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Research Article

VARIABILITY STUDY OF ADVANCED FINE RICE WITH CORRELATION, PATH CO-EFFICIENT ANALYSIS OF YIELD AND YIELD CONTRIBUTING CHARACTERS

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Abstract

The experiment was conducted in experimental Farm, Sher-e-Bangla Agricultural University, Bangladesh from July to December 2011 to study the variability of advanced lines of fine rice with correlation and path co-efficient of yield and yield contributing characters. Seven newly developed lines viz. S-1, S-2, S-5, AL-33(II), AL-36, AL-42(II), AL-44(I) and Chinigura. Grain yield/plant of newly developed advanced fine rice lines and check showed positive association in respect of number of effective tillers/hill (0.308), number of filled spikelets/panicle (0.110) and weight of 1000-grains (0.109), whereas significant negative association with panicle length (-0.609), number of unfilled spikelets/panicle (-0.542) and non significant negative association with plant height (-0.136) and number of ineffective tillers/hill (-0.304). Path analysis revealed that plant height had positive direct effect (0.154), number of effective tillers/hill had positive direct effect (0.065), number of ineffective tillers/hill had negative direct effect (-0.114), panicle length had positive direct effect (0.163), number of filled spikelets/panicle had positive direct effect (0.285), number of unfilled spikelets/panicle had negative direct effect (-0.154), weight of 1000-grains had positive direct effect (0.234) on grain yield/plant.

Keywords: Fine rice; variability; correlation and path co-efficient

Introduction

Economic product of rice (*Oryza sativa* belongs to Poaceae family) is paddy yield, which exhibits complex genetics as it is influenced by various yield contributing characters and the environment. In general, increased panicle number is the single most important yield component associated with rice yield, number of spikelets/panicle and percent filled grains/panicle being of secondary and tertiary importance (Jones and Synder, 1987). Another trait directly related to panicle is panicle density which chiefly affects the yield potential. Therefore, information about yield contributing traits is of immense importance to plant breeders for development of improved varieties or lines of rice with increased yield potential. Keeping these points in view the current study was undertaken with a view to evaluated the variability of advanced lines of fine rice with correlation, path co-efficient of yield and yield contributing characters.

Materials and methods

The experiment was conducted at experimental farm, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh during the period from July to December 2011 to study the variability of advanced lines of fine rice (*Oryza sativa*) with correlation and path co-efficient of yield and yield contributing characters. Seven advanced fine rice lines of 10th generation viz. S-1, S-2, S-5, AL-33(II), AL-36, AL-42(II) and AL-44(I) were collected from Department of Genetics and Plant Breeding, SAU and Chinigura rice were collected from Bangladesh Rice Research Institute and used as check variety for this study. The experiment was laid out in Randomized Complete Block Design with three replications. Each plot size was 2.5 m × 2.0 m. Urea (150 kg/ha), TSP (100 kg/ha), MP (100 kg/ha), gypsum (60 kg/ha), zinc sulphate (10 kg/ha) and borax (150 kg/ha) were applied (BRRI, 2012). The entire amount of TSP, MP, gypsum, zinc sulphate and borax were applied during the final preparation of plot land. Mixture of cowdung and compost was applied @ 10 t/ha during 15 days before transplantation. Urea was applied in three equal installments at after recovery, tillering and before panicle initiation. Rice seedlings were transplanted in lines each having a line to line 30 cm and plant to plant 25 cm distance. Flood irrigation was given to maintain a constant level of standing water upto 6 cm in the early stages to enhance tillering and 10-12 cm in the later stage to discourage late illering. The field was finally dried out 15 days before harvesting. Data were collected on plant height, number of effective tillers/hill, number of in-effective tillers/hill, number of total tillers/hill, panicle length, number of filled spikelets/panicle, number of unfilled spikelets/panicle, number of total spikelets/panicle, weight of 1000 seeds, grain yield/plant, grain yield/m^2 (converted into yield/ha) and grain yield/plot. Genotypic and phenotypic variances were estimated with the help of the formula suggested by Johnson *et al*. (1955). The genotypic variance (σ^2_g) was estimated by subtracting error mean square (σ^2_e) from the genotypic mean square and dividing it by the number of replication (r). The phenotypic variance (σ^2_p) was derived by adding genotypic variances (σ^2_g) with the error variance (σ^2_e).

Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were calculated following formula as suggested by Burton (1952).

$$\%\ \text{Genotypic coefficient of variance} = \frac{\sigma^2_g}{\bar{x}} \times 100$$

$$\%\ \text{Phenotypic coefficient of variance} = \frac{\sigma_{ph}}{\bar{x}} \times 100$$

Where; σ^2_g = genotypic standard deviation, $\bar{x}$ = population mean Where; σ_{ph} = phenotypic standard deviation, $\bar{x}$ = population mean

Heritability in broad sense was estimated following the formula as suggested by Johnson *et al*. (1955).

$$\text{Heritability (\%)} = \frac{\sigma^2_g}{\sigma^2_{ph}} \times 100$$

Where, σ^2_g = genotypic variance and σ^2_{ph} = phenotypic variance

The following formula was used to estimate the expected genetic advance (GA) for different characters under selection as suggested by Allard (1960).

$$GA = \frac{\sigma^2_g}{\sigma^2_{ph}} \times K.\sigma_{ph}$$

Where, GA = Genetic advance, σ^2_g = genotypic variance, σ^2_{ph} = phenotypic variance, σ_{ph} = phenotypic standard deviation, K = Selection differential which is equal to 2.64 at 5% selection intensity

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

$$\text{Genetic Advance in percentage of mean} = \frac{\text{Genetic advance}}{\bar{x}} \times 100$$

Path co-efficient analysis was done according to the procedure employed by Dewey and Lu (1959) also quoted in Singh and Chaudhary (1985), using simple correlation values. In order to estimate direct and indirect effect of the correlated characters, say x_1, x_2, x_3 yield y, a set of simultaneous equations (three equations in this example) is required to be formulated as given below:

$$ryx_1 = Pyx_1 + Pyx_2rx_1x_2 + Pyx_3rx_1x_3$$

$$ryx_2 = Pyx_1rx_1x_2 + Pyx_2 + Pyx_3rx_2x_3$$

$$ryx_3 = Pyx_1rx_1x_3 + Pyx_2\,rx_2x_3 + Pyx_3$$

Where, r's denotes simple correlation co-efficient and P's denote path co-efficient (unknown). P's in the above equations may be conveniently solved by arranging them in matrix form. Total correlation, say between x_1 and y is thus partitioned as follows.

Pyx_1 = The direct effect of x_1 on y

$Pyx_1rx_1x_2$ = The indirect effect of x_1 via x_2 on y

$Pyx_1rx_1x_3$ = The indirect effect of x_1 via x_3 on y

After calculating the direct and indirect effect of the characters, residual effect (R) was calculated by using the formula given below (Singh and Chaudhary, 1985):

$$P^2RY = 1 - \sum Piy.riy$$

Where; P^2RY = (R^2); and hence residual effect, R = $(P^2RY)^{1/2}$, Piy = Direct effect of the character on yield, riy = Correlation of the character with yield

The data obtained for different grain size and shape were statistically analyzed to find out the significance of the difference for different newly developed lines of advanced fine rice. The mean values of all the recorded characters were evaluated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference of means was estimated by Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984) and correlation was estimated by using SPSS computer package program at 1% and 5% level of significance.

Results and discussion

Plant height

It was revealed that phenotypic variation (144.3) was higher than the genotypic variance (90.8) for indicating high environmental influence on this characters which was supported by narrow difference between phenotypic (12.0%) and genotypic (9.5%) co-efficient of variation for plant height (Table 1). High heritability (62.9%) in plant height attached with high genetic advance (20.0%) and high genetic advance in percentage of mean (17.8). High estimate of heritability and high genetic advance were registered in plant height suggested that this character was predominantly controlled by environment with complex gene interaction. As this trait possessed high variation, it was potential for effective selection for further genetic improvement.

