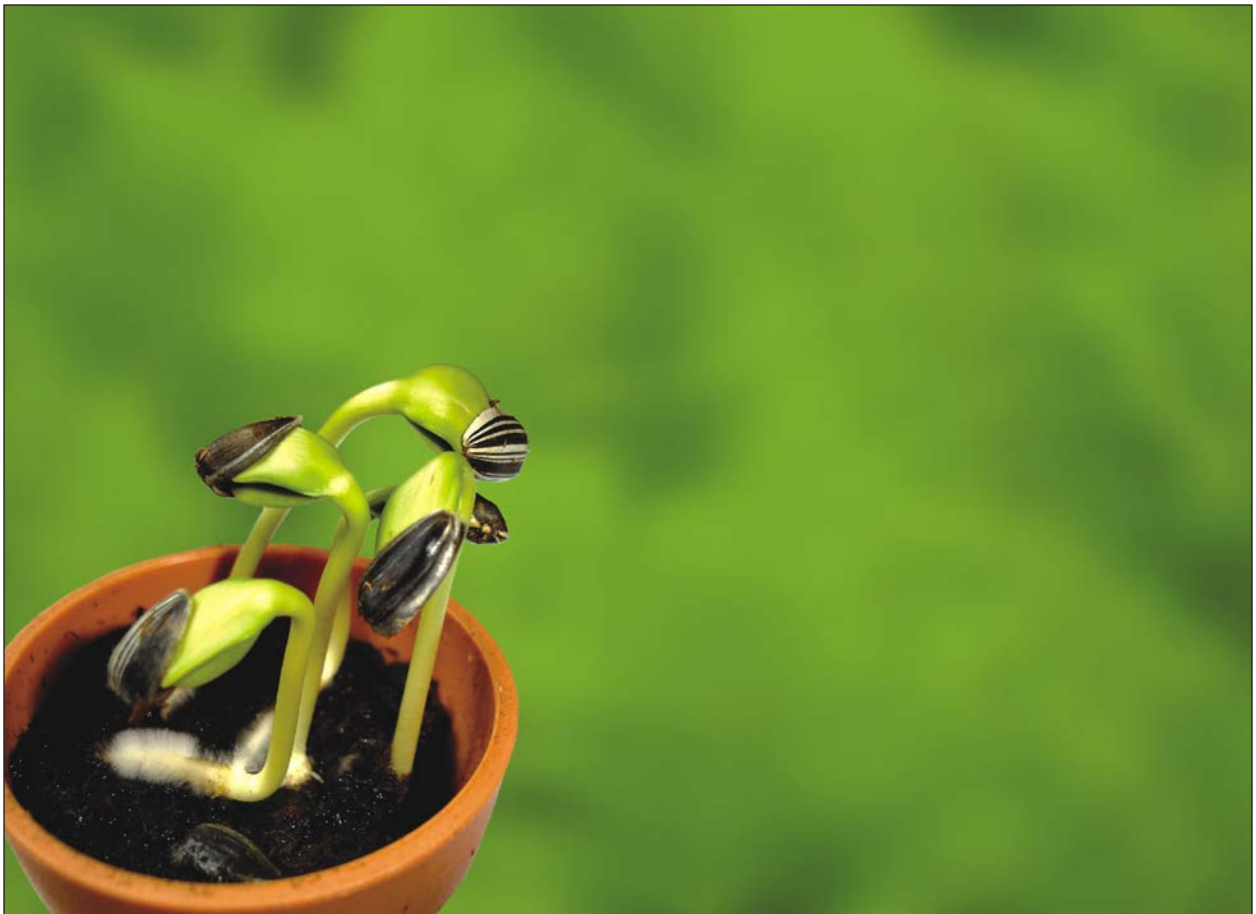

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Interrelationship and Cause-effect Analysis among Morpho-physiological Traits in Biroin Rice of Bangladesh

