Phenotypic and genotypic correlation co-efficient of quantitative characters and character association of aromatic rice

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Abstract

An experiment was conducted in research fields under the Department of Genetics and Plant Breeding of Bangabandhu Sheikh Mujibur Rahman Agricultural University in Bangladesh to study Phenotypic and genotypic correlation co-efficient of quantitative characters and character association of aromatic rice. Forty-one aromatic rice germplasm of diverse sources were used to assess the character association and contribution of characters towards grain yield. Path coefficient analyses were carried out for selected genotypes and to find out the direct and indirect effect of component characters on grain yield. Analysis of phenotypic and genotypic correlation co-efficient of quantitative characters and partitioning of genotypic correlation to grain revealed that the correlation coefficients of grain yield per hill with 1000-grain weight and harvest index were positive and highly significant. Spikelet sterility showed highly significant negative correlation with grain yield at genotypic level only. The parameter 1000-grain weight showed the highest positive direct effect on grain yield. Panicle length and spikelet sterility showed negative negligible direct effect. The highest positive indirect effect was observed for 1000-grain weight via plant height and the highest negative indirect effect for 1000-grain weight via number of filled grains per panicle. Data of this study might be useful for quantitative assessment of the variation in yield and yield components, their interrelationship, and direct and indirect effects of different characters on grain yield of aromatic rice.

Keywords: Rice, Phenotypic coefficient, genotypic coefficient Correlation, Grain Yield

Introduction

Rice production in Bangladesh has almost doubled during the past three decades (BRRI, 2014). But we can’t export the coarse rice after fulfillment of the demand due to high competition with other quality rice growing countries (Chowdhury, 1991). Breeding strategies, therefore, should be focused on to produce fine aromatic rice. Rice breeders of Bangladesh Rice Research Institute (BRRI), as well as national policy makers has given emphasis on fine and aromatic rice production. Aromatic rice has long been popular in the continent, and is now becoming more popular in Middle East, Europe and United States. There is a great opportunity to earn foreign currency by exporting aromatic rice, as the consumption area of aromatic rice throughout the world is large and price would be also high (Chowdhury and Bhuiyan, 1991). Furthermore, consumers in urban areas in our country also prefer fine and aromatic rice. Most of the aromatic rice germplasm that are available in Bangladesh are low yielding, photoperiod sensitive and are grown during Aman season (Transplanted rice) in the rain fed low land ecosystem (Begum et al., 1993). Therefore, attention should be given for breeding high yielding quality aromatic rice varieties.

Measurement of correlation coefficient helps identify the relative contribution of component characters towards yield (Panse, 1957). Moreover, the correlation between grain yield and a component character may sometimes be misleading due to an over estimation or underestimation for its association with other characters. Thus, yield components have influence on ultimate yield both directly and indirectly (Tukey, 1954). Splitting of total correlation into direct and indirect effects, therefore, would provide a more meaningful interpretation of such association. Path coefficient, which is a standard partial regression coefficient, specifies the cause and effect relationship and measures the relative importance of each variable (Wright, 1921). Therefore, correlation in combination with path coefficient analysis will be an important tool to find out the association and quantify the direct and indirect influence of one character upon another (Dewey and Lu, 1959). Considering the above facts the present study has been undertaken with the following objectives: **a)** to assess the character association and contribution of characters towards grain yield of selected genotypes, and **b)** to find out the direct and indirect effect of component characters on grain yield with the help of path coefficient analysis.