Number of effective tillers/hill

Phenotypic variation (19.7) was higher than the genotypic variance (16.9) for indicating high environmental influence on this characters which was supported by narrow difference between phenotypic (4.4%) and genotypic (4.1%) co-efficient of variation for number of effective tillers/hill (Table 1). The difference between these parameters was also moderately high suggested a considerable influence of environment on number of effective tillers/hill for its expression. High heritability (86.1%) in number of effective tillers/hill attached with moderate genetic advance (10.1%) and high genetic advance in percentage of mean (73.1). The high heritability along with high genetic advance in percentage of mean of diameter of fruit indicated the possible scope for improvement through selection of the character and breeder may expect reasonable benefit in next generation in respect of this trait.

Number of ineffective tillers/hill

From the data it was found the number of ineffective tillers/hill in terms of phenotypic variation (0.1) was same than the genotypic variance (0.1) for indicating now environmental influence on this characters which was supported by same phenotypic (0.3%) and genotypic (0.3%) co-efficient of variation (Table 1). The situation of phenotypic and genotypic variation indicated no influence of the environment for the expression of this character. Therefore, the breeder must have not to need consideration of genetic work predicted environment for improving the trait. High heritability (98.3%) for number of ineffective tillers/hill attached with low genetic advance (0.9%) and high genetic advance in percentage of mean (126.7). As this trait possessed low variation, it was not potential for effective selection for further genetic improvement.

Panicle length

Panicle length in respect of phenotypic variation (4.8) was higher than the genotypic variance (1.8) for indicating high environmental influence on this characters which was supported by narrow difference between phenotypic (2.2%) and genotypic (1.3%) co-efficient of variation (Table 1). That mean the phenotypic and genotypic variance which indicated that environment had played a little role with little genetic variation among the genotypes of this trait i.e. environmental influence was minimum. Therefore, panicle length was the inherent potential among the lines and check. Low heritability (37.9%) for panicle length attached with lowest genetic advance (2.2%) and highest genetic advance in percentage of mean (7.5). The low heritability along with high genetic advance in percentage of mean of panicle length indicated the possible scope for improvement through selection of the character and breeder may expect reasonable benefit in next generation in respect of this trait.

Number of filled spikelets/panicle

Number of filled spikelets/panicle in respect of phenotypic variation (1413.7) was higher than the genotypic variance (1008.2) for indicating high environmental influence on this characters which was supported by narrow difference between phenotypic (37.6%) and genotypic (31.8%) co-efficient of variation (Table 1). The difference between phenotypic and genotypic variance then was high indicated great influence of the environment for the expression of this character. High heritability (70.8%) for number of filled spikelets/panicle attached with high genetic advance (70.8%) with 51.9% mean. High heritability estimate coupled with high expected genetic advance for this trait indicated the importance additive genetic effects for the controlling the character. Genetic improvement of this character would therefore be moderately effective.

Number of unfilled spikelets/spike

It was revealed that number of unfilled spikelets/spike in terms of phenotypic variation (244.3) was higher than the genotypic variance (227.9) for indicating high environmental influence on this characters which was supported by narrow difference between phenotypic (15.6%) and genotypic (15.1%) co-efficient of variation (Table 1). The difference between phenotypic and genotypic variation then was low indicated minimum influence of the environment for the expression of this character. Therefore, the breeder have to minimum consideration of genetic work predicted environment for improving the trait. High heritability (93.3%) for number of unfilled spikelets/spike attached with high genetic advance (38.5%) and high genetic advance in percentage of mean (97.7). As this trait possessed high variation, it was potential for effective selection for further genetic improvement.

Weight of 1000-grains

Weight of 1000-grains in terms of phenotypic variation (0.4) was higher than the genotypic variance (0.4) for indicating minimum environmental influence on this characters which was supported by narrow difference between phenotypic (0.6%) and genotypic (0.6%) co-efficient of variation (Table 1). The difference between phenotypic and genotypic variation then was minimum indicated low influence of the environment for the expression of this trait. Therefore, the breeder must have no synchronize consideration of genetic work predicted environment for improving the trait. High heritability (95.3%) for weight of 1000-grains attached with low genetic advance (1.5%) and high genetic advance in percentage of mean (59.7). As this trait possessed high variation, it was potential for effective selection for further genetic improvement.