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ABSTRACT

The aim of this study was to find out genetic variability, interrelationship and cause effect analysis for morpho-physiological traits in Biroin rice varieties. Ten traditional fine Biroin rice cultivars were tested at research plot of Bangladesh Rice Research Institute, Gazipur, Bangladesh in Randomized Complete Block Design (RCBD) with three replications during Transplanting Aman season 2004. Statistically, significant variation was observed among tested materials for all the characters studied. The higher genotypic coefficient of variations was found in case of grains per panicle followed by grain yield/plant, 1000-grain weight and panicles per plant. High heritability was observed for all the tested characters except harvest index. High heritability with high genetic advance in percentage of mean was recorded for the characters grains per panicle, grain yield per plant and 1000-grain weight indicating role of additive gene action in the expression of these traits. Genotypic correlations were higher than the phenotypic correlations in most of the cases. Grains per panicle, panicle length, leaf area index, harvest index and chlorophyll content were the major characters contributing to grain yield as these traits were significantly and positively associated with grain yield per plant. Maximum contribution of more chlorophyll content to grain yield was observed in path analysis, which was followed by higher harvest index and grains per panicle through higher direct effect. Leaf area index, panicle length, days to maturity, grains per panicle, harvest index, 1000-grain weight and plant height had positive but indirect effect on grain yield through chlorophyll content. Similar trends were also observed in harvest index through leaf area index, panicles per plant, days to flowering, grains per panicle, chlorophyll content and panicle length. So for increasing grain yield per plant a Biroin rice cultivar should have more number of grains per panicle, large panicle length, high harvest index, high leaf area index value and more chlorophyll content.

Key words: Genetic variability, heritability, genetic advance, interrelationship, cause-effect analysis

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food crop of more than half of the world's population (Anonymous, 2009). Ninety percent of this crop is grown and consumed in South and South East

Asia, the major centers of the world's population (Nanda, 2002). Most of the consumers, who depend on rice as their primary food, live in less developed countries. Bangladesh is the fourth largest producer and consumer of rice in the world (Bhuiyan *et al*., 2002). In sub continent thousands of locally adapted genotypes of rice have evolved by nature and human (Singh *et al*., 2000), many of which are either fine grain or aromatic types. Biroin is one of the fine grain rice. The information on the quantitative and qualitative traits of Biroin rice varieties is still lacking in Bangladesh and may have some special characteristics to be essential for future breeding program. As these genotypes are traditional and low yielder so the yield performances of these genotypes need to be improved. For successful utilization of Biroin rice genotypes in yield improvement-breeding programs, selection criteria of these genotypes need to be found out. The progress in breeding for yield and its contributing characters of any crop is polygenic controlled, environmentally influenced and determined by the magnitude and nature of their genetic variability in which they grown (Falconer and Mackay, 1996; Singh *et al*., 2000). Genetic variability, interrelationship and cause effect 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). It is very difficult to judge whether observed variability is highly heritable or not. Moreover, knowledge of heritability is essential for selection based improvement as it indicates the extent of transmissibility of a character into future generations. The knowledge of association i.e., genotypic and phenotypic correlation between yield and its component characters is essential for yield improvement through selection programmes (Ismail *et al*., 2001; Kumar and Sukla, 2002). Cause-effect analysis provides an effective means of partitioning the correlation coefficients into direct and indirect effects of the component characters on yield on the basis of which crop improvement programmes can be logically devised (Kozak *et al*., 2007). Any successful hybridization program for varietals improvement depends mainly on the selection of parents having high genetic variability so that desired character (s) combinations may be selected to improve grain quality and higher grain yield. Keeping in view the above facts, the present study was undertaken to find out genetic variability, interrelationship and selection criteria for yield and yield components in traditional Biroin rice of Bangladesh.

MATERIALS AND METHODS

The experiment was conducted at Bangladesh Rice Research Institute, Gazipur, Bangladesh during T. Aman season, 2004. The trail consisted of 10 local Biroin rice varieties collected from Sylhet and greater Mymensingh region of Bangladesh. The trail was set in a Randomized Complete Block Design (RCBD) with three replications. Thirty-five days old seedlings grown in wet seedbed were transplanted in 3.4×2.4 m^{-2} plots with a spacing of 20×25 cm, using single seedling per hill. Fertilizers were applied @ 60:40:40 kg NPK ha^{-1}. All other recommended nutrients were applied except nitrogen at final land preparation. Nitrogen was applied in three equal splits, at 15 Days After Transplanting (DAT), 45 DAT and just before panicle initiation. Intercultural operations and pest control measures were employed as when necessary during whole growing period. Leaf chlorophyll content and leaf area for calculating leaf area index were measured by using Japanese SPAD and leaf area meter, respectively. At maturity, grain yield was taken excluding border area and yield was adjusted at 14% moisture level. Data were recorded on ten characters, viz., plant height in cm (Ph), Days to Maturity (DM), Panicles per plant (PN), Harvest Index (HI), leaf area index in cm^{-2} (LAI), Chlorophyll content (CHL) and Grain Yield in g (GY) from ten randomly selected plants from each plot. Again panicle characters viz., Panicle Length in cm (PL), Grains per panicle (GN), 1000-grain weight in g (GW) were recorded from 10 randomly selected panicles at maturity stage from each plot.