Materials and Method

The experiment was conducted in the field under the Department of Genetics and Plant Breeding of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur-1706, Bangladesh, during July to November 2003. The experimental field was typically rice growing low land. The location of the experimental site was at 24^0 09′ N latitude and 90^o 26′ E longitude with an elevation of 8.4 m from the mean sea level. The soil of the experimental field was Red Brown Terrace type under Salna soil series of the Madhupur Tract within Agro Ecological Zone (AEZ) 28. The experimental site is characterized by heavy rainfall during June to September and scanty rainfall during rest of the year. Forty-one aromatic rice germplasm of diverse sources were used in this experiment are shown below and further classified by Karim et al. (2007). The experiment was conducted using Randomized Complete Block Design (RCBD) with three replications. Two lines of 3 m long were constituted as experimental unit. Single seedling/hill was transplanted maintaining 20 cm × 20 cm spacing from row to row and plant to plant, respectively. Urea, TSP, MP and Gypsum were applied @ 150-100-70-60/h respectively as per recommendation for rice cultivation by Bangladesh Rice Research Institute (BRRI). The experimental crops were harvested plot wise at maturity. The harvested crops were threshed, cleaned and processed. Necessary data were collected on various crop characters. Data were collected from 10 randomly selected hills from the middle of the paired rows in order to avoid border effects. The following characters were studied: i) Days to maturity, i) Plant height (cm), iii) Number of panicles per hill, vi) Panicle length (cm), v) Number of primary branches per panicle, vi) No. of filled grains per panicle, vii) Spikelet sterility (%), viii) 1000-grain weight (g), ix) Grain yield per hill (g) and x) Harvest index.

The aromatic rice germplasm from diverse sources which are used for this experiment are: Chinikamini (990), Maloti (494), Buchi (516), Kalijira-5(2493), Khasha(2493), Kalijira-8 (2498), Kalijira-11(2501), Badshabhog-6(2485), Ovaltapi-600(2990), Badshabhog-1(2491), Duksail (2022), Saibail(873), Badshabhog-7(2486), Kalijira-6(2494), Kalijira (3)-4(2463), Awned-2(2940), Radhunipagal(2504), Badshabhog-10(2490), Kalgochi(956), Rajbhog(865), Jirabhog(finer)(4831), Sorukamini(2015), Keora(527), Badshabhog-8(2487), Kalijira-13(4814), Badshabhog-4(2481), Benaful(981), Kalijira-9(2499), Kalijira-12(4755), Dakshahi(983), Badshabhog (colored)(4355), Kataribhog(1215), Kaminisaru(2010), Badshabhog-9(2489), Thakurbhog(872), Kalijira-14(4832), Badshabhog-5(2482), Kalijira-10(2500), Chinisakkor(712), Kalijira-7(2497) and Agali (2009). Number in parenthesis is Bangladesh Rice Research Institute accession number.

Statistical analysis

All data obtained for each character were subjected for the analysis of variance. Mean (8), range and standard deviation (σ_x) for each character were also estimated. The mean sum of square (MS) of error and phenotypic variances were estimated followed by Johnson *et al*. (1955). The error mean sum of square was considered as error variance (σ^2e). Genotypic variances (σ^2g) were divided by subtracting error mean sum of square from the variety mean sum of square and dividing by number of replications Genotypic and phenotypic coefficient of variation were calculated by the formula suggested by Burton (1952). Broad sense heritability was estimated (defined by Lush 1949) by the formula suggested by Johnson *et al*. (1955), Hanson *et al*. (1956). The expected genetic advance for different characters under selection was estimated using the formula suggested by Lush (1949) and Johnson *et al*. (1955). Genetic advance in percentage of mean was calculated from the formula given by Comstock and Robinson (1952). These results arrived by these formulae were published and further described by Karim et al. (2007).

Here are the formulas used for this investigation and results are published by Karim et al. (2007):

Genotypic variance calculation:

$$(\sigma^2g) = \frac{GMS - EMS}{r}$$

Where,

GMS and EMS = Varietals and error mean sum of square and

r = Number of replication

The phenotypic variances (σ^2p), were derived by adding genotypic variances with the error variances (σ^2e), as given by the following formula,

$$(\sigma^2p) = (\sigma^2g) + (\sigma^2e)$$

Genotypic and phenotypic coefficient of variation were calculated by the formula suggested by Burton (1952) as,

$$\text{Genotypic coefficient of variation (GCV)} = \frac{\sigma_g \times 100}{8}$$

Where,

σ_g = Genotypic standard deviation

8 = Population mean

Similarly, the phenotypic coefficient of variation was calculated from the following formula,

$$\text{Phenotypic coefficient of variation (PCV)} = \frac{\sigma_p \times 100}{8}$$

Where,

σ_p = Phenotypic standard deviation

8 = Population mean

Broad sense heritability was estimated (defined by Lush 1949) by the formula suggested by Johnson *et al*. (1955), Hanson *et al*. (1956).

