.33
3	Panicle wt.(gm)	74.63	1.89	62.79
4	Rachillae/panicle(no.)	71.17	3.44	29.97
5	Sterile grain/panicle(no.)	78.21	55.42	113.3
6	Total grain/panicle(no.)	93.86	112.4	47.49
7	1000 grain wt.(gm)	95.81	6.88	49.18
8	Grain length(mm)	98.73	1.97	29.81
9	Grain breadth(mm)	17.36	0.39	19.95
10	Aroma content%	94.3	9.35	40.65
11	Productive tiller/plant(no.)	80.07	2.81	22.49
12	Total tiller/plant(no.)	95.34	8.72	43.42
13	Days to 50% flowering(day)	81.41	3.45	3.72
14	Days to maturity(day)	76.27	3.19	2.59
15	Yield(t/ha)	97.05	1.64	48.38

Table 6. Genotypic correlation (r_g) coefficients among fifteen characters of fine rice.

	PHT	PL	PW	RPP	SGPP	TGPP	TGW	GL	GB	AC	PTPP	TTPP	DF	DM	YPH
PHT	1														
PL	-0.53	1													
PW	0.062	-0.07	1												
RPP	-0	0.317	0.58	1											
SGPP	-0.2	0.371	0.529	.931**	1										
TGPP	0.031	0.088	0.329	.783*	0.235	1									
TGW	-.862*	.866*	0.7	0.183	-0.67	0.033	1								
GL	-.848*	.861*	0.712	0.189	-0.62	0.071	.997**	1							
GB	0.744	0.087	.892**	0.287	-0.83	-0.04	-0.38	-0.39	1						
AC	0.123	-0.34	0.728	-0.26	-0.36	0.118	-0.38	-0.39	0.713	1					
PTPP	-.823*	.881**	0.714	0.191	-0.6	0.076	.994**	.999**	.722*	0.324	1				
TTPP	0.073	0.664	0.447	0.706	-0.25	0.384	0.287	0.269	0.284	-0.15	0.296	1			
DF	-.931**	0.376	0.406	-0.18	-0.51	-0.08	.779*	.785*	0.588	0.428	.760*	-0.34	1		
DM	-0.73	.921**	0.663	0.165	-0.47	0.093	.961**	.971**	0.67	0.208	.982**	0.355	0.672	1	
YPH	-.830*	.861*	0.613	0.117	-0.51	0.082	.976**	.984**	0.666	0.221	.988**	0.249	.773*	.986**	1

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

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

Correlated response all possible paired combinations of characters were estimated to gain better response during indirect selection of different characters (Table 6.) The highest and negative correlated response (-.830) was paid by plant height. However, among the characters, tillers/hill, productive tillers/hill, panicle length, spikelets/panicle and spikelet length showed positive correlated response with yield and as a single character, In addition, productive tillers/hill alone developed strong response to selection (.988) when yield is considered to be increased. Akhtar *et al.* (2011) reported that grains/panicle; 1000-grain weight and days to maturity were positively correlated with grain yield both at phenotypic and genetic levels. Despite, grain yield was a complex character; indirect selection through correlated, less complex and easier measurable characters would be an advisable strategy to increase the grain yield. Efficiency of indirect selection depended on the magnitude of correlations between yield and target yield components.

Path coefficients analysis on yield and other related characters

The characters under selection were polygenic, hence the expression of the characters were influenced by the prevailing environment. Path coefficient analysis permits a thorough understanding of contribution of various characters by partitioning the correlation coefficient into components of direct and indirect effects (Laxuman *et al.*, 2011). Since the phenotypic correlation coefficients were developed by the interaction of genotype and phenotype, path analysis only one genotypic correlation put forwarded cause (characters) and effect (yield) in a definite pattern of presentation Table 7. However, the highest positive direct effect for the development of genotypic correlation with yield was exaggerated by days to maturity (1.32) followed by total grain /penicle (0.048) while the minimum positive direct effect for the creation of relation with yield. Therefore, the primary characters like, 1000-grain weight, total grain/panicle and the days to 50% flowering,days to maturitymight have prime importance in the selection to increase grain yield. Similar results were reported by Makwana *et al.* (2010) and Hairmansis*et al.* (2010). The highest indirect effect was given by (1.3) via effective tillers/hill.Not only that days to 50% flowering also displayed positive indirect effect (0.1) with yield that was opposite information generated from an investigation where days to flowering showed positive direct effect with yield (Khan *et al.*, 2009). Each and every character had both positive and negative indirect effects but through which these effect were exerted should be considered.

Accordingly, days to maturity paid only three negative indirect effects. Therefore, days to maturity appeared as important characters to gain maximum benefit from simultaneous selection.

Estimation of heterosis on different quantitative characters in fine rice

Heterosis of three experimental hybrids was estimated over the better parent (BP), over the mid parent (MP). The results of different types of heterosis for 15 characters along with their relative superior performances are presented in Table 8 and Table 9. Moreover, heterosis over better-parent (heterobeltiosis) could be a better measure for breeding purpose (El-Namaky, 2012).