Grain yield per plant

It was revealed that grain yield per plant in terms of phenotypic variation (19.2) was higher than the genotypic variance (10.8) for indicating high environmental influence on this characters which was supported by narrow difference between phenotypic (4.4%) and genotypic (3.3%) co-efficient of variation (Table 1). The difference between phenotypic and genotypic variation then was moderate indicated moderately influence of the environment for the expression of this character. Therefore, the breeder must have to consecutive consideration of genetic work predicted environment for improving the trait. High heritability (56.3%) for grain yield per plant attached with moderate genetic advance (6.5%) and high genetic advance in percentage of mean (23.8). As this trait possessed high variation, it was potential for effective selection for further genetic improvement with consideration of environmental effect. Sawant and Patil (1995) evaluated 75 genotypes of rice and found high coefficient of variation for grain yield/plant. High value of heritability coupled with high expected genetic advance was observed for grain yield/plant. Singh *et al.* (1994) who reported that characters with high heritability are more heritable and suggested that selection of such traits would be useful. On the other hand, environmental factors affected the other characters. Low coefficient of variation had been reported for percentage amylose content and grain length/width ratio (Chauha *et al.*, 1997).

Table 1: Genetic parameters of different yield contributing characters and yield of some newly developed advanced fine rice and check

Characters	**Genotypic variance ($\sigma^2 g$)**	**Phenotypic variance ($\sigma^2 p$)**	**Genotypic coefficient of variation (%)**	**Phenotypic coefficient of variation (%)**	**Heritability (%)**	**Genetic Advance (GA)**	**GA in percentage of mean**
Plant height (cm)	90.8	144.3	9.5	12	62.9	20	17.8
Number of effective tillers/hill	16.9	19.7	4.1	4.4	86.1	10.1	73.1
Number of ineffective tillers/hill	0.1	0.1	0.3	0.3	98.3	0.9	126.7
Panicle length (cm)	1.8	4.8	1.3	2.2	37.9	2.2	7.5
Number of filled spikelets/panicle	1008.2	1413.7	31.8	37.6	71.3	70.8	51.9
Number of unfilled spikelets/panicle	227.9	244.3	15.1	15.6	93.3	38.5	97.7
Weight of 1000-grains (g)	0.4	0.4	0.6	0.6	95.3	1.5	59.7
Grain yield (g/plant)	10.8	19.2	3.3	4.4	56.3	6.5	23.9

Relationship between yield contributing characters and yield

Plant height

Highly significant positive association was recorded for plant height for newly developed advanced fine rice lines and check in respect of number of effective tillers/hill (0.561), number of ineffective tillers/hill (0.443), number of filled grains/panicle (0.558), while non-significant positive association with number of unfilled grains/panicle (0.119) (Table 2). On the other hand, highly negative significant association was observed with weight of 1000-grains (-0.818) and negative non-significant association with panicle length (-0.085) and grain yield (-0.136) (Table 2).

Number of effective tillers/hill

Number of ineffective tiller/hill (0.505) and plant height (0.561) showed highly positive significant association with number of effective tillers/hill whereas non-significant positive association was found with number of filled spikelet/panicle (0.107), number of unfilled spikelets/panicle (0.002) and grain yield (0.308), again highly negative significant association for number of effective tillers/hill with panicle length (-0.436) and weight of 1000-grains (-0.506) (Table 2).

Number of ineffective tillers/hill

Data revealed that highly positive significant association was recorded for number of ineffective tillers/hill newly developed advanced fine rice lines and check in respect of plant height (0.443), number of effective tillers/hill (0.505) and number of unfilled spikelets/panicle (0.671) while non-significant positive association was recorded with number of filled spikelets/panicle (0.104) (Table 2). On the other hand, negative significant association was recorded with weight of 1000-grains (-0.441) whereas non-significant negative association was recorded with panicle length (-0.062) and grain yield (-0.304) (Table 2).

Panicle length

Non-significant positive association was recorded for newly developed advanced fine rice lines and check in respect of number of filled spikelets/panicle (0.007), number of unfilled spikelets/panicle (0.100) and weight of 1000-grains (0.156), while highly negative significant association for number of effective tillers/hill (-0.436) and grain yield (-0.609) and non-significant negative association was recorded with plant height (-0.085) and number of ineffective tillers/hill (-0.062) (Table 2).