$$\% h^2_b = \frac{\sigma^2g}{\sigma^2p} \times 100$$

Where, h^2_b = Heritability

σ^2g = Genotypic variance

σ^2p = Phenotypic variance

The expected genetic advance for different characters under selection was estimated using the formula suggested by Lush (1949) and Johnson *et al*. (1955).

$$\text{Genetic advance (G.A.)} = \frac{\sigma^2g}{\sigma^2p} \times k \times \sigma_p$$

Where,

k = Selection differential, the value of which is 2.06 at 5 % selection intensity
σ_p = Phenotypic standard deviation

Genetic advance in percentage of mean was calculated from the formula given by Comstock and Robinson (1952).

$$\text{Genetic advance in percentage of mean} = \frac{\text{Genetic advance}}{\text{Population mean}} \times 100$$

Estimation of genotypic and phenotypic correlation co-efficient: For calculating the genotypic and phenotypic correlation coefficient for all possible combinations the formula suggested by Miller *et al.* (1958), Hanson *et al.* (1956) and Johnson *et al*. (1955) were adopted. The genotypic co-variance components between two traits and the phenotypic co-variance component were derived in the same way as for the corresponding variance components. These co-variance components were used to compute genotypic and phenotypic correlation between the pairs of characters as follows:

$$r_g = \frac{Cov_g\ 1.2}{\sqrt{\sigma^2_g 1 \times \sigma^2_g 2}}$$

r_g = Genotypic correlation coefficient
Cov_g 1.2 = Genotypic covariance of traits 1 & 2
σ^2_g 1 = Genotypic variance of trait 1.
σ^2_g 2 = Genotypic variance of traits 2.

$$r_p = \frac{Cov_p\ 1.2}{\sqrt{\sigma^2_p 1 \times \sigma^2_p 2}}$$

r_p = Phenotypic correlation coefficient
Cov_p 1.2 = Phenotypic covariance of traits 1 & 2
σ^2_p 1 = Phenotypic variance of trait 1.
σ^2_p 2 = Phenotypic variance of traits 2.

Estimation of path co-efficient: Correlation coefficients were further partitioned into components of direct and indirect effects by path coefficient analysis originally developed by Wright (1921 and 1923) and later described by Dewey and Lu (1956). Path coefficient was estimated for 10 characters related to yield viz., Plant height, Number of panicles per hill, Panicle length, Number of primary branches per panicle, Number of filled grains per panicle, Spikelet sterility (%), 1000 grain weight, Days to maturity, Harvest index and Grain yield per hill. Grain yield per hill was considered as resultant variable.

Results and Discussion

A. Correlation co-efficient

Plant height: Plant height showed significant positive correlation with grain yield per hill at genotypic and phenotypic level indicating yield could be improved by increasing plant height. This character had non-significant negative correlation with panicle length, number of filled grains per panicle, days to maturity and harvest index (Table 1 and 2); which indicated that increased of plant height decreased the value of harvest index. De and Surya (1988) found significant positive correlation between grain yield and plant height.

Number of panicles per hill: Number of panicles per hill found to display significant positive correlation with grain yield per hill only at phenotypic level (Table 1). Therefore yield can be improved through the production of a good number of panicles per hill by appropriate agronomic management practice. Days to maturity showed highly significant positive association with this character at genotypic level only which indicated day to maturity was highly dependent on number of panicles per hill. The correlations of number of panicles per hill with other characters were non-significant. Ray *et al*. (1993) and Balan *et al*. (1999) also reported similar types of observations.

Panicle length: The trend of relationship of panicle length and number of filled grains per panicle was negatively significant at genotypic level. However panicle length had significant positive correlation with days to maturity both at genotypic and phenotypic level (Table 2). The association of this trait with 1000-grain weight was non-significant in positive direction. These results revealed that late maturing plant produced longer panicle and number of filled grains per panicle was not dependent on panicle length. Significant positive correlation between panicle length and days to maturity was also observed by Chaubey and Singh (1994).

Number of primary branches per panicle: Number of primary branches per panicle showed highly significant positive correlation with number of filled grains per panicle. The trend of relationship between 1000-grain weight and number of primary branches per panicle was significant but negative. This feature indicated that increased of primary branches per panicle would lead to increase the number of filled grains per panicle. Association between grain yields per hill and number of primary branches per panicle was negative and insignificant. So selection based on this character would not be effective for increasing grain yield. Yousuf *et al*. (1994) reported similar trend of relationship **(**Table 5).