The analysis of variance was done according to the MSTAT C software. The components of variance including error variance (σ^2_e) genotypic variance (σ^2_g) and phenotypic variance (σ^2_p) were estimated, according to the following formula:

$$\sigma^2_e = M_e$$

$$\sigma^2_g = (M_g - M_e)/r$$

$$\sigma^2_p = \sigma^2_g + \sigma^2_e$$

Heritability (h^2) was studied based on formula (σ^2_g/σ^2_p) stated by Singh and Ceccarelli (1996). The coefficient of genotypic and phenotypic variation was evaluated according to Burton's formula (Burton, 1952) as the square root of σ^2_g and σ^2_p divided by the mean and converted into percentage, and the genetic advanced was estimated based on formula of GA = (k) (h^2) ($\sqrt{\sigma^2_p}$). Here 2.06 values for k, was used to obtain the GA. The phenotypic and genotypic correlation between variable x and y ($r_{(xy)p}$ and $r_{(xy)g}$), were also estimated by following formula:

$$r(xy)p = \frac{Cov_{(x,y)p}}{\sqrt{\sigma^2_{(x)p}\,\sigma^2_{(y)p}}}$$

$$r(xy)g = \frac{Cov_{(x,y)g}}{\sqrt{\sigma^2_{(x)g}\,\sigma^2_{(y)g}}}$$

Where, $Cov_{(x,y)p}$ and $Cov_{(x,y)g}$ are phenotypic and genotypic covariance between variable x and y respectively. Finally the cause effect analysis i.e., path analysis was done to partition the correlation coefficients of independent variable with the dependent variable into direct and indirect effects using following formula described in Fig. 1 and Table 1.

In Fig. 1 and Table 1 nine independent (cause) variables were: 1) Plant height, 2) days to flowering, 3) panicles per plant, 4) panicle length, 5) grains per panicle, 6) 1000-grain weight, 7) harvest index, 8) leaf area index and 9) chlorophyll content and dependent (effect) variable was 8) grain yield per plant.

RESULTS

The analysis of variance revealed highly significant variations among the varieties for all the characters studied (Table 2), indicated presence of variation for all the characters among the population. The phenotypic variance was partitioned into genotypic and environmental variances for a clear understanding of the pattern of variations.

The highest genotypic, phenotypic and environmental variance was found in grains per panicle. The lowest magnitude of genotypic, environmental and phenotypic variance was recorded in harvest index.

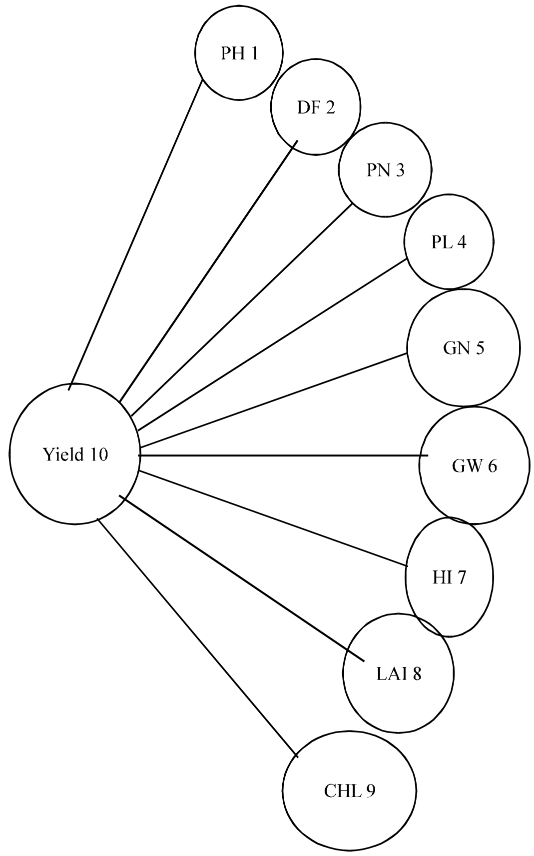

Fig. 1: Diagrammatic sketch of ten characters of bironi rice varieties are showing dependent (left) and independent (right) variables

