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Study on Genetic Variability and Character Association of Aromatic Rice (*Oryza sativa* L.) Cultivars

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted to evaluate correlation between some traits and yield components of six aromatic rice varieties and also to determine the most effective factors on its yield. The experiment was conducted in a randomized complete block design (RCBD) with 3 replications. Among six variteits Badshabhog was the topmost yielder followed by Kataribhog, Chinigura, and Radhunipagal, Begunbichi and Kalozira. Analysis of variability parameters revealed that the phenotypic coefficients of variation were higher than genotypic coefficient of variation for all the characters studied. The spikelets panicle^{-1} and 1000-grain weight showed high heritability and effective tillers hill^{-1} showed low heritability. Yield has positive significant correlation with days to maturity, spikelet length and 1000-grain weight. Negative significant correlation found with plant height and sterility percentage and non-significant correlation with other characters.

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1. INTRODUCTION

Rice is the principal food crop and most extensively grown cereal in the tropical and subtropical regions of the world and a major source of nutrition for about two-thirds of world's population [1] and it is the staple food consumed by more than half of the people, three billion of which are Asian [2].

It is the staple food for the people of Bangladesh and playing an important role in the national economy of many developing countries [3,4]. Bangladesh is the fourth largest producer and consumer of rice in the world where rice provides 75% of the calories and 55% of the protein in the average daily diet [5]. In Bangladesh most of the aromatic rice cultivars are of traditional type, photoperiod-sensitive and are grown during Aman season in the rainfed low land ecosystem [6]. Due to high prices and export potentiality, the production of aromatic rice is becoming popular in Bangladesh [7]. Generally, the price of the aromatic rice is three to four times greater than that of the non-aromatic or ordinary rice varieties in national and international markets. Aroma which is being appreciated by many people and represents a high value added trait is the major feature of these aromatic rice varieties [8]. The aroma in rice is merely due to the charisma of some volatile chemicals [9] and the most vital one is the 2-acetyl -1-pyrroline [10]. Therefore, rice needs attention toward improvement in its cooking qualities as well as several biochemical and morphological characteristics [11]. But unfortunately, the aromatic rice often has undesirable agronomic characters, such as low yield, susceptibility to pests and diseases, and strong shedding [12]. Study on yield contributing characters involves greater importance of fixing up characters that influence yield [13,14].

In breeding programs designed to increase the yield potential of a crop plant, an understanding of the mode of inheritance of the yield components, the correlations among them and the relationship between the components and yield is necessary for a better selection of breeding procedures for developing high-yielding varieties [15,16]. Significant improvement in the efficiency of crop breeding programs through the use of proper selection indices where Interrelationships between yield and its contributing components are existed [17,18]. It is useful in the selection of several traits simultaneously influencing yield through the correlation coefficient analysis [19]. For better insight into cause and effect relationship between different pairs of traits the association in amalgamation with path analysis can effectively use [20]. By genotypic and/or phenotypic coefficients of correlation the association among traits may be measured depending on the types of studied materials and the kind of experimental design used [21]. In aromatic rice, genotypic evaluation can identify the relationship of yield components with grain yield and the information of these relationships can be helpful to find superior aromatic rice genotypes [22]. The present investigation was carried out to understand the association of grain yield with yield contributing traits to determine the inter-correlation between the traits at genotypic level to obtain path values, showing the extent of direct and indirect effects of various biometrical traits upon grain yield.

2. MATERIALS AND METHODS

2.1 Plant Material

Six aromatic rice genotypes namely Radhunipagol, Chinigura, Kataribhog, Begunbichi, Kalozira, Badshabhog were used in this investigation. The seeds were collected from the Genetics and Plant Breeding laboratory of Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh.

2.2 Experimental Design and Growing Condition

All of six genotypes are raised in small plots (3×2 m^2) with three replications laid out on Randomized Complete Block Design (RCBD). Recommended rice production practice of Bangladesh Agricultural Research Council [23] was followed. The experimental site is situated in the tropical climatic zone, characterized by heavy rainfall during the months from May to September and minimum rainfall during winter season. The soil of the experimental field was sandy loam in texture having a pH of around 6.2 Each seedbed was prepared with 2 m length and 1 m width and recommended doses of manure and fertilizers were applied. A 50 cm drainage channel was allowed between two adjacent seedbeds to drain out excess water whenever needed. The grains were soaked in water for 24 hours and then incubated in a moist jute sack for

48 hours with a view of quick germination. The beds were irrigated to a depth of 2-3 cm after establishing the roots. Excess water was occasionally drained off to attain water depth of 5 cm that partially controlled weeds, and the remaining weeds were removed to raise healthy and vigorous seedlings.