Table 1. Phenotypic correlation coefficient (r_p) among 10 quantitative characters in aromatic rice

Characters	Number of panicle per hill(B)	Panicle length (cm)(C)	No. of primary branches per panicle(D)	Nr. of filled grains per panicle(E)	Spikelet sterility (%)(F)	1000-grain weight(g)(G)	Days to maturity(H)	Harvest index(I)	Grain yield per hill (g)(J)
Plant height	0.060	-0.085	0.178	-0.230	0.063	0.287	-0.129	-0.158	0.355*
B		0.006	0.071	-0.104	0.063	-0.052	0.224	0.109	0.343*
C			-0.027	-0.134	-0.050	0.254	0.344*	-0.029	0.101
D				0.448**	0.044	-0.373*	-0.193	-0.028	-0.210
E					-0.209	-0.435**	-0.281	0.100	-0.017
F						-0.276	-0.037	-0.354*	-0.242
G							0.281	0.145	0.529**
H								-0.097	0.151
I									0.498**

*,** significant at 5% and 1%, respectively

Number of filled grains per panicle: Highly significant negative correlation was observed between 1000-grain weight and number of filled grains per panicle, which revealed that 1000-grain weight depend on this character. Association between days to maturity and number of filled grains per panicle was significant and negative. This character was however weakly and negatively correlated with grain yield per hill (Table 2). Balakrishna *et al*. (1973) and Biswas *et al*. (2000) reported significant negative association between number of filled grains per panicle and 1000-grain weight that confirmed the present findings.

Spikelet sterility (%): Association between spikelet sterility (%) and grain yield per hill was negative and highly significant at genotypic level only. Harvest index showed significant negative correlation with spikelet sterility (%) both at genotypic and phenotypic level (Table 1 and 2). Correlation between

1000-grain weight and spikelet sterility (%) was negatively significant at genotypic level. This feature indicated that increased of spikelet sterility (%) decreased harvest index, 1000-grain weight and grain yield per hill. Paul and Sharma (1997) reported similar types of observation.

1000-grain weight: The trend of relationship of 1000-grain weight with grain yield per hill was positive and highly significant both at genotypic and phenotypic level. Therefore selection based on this trait would be effective for increasing grain yield. But this character showed significant negative association with number of primary branches per panicle and number of filled grains per panicle. Ray *et al*. (1993), Paul and Sharma (1997) and Balan *et al*. (1999) reported highly significant positive correlation between 1000-grain weight and grain yield per hill (Table 1 and 2).

Table 2. Genotypic correlation coefficient (r_g) among 10 quantitative characters of aromatic rice

Characters	No. of panicle per hill(B)	Panicle length (cm)(C)	No. of primary branches per panicle(D)	No. of filled grains per panicle(E)	Spikelet sterility (%)(F)	1000-grain weight(g)(G)	Days to maturity(H)	Harvest index(I)	Grain yield per hill (g)(J)
Plant height	0.003	-0.136	0.244	-0.018	0.071	0.304	-0.115	-0.208	0.437**
B		-0.059	0.114	-0.124	0.032	-0.056	0.402**	0.066	0.206
C			-0.239	-0.345*	-0.086	0.291	0.400**	0.004	0.064
D				0.631**	0.176	-0.531**	-0.281	-0.015	-0.051
E					0.002	-0.592**	-0.375*	0.152	-0.125
F						-0.350*	-0.086	-0.562**	-0.506**
G							0.298	0.140	0.707**
H								-0.126	0.241
I									0.506**

*,** significant at 5% and 1%, respectively

Days to maturity: Days to maturity represented insignificant positive correlation with grain yield per hill. However, days to maturity have positive significant correlation with number of panicles per hill and panicle length but significant negative correlation with number of filled grains per panicle which indicated that late maturing genotypes furnished more number of panicles per hill associated with less number of filled grains per panicle (Table 1 and 2). Iftekharuddaula *et al*. (2001) found similar findings that satisfied the present findings.

Harvest index: Highly significant positive correlation was observed between harvest index and grain yield per hill (Table 1 and 2). Spikelet sterility (%) showed significant negative association with this character. This result implies that grain yield could be increased by increasing harvest index but increased of spikelet sterility (%) reduced the value of harvest index. Chandra and Das (2000) and Iftekharuddaula *et al*. (2001) reported similar findings.