Table 1: Symbolic formula of total effect i.e. total correlation direct and indirect effect

Total correlation	Direct effect	Indirect effect
r_{110}	P_{110}	$r_{12}P_{210} + r_{13}P_{310} + r_{14}P_{410} + r_{15}P_{510} + r_{16}P_{610} + r_{17}P_{710} + r_{18}P_{810} + r_{19}P_{910}$
r_{210}	P_{210}	$r_{12}P_{110} + r_{23}P_{310} + r_{24}P_{410} + r_{25}P_{510} + r_{26}P_{610} + r_{27}P_{710} + r_{28}P_{810} + r_{29}P_{910}$
r_{310}	P_{310}	$r_{13}P_{110} + r_{23}P_{210} + r_{34}P_{410} + r_{35}P_{510} + r_{36}P_{610} + r_{37}P_{710} + r_{38}P_{810} + r_{39}P_{910}$
r_{410}	P_{410}	$r_{14}P_{110} + r_{24}P_{210} + r_{34}P_{310} + r_{45}P_{510} + r_{46}P_{610} + r_{47}P_{710} + r_{48}P_{810} + r_{49}P_{910}$
r_{510}	P_{510}	$r_{15}P_{110} + r_{25}P_{210} + r_{35}P_{310} + r_{45}P_{410} + r_{56}P_{610} + r_{57}P_{710} + r_{58}P_{810} + r_{59}P_{910}$
r_{610}	P_{610}	$r_{16}P_{110} + r_{26}P_{210} + r_{36}P_{310} + r_{46}P_{410} + r_{56}P_{510} + r_{67}P_{710} + r_{68}P_{810} + r_{69}P_{910}$
r_{710}	P_{710}	$r_{17}P_{110} + r_{27}P_{210} + r_{37}P_{310} + r_{47}P_{410} + r_{57}P_{510} + r_{67}P_{610} + r_{78}P_{810} + r_{79}P_{910}$
r_{810}	P_{810}	$r_{18}P_{110} + r_{28}P_{210} + r_{38}P_{310} + r_{48}P_{410} + r_{58}P_{510} + r_{68}P_{610} + r_{78}P_{710} + r_{89}P_{910}$
r_{910}	P_{910}	$r_{19}P_{110} + r_{29}P_{210} + r_{39}P_{310} + r_{49}P_{410} + r_{59}P_{510} + r_{69}P_{610} + r_{79}P_{710} + r_{89}P_{810}$

The highest GCV and PCV were obtained from grains per panicle (20.45 and 21.89) followed by grain yield per plant (15.27 and 16.70), 1000-grain weight (14.42 and 15.68) and panicles per plants (10.10 and 10.85), indicated presence of high variation and role of environment on the expression of these traits.

The estimates of heritability were varied from 40.90 to 95.89 % (Table 2). Days to flowering exhibited high heritability (95.89%) followed by plant height (92.92%), grains per panicle (87.28%), panicles per plant (86.70%), 1000-grain weight (84.61%) and grain yield per plant (83.56%).

Table 2: Estimation of statistical and genetical parameters of morpho-physiological characters for different genotypes of biroin rice

Parameters	PH (cm)	DF	PN	PL (cm)	GN	GW (g)	HI	LAI (cm^2)	CHL	GY (g)
Mean	124.198	110.779	11.38	24.342	97.462	20.035	0.292	0.972	40.383	19.163
Range	116.8-	103.0-	9.333-	23.56-	60.50-	13.49-	0.230-	0.863-	39.78-	15.70-
	133.9	114.9	13.17	25.15	118.7	23.97	0.336	1.140	41.95	23.90
MS	59.82**	43.59**	4.169**	0.680**	1249.20**	26.556**	0.003*	0.025**	1.295**	27.37**
σ^2p	20.93	14.94	1.52	0.31	454.99	9.86	0.000	0.01	0.56	10.24
σ^2g	19.45	14.32	1.32	0.19	397.11	8.35	0.000	0.01	0.37	8.56
σ^2e	1.48	0.61	0.20	0.12	57.88	1.52	0.000	0.01	0.19	1.68
H^{2}b (%)	92.92	95.89	86.70	59.85	87.28	84.61	40.90	50.05	65.97	83.56
GA (5%)	8.76	7.63	2.21	0.69	38.35	5.47	0.03	0.12	1.02	5.51
GA (% of mean)	7.05	6.89	19.38	2.82	39.35	27.32	11.87	11.87	2.51	28.75
PCV	3.68	3.49	10.85	2.29	21.89	15.68	14.09	11.51	1.85	16.70
GCV	3.55	3.42	10.10	1.77	20.45	14.42	9.01	8.14	1.50	15.27
ECV	0.98	0.71	3.96	1.45	7.81	6.15	10.83	8.13	1.08	6.77