Table 7. Path Analysis (genotypic) of characters on yield.

	PL	TGPP	TGW	GL	PTPP	DF	DM	YPH
PL	-0.19	0.004	0.917	-0.37	-0.76	0.05	1.22	0.861
TGPP	-0.016	0.048	0.035	-0.03	-0.066	-0.01	0.12	0.082
TGW	-0.16	0.001	1.059	-0.43	-0.866	0.105	1.27	0.976
GL	-0.164	0.003	1.055	-0.434	-0.871	0.106	1.286	0.984
PTPP	-0.167	0.003	1.052	-0.43	-0.872	0.103	1.3	0.988
DF	-0.071	-0.003	0.824	-0.34	-0.662	0.136	0.89	0.773
DM	-0.17	0.004	1.017	-0.421	-0.856	0.091	1.325	0.986

Table 8. Estimation of heterosis in F1 hybrids over better parent of fine rice.

variety	PHT	PL	PW	RPP	SGPP	TGPP	TGW	GL	GB	AC	PTPP	TTPP	DF	DM	YPH
katari × begunbichi	13.58	18.23	-33.61	-12.37	-44.44	-32.61	4.76	3.17	4.36	20	31.91	20	-1.29	0	0.36
ranjit × salna	50.99	11.9	-29.18	8.82	23.2	1.44	-10.03	-23.46	108	-16	5.62	58.09	1.19	1.9	-37.32
ranjit × katari	37.81	18.23	15.07	39.18	233.2	47.8	-13.23	4.77	7.08	-20	3.83	62.43	-1.14	0.24	-24.84

Table 9. Estimation of heterosis in F1 hybrids over mid parent of fine rice.

variety	PHT	PL	PW	RPP	SGPP	TGPP	TGW	GL	GB	AC	PTPP	TTPP	DF	DM	YPH
katari × begunbichi	7.71	1.76	-16.99	-6.55	-17.47	-12.47	2.73	4.09	3.91	50	26.03	22.51	1.01	1.46	1.94
ranjit × salna	30.16	11.81	-10.57	13.11	12.12	-3.08	14.42	-14.77	118.96	-16	2.86	59.37	-0.78	0.12	-27.7
ranjit × katari	19.12	16.83	35.11	40.8	156.11	27.78	9.54	18.69	11.37	-20	0.25	53.57	-2.73	-1.1	-3.54

The plant height of the F_1 (Kataribhog×Begunbichi) hybrid showed positive heterosis (13.58%). peniclewt.racilla per penicle,sterile grain per penicle,total grain per penicle ,days to 50% flowering, had significantly reduced as projected by the negative over better parents (-33.61%, -12.37% , -32.61%, -1.29%) over mid parent (-16.99%, -6.55%,-17.47%, 12.47%, 1.01%) for developing Moreover, this combination showed positive heterosis for productive tillers/hill (26.03%), 1000-grain weight (2.73%) and yield/ha (1.94%) against mid variety, which indicated that the developed hybrid to be a outstanding for commercial utilization. Again, among the two levels of heterosis, the highest positive heterosis of yield against mid parent was estimated.

The F_1 (Ranjit × Kataribhog) hybrid showed negativeheterosis against the days to 50% flowering and aroma content (-2.73% and -20%) over mid parent.Negativeheterosis for earliness was also reported in mid parent. penicle wt.racilla per penicle,sterile grain per penicle,total grain per penicle, 1000 grain wt. productive tiller/plant showed positive heterosis.

The standard heterosis of the F_1 (Ranjit×Salna) hybrid was positive and significant against productive tillers/plant (5.62%) and days to maturity (1.9%). Further, negative significant heterosis against the yield ton/ha (-37.32%) in better parent heterosis

Assessment of aroma from grain

Aroma was emitted from grain, seedling, young leaf, panicle, raw rice and from cooked rice but it was not emitted from root of the cultivars. The aromatic compound, 2AP is volatile in nature, emits continuously and the degree of emission increased with correspondence increase of temperature during cooking. It noted that artificial addition of 2AP either in the field or in raw rice would not produce aroma. However, aroma was assessed from grain. The degree of aroma was assessed through applying a scale.

A panel of four members took aroma by the sensory method. The cultivar, Kalozira scored the highest rank (35%) followed by Kalosoru (30%), Chinigura (30%), Badshabogh (30%), Raghunipagol (30%) and none of the cultivars had low aroma content as denoted by the higher scale (15%-25%). Not only the yield potential but also the aroma content is considered to determine the breeding of aromatic rice. The popularity as well as market demand of aromatic rice cultivars invariably influenced by the grain type and aroma content. Further it may be forwarded that the cultivar, Kalozira with the highest aroma content ought to be directly beneficial to uphold socio-economic scenario of the aromatic rice growers of the country. Again it was of great interest to disseminate the quality seeds of the most desirable cultivars to the farmers. It is well known to everybody that most of the aromatic cultivars are locally adapted due to narrow genetic base, hence hybridization program must be launched among the collected cultivars to evolve the outstanding genotypes suitable to grow over the wide range of environment. The aroma content in different fine rice cultivars is presented in Fig. From the presentation was depicted that none of the cultivar had poor aroma content. Since the aromatic compounds are usually volatile in nature, the emission of aroma in general higher from cooked than aroma emitted from any of the plant parts. Furthermore, it may be stated that there is no suitable aromatic rice variety to cultivate in Boro season, therefore, it is a burning issue to the fine rice breeders to immediately develop new fine rice varieties suitable to cultivate almost around the year.