B. Path co-efficient analysis

In the present investigation grain yield was considered as a resultant variable and plant height, number of panicles per hill, panicle length, number of primary branches per panicle, number of filled grains per panicle, spikelet sterility (%), 1000-grain weight, days to maturity and harvest index were causal (independent) variables. The cause and effect relationship between grain yield and yield related characters has been presented diagrammatically in figure 1. Residual effects of other independent variables, which have influence yield to a small extent, have been denoted as "R" in the diagram shown in Appendix. Estimates of direct effect and indirect effect are presented in Table 3. The results are discussed character wise as follows:

Plant height: Plant height showed positive direct effect (0.2810) on grain yield (Table 3). The positive indirect effect via number of panicles per hill (0.0004), panicle length (0.0106) and number of primary branches per panicle (0.0442) were however, very low. The indirect effect of this character on grain yield via number of filled grain per panicles (-0.0036), spikelet sterility (%) (-0.0046), days to maturity (-0.0237) and harvest index (-0.208) were negative and almost negligible in magnitude. Whereas via 1000-grain weight (0.2195) showed considerable positive indirect effect on grain yield and the total correlation was highly significant and positive (0.437). So direct selection based on this character or indirect selection via 1000-grain weight could be effective for increasing grain yield. Kumar (1992), Ray *et al.* (1993) and Chowdhury and Das (1998) also reported positive direct effect of plant height on grain yield of rice.

Number of panicles per hill: The direct effect of number of panicles per hill was positive (0.1360). The indirect effect of plant height (0.008), panicle length (0.0046), number of primary branch (0.0206), days to maturity (0.0828) and harvest index (0.0275) via this character were positive but very small in magnitude. Number of panicles per hill showed negative indirect effect through number of filled grains per panicle (-0.0246), spikelet sterility (%) (-0.0021) and 1000-grain weight (-0.0404). But these indirect effects were also almost negligible in magnitude. The correlation between number of panicles per hill and grains yield was insignificant and positive (Table 3). Chaubey and Singh (1994), Marwat *et al*. (1994), Patmavathi *et al.* (1996) and Iftekharuddaula *et al.* (2001) also reported positive direct effect of number of panicles per hill on grain yield.

Panicle length: Panicle length registered small negative direct effect (-0.0780) on grain yield. The indirect effect of this trait on yield via spikelet sterility (0.0056), days to maturity (0.0700) and harvest index (0.0275) were positive but small in magnitude. Whereas plant height (-0.0382), number of panicle per hill (-0.0080), number of primary branches per panicle (-0.0433) and number of filled grains per panicle (-0.0683) showed negative negligible indirect effect via this character on grain yield. The negative direct effect was counter balanced by considerable indirect positive effect of 1000-grain weight (0.210), and making the total correlation between yield and panicle length positive but low (0.064) (Table 3). Sarduna *et al.* (1989) reported that panicle length had negative direct effects on yield, which support these present findings. But several investigators- Kumar (1992), Ray *et al*. (1993), Marwat *et al*. (1994), Dash *et al*. (1996), Chowdhury and Das (1998) and Kumar *et al*. (1998) reported high and positive direct effect of panicle length on grain yield of rice. This discrepancy with present finding might be due to environmental condition (Table 3).

Table 3. Partitioning of genotypic correlation into direct (bold phase) and indirect components to grain yield in aromatic rice