** Significant at 1% level of probability, * Significant at 5% level of probability. MS: Mean square, σ^2p: Phenotypic variance, σ^2g: Genotypic variance, σ^2e: Environmental variance, PCV: Phenotypic coefficient of variation, GCV: Genotypic coefficient of variation, ECV: Environmental coefficient of variation, GA: Genetic advance, PH: Plant height (cm), DF: Days to flowering, PN: Panicles per plant, PL: Panicle length (cm), GN: Grains per panicle, GW: 1000-grain weight (g), HI: Harvest index, LAI: Leaf area index (cm^2), CHL: Chlorophyll content, GY: Grain yield/plant (g)

Table 3: Correlation coefficients among different pairs of morpho-physiological characters for different genotypes of biroin rice

Characters		DF	PN	PL (cm)	GN	GW (g)	HI	LAI (cm^2)	CHL	GY (g)
PH (cm)	G	-0.303	-0.459*	-0.003	0.237	0.530**	-0.392*	-0.188	0.217	0.251
	P	-0.287	-0.435*	0.049	0.180	0.467**	-0.227	-0.131	0.172	0.266
DF	G		-0.003	-0.289	-0.042	-0.049	0.554**	0.541**	0.534**	0.025
	P		-0.007	-0.210	-0.020	-0.051	0.386*	0.288	0.399**	0.058
PN	G			0.070	0.161	-0.431*	0.771**	0.046	-0.262	0.204
	P			-0.007	0.136	-0.369*	0.376*	-0.033	-0.238	0.136
PL	G				0.544**	-0.228	0.129	0.610**	0.495**	0.740**
	P				0.401*	-0.066	0.240	0.213	0.264	0.579**
GN	G					-0.592**	0.487**	0.522**	0.330	0.855**
	P					-0.463**	0.293	0.296	0.186	0.709**
GW	G						-0.636**	-0.102	0.419*	-0.157
	P						-0.378*	-0.110	0.266	-0.142
HI	G							0.823**	0.373*	0.477**
	P							0.248	-0.047	0.481**
LAI	G								0.728**	0.791**
	P								0.536**	0.399*
CHL	G									0.753**
	P									0.536**

**Significant at 1% level of probability, * Significant at 5% level of probability. G: Genotypic correlation, P: Phenotypic correlation DF: Days to flowering, PL: Panicle length (cm), PN: Panicle per plant, GN: Grains per panicle, GW: 1000-grain weight, HI: Harvest index, LAI: Leaf area index (cm^2), CHL: Chlorophyll content

Accordingly, high genetic advance in percent of mean exhibited by grains per panicle (39.35) which followed by grain yield per plant (28.75) and 1000-grain weight (27.32). High heritability associated with high genetic advance percent of mean obtained in grains per panicle, 1000-grain weight and grain yield per plant.

Table 4: Path coefficient showing direct and indirect effects of morpho-physiological characters on grain yield of boroin rice

		Indirect effects									Genotypic correlation
Characters	Direct effects	PH (cm)	DF	PN	PL (cm)	GN	GW (g)	HI	LAI (cm^2)	CHL	with yield
PH	-0.553	-	0.495	0.276	0.002	0.097	-0.035	-0.488	0.092	0.365	0.251
DF	-1.634	0.167	-	0.002	0.181	-0.017	0.003	0.689	-0.263	0.897	0.025
PN	-0.602	0.254	0.005	-	-0.004	0.066	0.028	0.959	-0.022	-0.440	0.204
PL	-0.627	0.002	0.472	-0.042	-	0.224	0.015	0.161	-0.297	0.833	0.740**
GN	0.411	-0.131	0.069	-0.097	-0.341	-	0.039	0.605	-0.254	0.554	0.855**
GW	-0.065	-0.293	0.080	0.259	0.143	-0.243	-	-0.791	0.049	0.704	-0.157
HI	1.244	0.217	-0.905	-0.464	-0.081	0.200	0.042	-	-0.401	0.627	0.477**
LAI	-0.487	0.104	-0.884	-0.028	-0.382	0.214	0.007	1.023	-	1.224	0.791**
CHL	1.681	-0.120	-0.872	0.158	-0.311	0.135	-0.027	0.464	-0.355	-	0.753**