2.3 Data Collection of Agronomic Traits

Data were collected on plant height (cm), tillers hill^{-1} (maximum vegetative stage), effective tillers hill^{-1}, days to 50% flowering, days to maturity, panicle length (cm), racillae panicle^{-1}, spikelets panicle^{-1}, sterility percentage, flag leaf angle (0º), flag leaf length (cm), spikelet length (mm), length-breadth ratio, 1000-grain weight (g) and yield (t ha^{-1}). After the appearance of 70% of the panicles, days to flowering have been recorded as soon as possible. Number of tillers was recorded after emerging the fertile panicles and grain development. The plant height was measured from ground level to the tip of the longest panicle. At maturity, panicles were harvested separately and placed individually in an envelope. The panicles were taken out of the envelopes and air-dried for one week at room temperature. Fertility of panicle, 1000 grain-weight and grain yield plot^{-1} was estimated after that.

2.4 Data Analysis

The collected data were analyzed by using the statistical program SPSS (Version 16.0, 2007) for analysis of variance (ANOVA) and mean separation.

3. RESULTS AND DISCUSSION

Performance of different characters in six aromatic cultivars is shown in Table 1. The highest value for plant height was observed in Begunbichi which was however statistically different from other varieties. The lowest value was exhibited in Kataribhog. Kalozira found to produce highest value for tillers hill^{-1} (maximum vegetative stage) while the lowest value was exhibited Radhunipagol.

Effective tillers hill^{-1} was observed maximum in Badshabhog which was however statistically different from other varieties and the lowest value was exhibited Radhunipagol that is also different from other varieties

The variety Kalozira required highest value for days to 50% flowering and days to maturity while Begunbichi required the lowest period for 50% flowering and days to maturity.

Panicle length was observed highest in Kataribhog and varied significantly from other varieties while the lowest value was exhibited Chinigura.

Spikelets panicle^{-1}, length of flag leaf and 1000-grain weight were observed maximum in Radhunipagol and varied significantly from other varieties. The lowest value of spikelets panicle^{-1} was exhibited in Kalozira while lowest length of flag leaf and 1000-grain weight was found in Begunbichi.

Highest yield was found in Badshabhog which was however statistically different from other varieties and the lowest was in Kalozira.

Variability of different characters of the rice varieties are shown in Table 2. Analysis of variability parameters revealed that the phenotypic coefficient of variation were higher than genotypic coefficient of variation for all the characters studied. In case of plant height, the difference between phenotypic and genotypic variance was low indicating minimum environmental influence on this trait. The character showed moderate genotypic and phenotypic coefficient of variation, high heritability in broad sense, moderate genetic advance and moderate genetic advance in percentage of mean.

The difference between phenotypic and genotypic variance was also low in case of number of tillers hill^{-1}, effective tillers hill^{-1}, days to 50% flowering, days to maturity, panicle length, rachillae panicle^{-1}, spikelets panicle^{-1}, sterility percentage, flag leaf length, spikelet length, 1000-grain weight, and yield. The characters showed moderate genotypic and phenotypic coefficient of variation, high heritability in broad sense, moderate genetic advance and moderate genetic advance in percentage of mean. These indicate that the influence of environmental condition low on expression of genes controlling the characters. In other words, the expression of these traits is mainly due to the genetic constituents rather than environmental influence. Therefore selection for improvement of these traits might be beneficial. Similar observations were reported for one or more characters [24-26].