Characters	Plant height(A)	Number of panicle per hill(B)	Panicle length(C)	Number of primary branches per panicle(D)	Number of filled grains per panicle(E)	Spikelet sterility (%)(F)	1000-grain weight(G)	Days to maturity(H)	Harvest index(I)	r_g
A	**0.2810**	0.0004	0.0106	0.0442	-0.0036	-0.0046	0.2195	-0.0237	-0.0865	0.437**
B	0.0008	**0.1360**	0.0046	0.0206	-0.0246	-0.0021	-0.0404	0.0828	0.0275	0.206
C	-0.0382	-0.0080	**-0.0780**	-0.0433	-0.0683	0.0056	0.2101	0.0700	0.0017	0.064
D	0.0686	0.0155	0.0186	**0.1810**	0.1249	-0.0114	-0.3834	-0.0579	-0.0062	-0.051
E	-0.0051	-0.0169	0.0269	0.1142	**0.1980**	-0.0001	-0.4274	-0.0773	0.0632	-0.125
F	0.0200	0.0044	0.0067	0.0319	0.0004	**-0.0650**	-0.2527	-0.0177	-0.2334	-0.506**
G	0.0854	-0.0076	-0.0227	-0.0961	-0.1172	0.0228	**0.7220**	0.0614	0.0582	0.707**
H	-0.0323	0.0547	-0.0265	-0.0509	-0.0743	0.0056	0.2152	**0.2060**	-0.0524	0.241
I	-0.0584	0.0090	-0.0003	-0.0027	-0.0301	0.0365	0.1011	-0.0260	**0.4160**	0.506**

Residual effect=0.291, ** Significant at 1% level

Number of primary branches per panicle: The direct effect of number of primary branches per panicle was positive (0.1810). The indirect effect of number of primary branches per panicle on yield via plant height, number of panicle per hill, panicle length was positive and relatively unimportant. Here, direct effect of number of primary branches per panicle were positive but the total correlation value were insignificant and negative, this was due to the considerable negative indirect effect of 1000-grain weight (-0.3834) via this traits (Table 3). Dash *et al*. (1996) reported positive direct effect of number of primary branches on yield. Biswas *et al*. (2000) reported negative indirect effects of 1000-grain weight via number of primary branches per panicle on yield, which confirmed these findings.

Number of filled grains per panicle: This character showed positive direct effect (0.1980) on yield. A strong negative indirect effect of this trait on yield was registered through 1000-grain weight (-0.4274). The indirect effect of number of filled grain per panicle via panicle length, numbers of primary branches per panicle and harvest index were positive but low in magnitude. The total correlation for this trait was insignificant and negative (-0.125) which was mainly due to the indirect negative contribution of 1000-grain weight, days to maturity, spikelet sterility (%) and plant height. Here indirect selection via 1000-grain weight was effective for increasing grain yield (Table 3). Considerable positive direct effects of number of filled grains per panicle on yield where also reported by Dash *et al*. (1996), Padmavathi *et al*. (1996) and Iftekharuddaula *et al*. (2001).

Spikelet sterility: Spikelet sterility (%) showed negative direct effect (-0.0650) on grain yield. The indirect effect of plant height, number of panicles per hill, panicle length, number of primary branches per panicle and number of filled grains per panicle via this trait were positive but very small. On the other hand, indirect effect of spikelet sterility (%) through 1000-grain weight, harvest index and days to maturity were negative and considerable as a consequence the total correlation was negative and highly significant (-0.506) (Table 3). Kumar *et al*. (1998) also reported minimum negative direct effect of spikelet sterility (%) on grain yield of rice, which showed agreement to these findings.

1000-grain weight: Thousands grain weight had the highest positive direct effect (0.7220) on grain yield. Small and negligible negative indirect effect of this trait on yield was registered through number of panicles per hill, panicle length, number of primary branches per panicle and number of filled grains per panicle. Relatively high and positive correlation between 1000-grain weight and grain yield (0.707) was largely due to the highest positive direct effect and positive indirect effect through plant height, days to maturity and harvest index (Table 3). The result revealed that directs election for this trait for improving grain yield was highly effective as it furnished the highest direct contribution towards yield. Maximum positive direct effect of 1000-grain weight on yield was also reported by Ray *et al*. (1993), Marwat *et al*. (1994), Kumar *et al*. (1998) and Iftekharuddaula *et al*. (2001) in grain yield of rice.

Days to maturity: Direct effect of days to maturity on grain yield (0.2060) was positive. The character showed considerable indirect positive effect on grain yield through 1000-grain weight. Whereas plant height, number of panicles per hill, panicle length, number of primary branches per panicle and number of filled grains per panicle showed small negative indirect effect on yield via this trait (Table 3). Yousuf *et al*. (1994), Padmavathi *et al*. (1996), Choudhury and Das (1997) reported high positive direct effect of days to maturity on yield but Dash *et al*. (1996) found low direct positive effects of this trait on yield. This finding confirmed this result.