Residual effect, R = 0.2658 ** Significant at 1% level of probability, * Significant at 5% level of probability. DF: Days to flowering, PL: Panicle length (cm), PN: Panicle per panicle, GN: Grains per panicle, GW: 1000-grain weight, HI: Harvest index, LAI: Leaf area index (cm^2), CHL: Chlorophyll content

Genotypic and phenotypic correlation coefficients studied (Table 3) among yield and yield contributing morpho-physiological traits of Biroin rice revealed that panicle length, grains per panicle, harvest index, leaf area index and chlorophyll content exhibited significant and positive association with grain yield per plant. On the contrary, 1000-grain weight exhibited negative association with grain yield per plant.

From the path analysis (Table 4) it was revealed that trait chlorophyll content (1.681) exhibited maximum positive direct effect on grain yield followed by harvest index (1.244) and filled grains per panicle (0.411).

DISCUSSION

The analysis of variance revealed highly significant variations among the varieties for all the characters studied, indicated presence of variation for all the characters among the population. High genetic variability for different quantitative traits in rice was also reported earlier by Umadevi *et al.* (2009), Akter *et al.* (2004), Hossain and Haque (2003) and Pandey and Awasthi (2002). Genotypic and phenotypic coefficient of variation indicated that the magnitude of GCV and PCV was highest in case of grains per panicle followed by grain yield per plant, 1000-grain weight and panicles per plant, indicated presence of high variation and role of environment on the expression of these traits. The magnitudinal differences were medium to low in GCV and PCV for Plant height, days to flowering, panicle length and chlorophyll content suggesting the little role of environment in the expression of these characters. These findings were in agreement with the findings of Pushpa *et al.* (1999), Venkataramana *et al.* (1999), Kumar *et al.* (1998) and Kaw *et al.* (1999).

Plant height, days to flowering, panicles per plant, grains per panicle, 1000-grain weight and harvest index exhibited high heritability supported these with the findings of Iftekharudduaula *et al.* (2001) and Karthikeyan *et al.* (2010). High heritability have been found to be effective in the selection of superior genotypes on the basis of phenotypic performance. High heritability associated with high genetic advance percent of mean obtained in grains per panicle that was supported by Bagheri *et al.* (2008) and grain yield per plant that supported by Manickavelu *et al.* (2006). 1000-grain weight and grain yield per plant also showed high heritability and high genetic advance percent of mean were in agreement with the results of

Chaudhury and Das (1998) and Shanthi and Singh (2001). High heritability along with low genetic advance indicates non-additive type of gene action and genotype-environment interaction plays a significant role in the expression of the trait as observed in days to flowering. Grains per panicle, 1000-grain weight and grain yield per plant had high heritability with high genetic advance in percentage of mean made these three characters most effective in the selection of best Biroin rice varieties. High GCV, PCV, heritability and GA% mean of grains per panicle and grain yield per plant suggested that these two characters could be transmitted to the progeny when hybridization would be conducted and phenotypic based selection on these would be effective.

The correlation coefficient showed grains per panicle serve as most important selection indices of grain yield. Meenakshi *et al.* (1999) and Mustafa and Elsheikh (2007), Janardhanam *et al.* (2001), Rao and Saxena (1999), Ray and Debi (1999) and Pushpa *et al.* (1999) emphasized the importance of grains per panicle in determining grain yield in rice. Chakraborty and Chakraborty (2010), Hossain and Haque (2003), Singh *et al.* (2002) and Biswas *et al.* (2000) reported positive significant association of panicle length with grain yield per plant. Kole *et al.* (2008), Jayasudha and Sharma (2010) and Saif-ur-Rasheed *et al.* (2002) in rice and Kotal *el al.* (2010) in wheat reported similar finding that is harvest index exhibited significant and positive association with grain yield per plant. Chlorophyll content revealed significant positive correlation with yield which was supported the results of Poshtmasari *et al.* (2007).

Chlorophyll content exerted highest direct effect on grain yield reported by Akter *et al.* (2004) in rice. This indicates that more chlorophyll content of leaf of plant is highly reliable component on grain yield by supporting in photosynthesis.