Number of filled spikelets/panicle

Highly positive significant association was recorded for number of filled spikelets/panicle for newly developed advanced fine rice lines and check with plant height (0.558), while non-significant positive association was found with number of effective tillers/hill (0.107), number of ineffective tillers/hill (0.104), panicle length (0.007), number of unfilled spikelets/panicle (0.162) and grain yield (0.110) (Table 2). On the other hand, highly significant negative association was recorded for weight of 1000-grains (-0.745) (Table 2).

Number of unfilled spikelets/panicle

Data revealed that highly positive significant association was recorded for number of filled spikelets/panicle for newly developed advanced fine rice lines and check with number of ineffective tiller/hill (0.671), while non-significant positive association was found with plant height (0.119), number of effective tillers/hill (0.002), panicle length (0.100), number of filled spikelets/panicle (0.162). On the other hand, highly significant negative association was recorded with grain yield (-0.542) and non-significant negative association with weight of 1000-grains (-0.276).

Weight of 1000-grains

Positive non-significant association was recorded for weight of 1000-grains of newly developed advanced fine rice lines and check in respect of panicle length (0.156) and grain yield (0.109), while highly significant negative association was found with plant height (-0.818), number of effective tillers/hill (-0.506), number of ineffective tillers/hill (-0.441), number of filled spikelets/panicle (0-.745) and non-significant negative association with number of unfilled spikelets/panicle (-0.276) (Table 2).

Grain yield/plant

Grain yield/plant of newly developed advanced fine rice lines and check showed positive association in respect of number of effective tillers/hill (0.308), number of filled spikelets/panicle (0.110) and weight of 1000-grains (0.109) whereas highly significant negative association with panicle length (-0.609), number of unfilled spikelets/panicle (-0.542) and non-significant negative association with plant height (-0.136) and number of ineffective tillers/hill (-0.304) (Table 2). Positive association between grain number/panicle and grain yield has been reported by number of workers (Chauhan *et al*., 1986; Janagle *et al*., 1987). Interestingly it is observed that total number of filled spikelets, total number of spikelets and spikelet fertility show positive but non-significant association among those characters. Ghosh and Hossain (1988) reported that effective tillers/plant, number of grains/panicle and grain weight as the major contributory characters for grain yield it had positive correlations with number of productive tillers/plant. Vijayakumar *et al*. (1997) and Hossain (2004) reported high correlation between 1000 grain weight and grain yield per plant.

Table 2: Genotypic correlation among different yield contributing characters and yield of some newly developed advanced fine rice and check

Characters	1	2	3	4	5	6	7	8
1	1.00							
2	0.561**	1.00						
3	0.443*	0.505**	1.00					
4	-0.085	-0.436**	-0.062	1.00				
5	0.558**	0.107	0.104	0.007	1.00			
6	0.119	0.002	0.671**	0.100	0.162	1.00		
7	-0.818**	-0.506**	-0.441*	0.156	-0.745**	-0.276	1.00	
8	-0.136	0.308	-0.304	-0.609**	0.110	-0.542**	0.109	1.00

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

1= Plant height (cm); 2= Number of effective tillers/plant; 3= Number of ineffective tillers/plant; 4= Panicle length (cm); 5= Number of filled spikelets/panicle; 6= Number of unfilled spikelets/panicle; 8= Weight of 1000-grains (g); 9= Grain yield (g/plant)

Path Co-efficient analysis

Grain yield/plant vs plant height

Path analysis revealed that plant height had positive direct effect (0.154) on grain yield/plant (Table 3). It showed negligible negative indirect effect through number of ineffective tillers/hill and number of unfilled spikelets/panicle. Plant height showed positive indirect effect through number of effective tillers/hill, panicle length, number of filled spikelets/panicle and weight of 1000-grains.

Grain yield/plant vs number of effective tillers/hill

Path analysis revealed that number of effective tillers/hill had positive direct effect (0.065) on grain yield/plant (Table 3). It showed negligible negative indirect effect through number of unfilled spikelets/panicle. Number of effective tillers/hill showed positive indirect effect through plant height, number of ineffective tillers/hill, panicle length, number of filled spikelets/panicle and weight of 1000-grains.