Harvest index: Harvest index had a high positive direct effect (0.4160) on yield. The indirect effect observed via number of panicles per hill, spikelet sterility and 1000-grain weight on grain yield. Plant height, panicle length, number of primary branches per panicle, number of filled grains per panicle and days to maturity had negligible negative indirect effect via harvest index on yield. The total correlation was highly significant and positive (0.506). High positive direct effect on harvest index on yield was also reported by Surek *et al*. (1998) and Iftekharuddaula *et al*. (2001). Path analysis indicated that 1000-grain weight was the most important character that had the maximum contribution to grain yield per plant as it exhibited the highest direct effect on yield. The second most important character was harvest index followed by plant height. The residual effect was found 0.291 which, indicated that there were other contributors which were responsible for yield but not taken into consideration in the present investigation. According to Sengupta and Kataria (1971), this residual effect towards yield might be due to other characters (which were not studied), environmental factors and sampling errors.

Summary and Conclusion

The investigation was undertaken to study the quantitative assessment of the variation in yield and yield components, their interrelationship and direct and indirect effects of different characters on grain yield of aromatic rice and included 41 varieties of aromatic rice from diverse sources in Bangladesh.

The genotypic correlation coefficient was generally higher than the corresponding phenotypic correlation coefficient which indicated that the apparent association might be due to genetic reason. Grain yield per hill was significantly and positively correlated with plant height, 1000-grain weight and harvest index both at genotypic and phenotypic levels. Spikelet sterility (%) showed highly significant negative correlation coefficient with grain yield (-0.506) only at genotypic level. Phenotypic correlation coefficients between grain yield per hill with plant height (0.355) and number of panicles per hill (0.343) were positive and significant at 5% level only. Highly significant and positive inter character association at both genotypic and phenotypic levels were obtained between days to maturity vs. panicle length and number of filled grains per panicle vs. number of primary branches per panicle. Such results indicated that late maturing plant produced longer panicle and panicle having more primary branches produced higher number of filled grains. Thousands grain weight showed highly significant negative correlation with number of filled grains per panicle both at genotypic and phenotypic level. Highly significant negative correlations were observed between 1000-grain weight vs. number of primary branches per panicle (-0.531) and harvest index vs. spikelet sterility (-0.562) only at genotypic level. The genotypic correlation between days to maturity vs. number of filled grains per panicle (-0.375), 1000-grain weight vs. spikelet sterility (%) (-0.350) and number of filled grains per panicle vs. panicle length (-0.345) were negative and significant at 5% level only. So, correlation study revealed that selection based on plant height, number of panicles per hill, 1000-grain weight and harvest index would be effective for increasing grain yield. Where, spikelet sterility (%) had a negative consequence on yield.

The results of path coefficient analysis revealed that 1000-grain weight had the highest positive direct (0.7220) effect on grain yield followed by harvest index (0.4160), plant height (0.2810), days to maturity (0.2060), number of filled grains per panicle (0.1980) and number of primary branches per panicle ((0.1810). Such results indicated that direct selection based on these characters would be effective for yield improvement. On the other hand panicle length (-0.0780) and spikelet sterility (%) (-0.0650) showed negative negligible direct effect on grain yield per hill. So, direct selection based on these traits would not be effective. Plant height had considerable positive indirect effect via 1000-grain weight. The highest negative indirect effect was displayed by 1000-grain weight via number of filled grains per panicle (-0.4274). The indirect effect of 1000-grain weight via number of primary branches (-0.3834) and spikelet sterility (%) (-0.2527) and harvest index via spikelet sterility (-0.2334) were also considerable and negative. The residual effect was 0.291, which indicated that some more other characters were responsible for contribution to grain yield but not taken into consideration in the present investigation.

Based on the findings of the present investigation the following conclusion could be made; the correlation coefficients of grain yield per hill with 1000-graion weight and harvest index were positive and highly significant. Spikelet sterility showed highly significant negative correlation with grain yield at genotypic level only. The parameter 1000-grain weight showed the highest positive direct effect on grain yield. Panicle length and spikelet sterility showed negative negligible direct effect. The highest positive indirect effect was observed for 1000-grain weight via plant height and the highest negative indirect effect for 1000-grain weight via number of filled grains per panicle.