Another important character with high direct effect on seed yield is harvest index showed positive direct effect on seed yield, which were earlier reported by Jayasudha and Sharma (2010), Iftekharudduaula *et al.* (2001) and Surek *et al.* (1998). Data analysis revealed that grains per panicle had the highest genotypic correlation coefficient and accordingly chlorophyll content had the maximum direct effect on grain. Hence, grains per panicle and chlorophyll content should be given prior attention in Biroin rice improvement programme because of their major influence on yield. The residual effect was 0.2658, indicated that the contribution of component characters on grain yield was 73.5% by the ten characters studied in path analysis, the rest 26.5% was the contribution of other factors such as characters not studied and sampling error.

CONCLUSION

From this study it is clearly observed that grains per panicle, panicle length, leaf area index, harvest index and chlorophyll content appeared most yield contributing characters for local Biroin rice. Further study with different Biroin rice varieties of Bangladesh may help confirmation of this study as well as genetic improvement for yield potentiality of local Biroin rice.

REFERENCES

Akter, K., K.M. Iftekharuddaula, M.K. Bashar, M.H. Kabir and M.Z.A. Sarker, 2004. Genetic variability, correlation and path analysis in irrigated hybrid rice. J. Subtrop. Agric. Res. Dev., 2: 17-23.

Anonymous, 2009. Annual report for 2008. IRRI, Los Banos, Philippines.

Bagheri, N., N.B. Jelodar and A. Ghanbari, 2008. Diallel analysis study of yield and yield-related traits in rice genotypes. Int. J. Agric. Res., 3: 386-396.

Bhuiyan, N.I., D.N.R. Paul and M.A. Jabber, 2002. Feeding the extra millions by 2025-challenges for rice research and extension in Bangladesh. Proceedings of the National Workshop on Rice Research and Extension, 2002, Jan. 29-31, Bangladesh Rice Research Institute, Joydebpur, pp: 9-9.

Biswas, P.S., B. Prasad and S.B.A. Dewan, 2000. Variability, character association and path analysis in rice (*Oryza sativa* L.). Bangladesh J. Plant Breed. Genet., 13: 19-25.

Burton, G.W., 1952. Quantitative inheritance in grasses. National Publishing Co., Washington D.C., New York, pp: 277-283.

Chakraborty, R. and S. Chakraborty, 2010. Genetic variability and correlation of some morphometric traits with grain yield in bold grained rice (*Oryza sativa* L.) gene pool of Barak valley. American-Eurasian J. Sustainable Agric., 4: 26-29.

Chaudhury, P.K.D. and P.K. Das, 1998. Genetic variability, correlation and path coefficient analysis in deep water rice. Ann. Agric. Res., 19: 120-124.

Falconer, D.S. and T.F.C. Mackay, 1996. Introduction to Quantitative Genetics. 4th Edn., Benjamin Cummings, England, ISBN-10: 0582243025.

Hossain, M.A. and M.H. Haque, 2003. Genetic variability and path analysis in rice genotypes. Bangladesh J. Pl. Breed. Genet., 16: 33-37.

Iftekharudduaula, K.M., M.A. Badshah, M.S. Hossain, M.K. Basher and Akter Khaleda, 2001. Genetic variability, character association and path analysis of yield components in irrigated rice (*Oryza sativa* L.). Bangladesh J. Pl. Breed. Genet., 14: 43-49.

Ismail, A.A., M.A. Khalifa and K.A. Hamam, 2001. Genetic studies on some yield traits of durum wheat. Asian J. Agric. Sci., 32: 103-120.

Janardhanam, V., N. Nadarajan and S. Jebaraj, 2001. Correlation and Path analysis in rice (*Oryza sativa* L.). Madras Agric. J., 88: 719-720.

Jayasudha, S. and D. Sharma, 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 J. Plant Breed., 1: 1332-1338.

Karthikeyan, P., Y. Anbuselvam, R. Elangaimannan and M. Venkatesan, 2010. Variability and heritability studies in rice (*Oryza sativa* L.) under coastal salinity. Electronic J. Plant Breed., 1: 196-198.

Kaw, R.N., R.C. Aquino, H.P Moon, J.D. Yae and N. Haq, 1999. Variability and interrelations in rice under cold stress environment. Oryza, 36: 1-4.

Kole, P.C., N.R Chakraborty and J.S. Bhat, 2008. Analysis of variability, correlation and path coefficients in induced mutants of aromatic non-basmati rice. Tropic. Agric. research and extension, 11. http://www.sljol.info/index.php/TARE/article/view/1791.