Grain yield/plant vs number of ineffective tillers/hill

Path analysis revealed that number of ineffective tillers/hill had negative direct effect (-0.114) on grain yield/plant (Table 3). It showed negligible negative indirect effect through plant height, panicle length and number of filled spikelets/panicle. Number of ineffective tillers/hill showed positive indirect effect through number of effective tillers/hill, number of unfilled spikelets/panicle and weight of 1000-grains.

Grain yield/plant vs panicle length

Path analysis revealed that panicle length had positive direct effect (0.163) on grain yield per plant (Table 3). It showed negligible negative indirect effect through number of ineffective tillers/hill and weight of 1000-grains. Panicle length showed positive indirect effect through plant height, number of effective tillers/hill, number of filled spikelets/panicle and number of unfilled spikelets/panicle.

Grain yield/plant vs number of filled spikelets/panicle

Path analysis revealed that number of filled spikelets/panicle had positive direct effect (0.285) on grain yield per plant (Table 3). It showed negligible negative indirect effect through plant height, number of ineffective tillers/hill and number of unfilled spikelets/panicle. Number of filled spikelets/panicle showed positive indirect effect through number of effective tillers/hill, panicle length and weight of 1000-grains.

Grain yield/plant vs number of unfilled spikelets/panicle

Path analysis revealed that number of unfilled spikelets/panicle had negative direct effect (-0.154) on grain yield per plant (Table 3). It showed negligible negative indirect effect through plant height, number of ineffective tillers/hill, number of filled spikelets/panicle and weight of 1000-grains. Number of unfilled spikelets/panicle showed positive indirect effect through number of effective tillers/hill and panicle length.

Grain yield/plant vs weight of 1000-grains

Path analysis revealed that weight of 1000-grains had positive direct effect (0.234) on grain yield/plant (Table 3). It showed negligible negative indirect effect through number of ineffective tillers/hill and number of filled spikelets/panicle. Weight of 1000-grains showed positive indirect effect through plant height, number of effective tillers/hill panicle length and number of unfilled spikelets/panicle.

Table 3. Path coefficients of different yield contributing characters and yield of some newly developed advanced fine rice and check

Characters	1	2	3	4	5	6	7	8
1	**0.154**	0.022	-0.366	0.109	0.145	-0.305	0.105	0.136
2	0.132	**0.065**	0.022	0.135	0.117	-0.209	0.046	0.308
3	-0.245	0.146	**-0.114**	-0.194	-0.138	0.043	0.198	0.304
4	0.031	0.033	-0.393	**0.163**	0.008	0.027	-0.478	0.609
5	-0.126	0.174	-0.145	0.021	**0.285**	-0.135	0.036	0.110
6	-0.189	0.165	-0.114	0.054	-0.155	**-0.154**	-0.149	0.542
7	0.075	0.131	-0.222	0.038	-0.192	0.045	**0.234**	0.109

1= Plant height (cm); 2= Number of effective tillers/plant; 3= Number of ineffective tillers/plant; 4= Panicle length (cm); 5= Number of filled spikelets/panicle; 6= Number of unfilled spikelets/panicle; 8= Weight of 1000-grains (g); 9= Grain yield (g/plant)

Residual effect = 0.4512

Conclusion

Genotypic and phenotypic variance, heritability, genetic advance and genetic advance in percentage of mean were significantly influenced by environment. As these trait possessed high variation, it was potential for effective selection for further genetic improvement and breeder may expect reasonable benefit in next generation in respect of this trait. Correlation coefficient analysis showed significant positive association with grain yield/plant and number of effective tillers/hill and number of filled spikelets/panicle whereas significant negative association with grain yield/plant and panicle length and number of unfilled spikelets/panicle. Path analysis revealed that plant height, number of effective tillers/hill, panicle length, number of filled spikelets/panicle and weight of 1000-grains had positive direct effect while number of ineffective tillers/hill and unfilled spikelets/panicle had negative direct effect on grain yield/plant.

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