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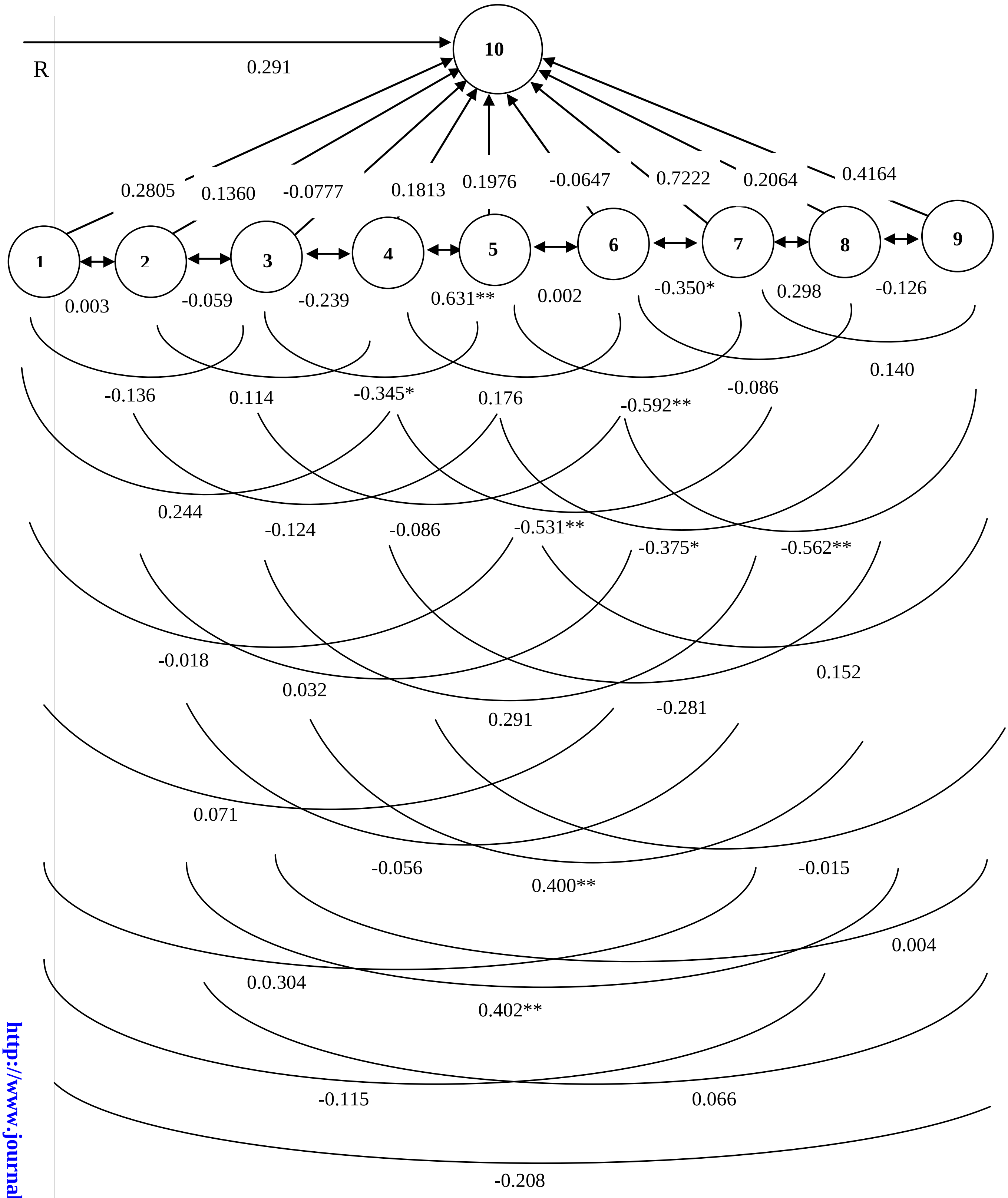
<u>Appendix</u>



Appendix. Path diagram of 9 yield contributing traits in aromatic rice

1= Plant height, 2= Number of panicle per hill, 3 = Panicle length, 4= Number of primary branches per panicle, 5= Number of filled grains per panicle, 6= Spikelet sterility (%), 7= 1000- grain weight, 8= Days to maturity, 9= Harvest index, 10= Grain yield per hill