Kotal, B.D., A. Das and B.K. Choudhury, 2010. Genetic variability and association of characters in wheat (*Triticum aestivum* L.). Asian J. Crop Sci., 2: 155-160.

Kozak, M., K.P. Singh, M.R. Verma and D.K. Hore, 2007. Causal mechanism for determination of grain yield and milling quality of lowland rice. Field Crops Res., 102: 178-184.

Krishnaveni, B., N. Shobharani and A.S. Ramprasad, 2006. Genetic parameters for quality characteristics in aromatic rice. Oryza, 43: 234-237.

Kumar, G.S., M. Mahadevappa and M. Rudradhya, 1998. Studies on genetic variability, correlation and path analysis in rice during winter across the locations. Karnataka J. Agric. Sci., 11: 73-77.

Kumar, P. and R.S. Shukla, 2002. Genetic analysis for yield and its attributed traits in bread wheat under various situation. JNKVV Res. J., 36: 95-97.

Manickavelu, A., R.P. Gnanamalar, N. Nadarajan and S.K. Ganesh, 2006. Genetic variability studies on different genetic populations of rice under drought condition. J. Plant Sci., 1: 332-339.

Meenakshi, T., A.A.D. Ratinam and S. Backiyarani, 1999. Correlation and path analysis of yield and some physiological characters in rain fed rice. Oryza, 6: 154-156.

Mustafa, M.A. and M.A.Y. Elsheikh, 2007. Variability, correlation and path co-efficient analysis for yield and its components in rice. Afr. Crop Sci. J., 15: 183-189.

Nanda, J.S., 2002. Rice Breeding and Genetics: Research Priorities and Challenges. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, pp: 1-15.

Pandey, V.K. and L.P. Awasthi, 2002. Studies on genetic variability for yield contributing traits in aromatic rice. Crop Res., 23: 214-218.

Poshtmasari, H.K., H. Pirdashti, M. Nasiri and M.A. Bahmanyar, 2007. Chlorophyll content and biological yield of modern and old rice cultivars in different urea fertilizer rates and applications. Asian J. Plant Sci., 6: 177-180.

Pushpa, K., D.N. Singh, M.P. Singh, M.F. Haque and P. Kumari, 1999. Genetic variability in gora rice (*Oryza sativa* L.). J. Res., 11: 23-26.

Rao, S.S. and R.R. Saxena, 1999. Correlation and regression analysis in upland rice. Oryza, 36: 82-84.

Ray, P.K.S. and B.P. Debi, 1999. Correlation response and path analysis in irrigated rice and their implication in selection. J. Bio-Sci., 7: 99-101.

Saif-ur-Rasheed, M., H.A. Sadaqat and M. Babar, 2002. Correlation and path co-efficient analysis for yield and its components in rice (*Oryza sativa* L.). Asian J. Plant Sci., 1: 241-244.

Shanthi, P. and J. Singh, 2001. Variability studies in induced mutants of Mahsuri rice (*Oryza sativa* L.). Madras Agric. J., 88: 707-709.

Singh M. and S. Ceccarelli, 1996. Estimation of heritability of crop traits from variety trial data. Technical Manual International Center for Agricultural Research in the Dry Areas, Aleppo, Syria, pp: 21.

Singh, R.K., P.L. Gautam, S. Saxena and S. Singh, 2000. Scented Rice Germplasm: Consevation, Evaluation and Utilization. In: Aromatic Rices, Singh, R.K., U.S. Singh and G.S. Khush (Eds.). Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, pp: 107-133.

Singh, L., J.D. Singh, and N.S. Sachan, 2002. Intercharacter association and path analysis in paddy (*Oryza sativa* L.). Annals Biol., 18: 125-128.

Surek, H., Z.K. Korkut and O. Bilgin, 1998. Correlation and path analysis for yield and yield components in rice in a 8-parent half diallel set of crosses. Oryza, 35: 15-18.

Umadevi, M., P. Veerabadhiran and S. Manonmani, 2009. Genetic variability, heritability, genetic advance and correlation for morphological traits in rice genotypes. Madras Agric. J., 96: 316-318.

Venkataramana, P., Shailaja Hittalmani and S. Hittalamani, 1999. Genetic variability on some important trits in two F2 segregants of rice (*Oryza sativa* L.) under non-submergence condition. Crop Res. Hisar., 18: 53-56.