Conclusion

Consideration of yield potential and aroma content, the combinations, Kataribhog × begunbichi may be advanced into the next generations to evolve high yielding as well as high aroma content fine rice varieties to meet up the demand of the farmers to earn more foreign currency by exporting the excellent quality fine rice.

Acknowledgements

The author extends his sincere appreciations, heartfelt gratitude and immense indebtedness to his reverend teacher Prof. Dr. Bhabendra Kumar Biswas , Department of Genetics and Plant Breeding, and Prof. Dr. Md.Hasanuzzaman, Department of Genetics and Plant Breeding, Hajee Mohammad Danesh Science and Technology University (H.S.T.U.),Dinajpur for their scholastic guidance, constant instructions, keen supervision, critical suggestions, affectionate feelings and endless inspirations throughout the period of the research work as well as during the preparation of the manuscript of this dissertation. The Author is very thankful and gratitude to their beloved parents and wife Nilufa Yasimin Adury.

References

Akhtar N, Nazir MF, Rabnawaz A, Mahmood T, Safdar ME, Asif M, Rehman A. 2011. Estimation of heritability, correlation and path coefficient analysis in fine grain rice (*Oryza sativa* L.). The Journal of Animal & Plant Sciences **21(4),** 660-664.

Comstock RE, Robinson HE. 1952. Genetic parameters, their estimation and significance. Proc. 6th Intercropping. Grassland Cong **1,** 284-291.

El-Namaky RA. 2012. Heterosis and combining ability of some agronomic and physiological characters in rice. Journal of Agriculture Research Kafer El-Sheikh University **38(2),** 266-283.

Gomez KA, Gomez AA. 1984. Statistical Procedures for Agricultural Research, John Willey and Sons, New York, Brisbance. Singapore. pp. 139-142.

Hairmansis AB, Kustianto AK. Supartopo and A. Suwarno.2010.Correlation analysis of agronomic characters and grain yield of rice for tidal swamp areas.Indonesian Journal of Agricultural Science **11(1),** 11-15.

Hien NL, Sarhadi WA, Oikawa Y, Hirata Y. 2007. Genetic diversity of morphological responses and the relationships among aromatic rice (*Oryza sativa* L.) cultivars. Tropics, **16(4),** 343-355.

Hosan SM, Sultana N, Iftekharuddaula, KM, Ahmed MNU, Mia S.2010. Genetic divergence in landraces of Bangladesh rice (*Oryza sativa* L.). The Agriculturists **8(2),** 28-33.

Jayasudha S, Sharma D. 2010.Genetic parameters of variability, correlation and path coefficient for grain yield and physiological traits in rice (*Oryza sativa* L.) under shallow lowland situation. Electronic Journal of Plant Breeding **1(5),** 33-38.

Johnson HW, Robinson HF, Comstock RE. 1955. Estimate of genetic and environmental variability in soybean. Agron. Journal **47,** 314-318.

Khan AS, Imran M, Ashfaq M. 2009. Estimation of genetic variability and correlation for grain yield components in rice (*Oryza sativa*). American-Eurasian Journal of Agricultural and Environmental Science **6(5),** 385-590.

Krishnaveni B, Shobharani N, Ramprasad AS. 2006. Genetic parameters for quality characteristics in aromatic rice. Oryza **43(3),** 234-237.

Laxuman P, Salimath PM, Shashidhar HE, Mohankumar HD, Patil SS, Vamadevaiah HM, Janagoudar BS. 2011. Character association and path coefficient analysis among the backcross inbred lines derived from Indica × Nerica cross for productivity traits in rice (*Oryza sativa* L.). Karnataka Journal of Agricultural Science **24(5),** 626-628.

Makwana BP, Jadeja GC, Patel CG, Patel RM, Gami RA. 2010. Path analysis of qualitative and quantitative characters in slender grain rice (*Oryza sativa* L.). International Journal ofPlant Science **5(1),** 294-296.

Rokonuzzaman M, Zahangir MS, Hussain MI, Hossain MS. 2008. Genotypic variability of the components and their effects on the rice yield: correlation and path analysis study. Italian Journal of Agronomy **2,** 131-134.

Singh RK, Chaudhary BD. 2010. Biometrical Methods in Quantitative Genetic Analysis. Kalyain Publishers, New Delhi, India.

Surek H, Befier N. 2003. Correlation and path coefficient analysis for some yield-related traitsin rice (*Oryza sativa* L.) under thrace conditions**.** Turki J. Agri **27,** 77-83.