Table 1. Mean performance of different characters in six aromatic cultivars

Cultivars	Plant height (cm)	Tillers/hill	Effective tillers/hill	Days to 50% flowering	Days to maturity	Panicle length (cm)	Racillae/ panicle	Spikelets/ panicle	Sterility percentage	Flag leaf angle(^{0})	Flag leaf length (cm)	Spikelet length (mm)	Length-breadth ratio	1000 grain weight (g)	Yield (ton ha^{-1})
Radhunipagol	148.1b	12.53 d	9.76 b	94.33 a	124.0 a	26.32ab	13.47 a	327.0 a	12.58 bc	26.19 b	37.26a	6.43 c	4.62 a	11.68 a	3.34a
Chinigura	136.2c	16.17 b	11.00 ab	95.33 a	124.7 a	24.30 d	10.02 c	224.3 c	12.00 bc	17.73 d	29.00c	6.37 c	3.87 b	10.34 d	3.43ab
Kataribhog	133.7c	14.33 c	10.76 ab	94.67 a	124.7 a	28.45 a	14.00 a	316.7 ab	14.11 ab	24.31 c	34.43b	6.59 b	4.51 a	9.48 e	3.72 a
Begunbichi	153.3a	15.20 bc	11.21 ab	90.33 b	121.0 b	26.75 b	11.99 b	203.9 d	12.19 bc	29.43 a	26.62d	6.42 c	4.55 a	9.23 f	3.16 b
Kalozira	146.4b	17.77 a	11.99 a	95.67 a	125.7 a	25.72 c	13.25 a	163.0 e	10.27 c	25.10 bc	26.58d	6.10 d	3.73 c	11.21 b	3.13 b
Badshabhog	136.4c	16.20 b	12.05 a	95.33 a	124.0 a	24.50 d	10.60 c	305.3 b	16.00 a	29.40 a	33.40b	6.73 a	4.57 a	10.61 c	3.74 a
LSD	2.61	1.40	1.71	1.39	1.99	o.82	0.99	13.99	2.81	1.18	1.60	0.08	0.12	0.21	0.41
Range	133.7-153.3	12.53-17.77	9.76-12.05	90.33-95.67	121-125.7	24.30-28.45	10.02-14.00	163-327	10.27-16.00	17.73-29.43	26.58-37.26	6.10-6.73	3.73-4.62	9.23-11.68	3.13-3.74

Mean values having same letter did not differ significantly when tested against DMRT at 0.05 level of probability

Table 2.Estimation of genetic variability parameters on fifteen characters in aromatic rice

Characters	Genotypic variance (σ^2g)	Phenotypic variance (σ^2p)	GCV (%)	PCV (%)	Heritability (%)	GA	GA in 1% mean
Plant height (cm)	63.00	65.07	5.57	5.67	96.81	16.08	11.30
Tillers/hill	3.04	3.64	11.35	12.42	83.60	3.28	21.34
Effective tillers/hill	0.42	1.31	5.84	10.28	32.26	0.76	6.83
Days to 50% flowering	3.77	4.36	2.06	2.22	86.51	3.72	3.95
Days to maturity	2.13	3.33	1.18	1.47	63.99	2.41	1.94
Panicle length(cm)	2.30	2.51	5.84	6.19	91.83	3.0	11.53
Rachillae /panicle	2.56	2.86	13.11	13.85	89.54	3.12	25.55
Spikelets /panicle	4681.97	4741.08	26.66	26.82	98.75	140.06	54.57
Sterility (%)	3.07	5.47	13.64	18.19	56.26	2.71	21.07
Flag leaf angle (◦)	18.44	18.866	16.93	17.13	97.74	8.75	34.50
Flag leaf length(cm)	19.55	20.33	14.16	14.44	96.18	8.93	28.62
Spikelet length(mm)	0.045	0.047	3.29	3.36	95.74	0.42	6.64
Spikelet L/B	0.15	0.16	9.15	9.30	96.89	0.80	18.55
1000-grain wt(g)	0.90	0.91	9.12	9.18	98.47	1.94	18.63
Yield(t/ha)	0.08	0.13	8.61	10.88	62.58	0.48	14.04

GCV= Genotypic coefficient of variation, PCV=Phenotypic coefficient of variation, GA=Genetic Advance

Table 3. Phenotypic correlation (r_{ph}) of different characteristics of aromatic rice

	PH	T/H	ET/H	DF	DM	PL	R/P	Sp/P	St. P	FLA	FLL	Sp. L	L/B	TGW	YLD
PH	1														
T/H	-0.127	1													
ET/H	-0.145	0.909*	1												
DF	-0.671	-0.287	0.176	1											
DM	-0.565	0.303	0.127	0.953**	1										
PL	0.114	-0.492	0.407	-0.373	0.180	1									
R/P	0.255	-0.407	0.389	-0.056	0.165	0.832*	1								
Sp/P	-0.429	-0.749	0.527	0.179	0.037	0.261	0.184	1							
St. P	-0.558	-0.264	0.078	-0.097	-0.131	0.704	0.239	-0.760	1						
FLA	-0.466	-0.136	0.224	-0.478	-0.537	0.232	0.233	0.168	0.369	1					
FLL	-0.350	-0.767	-0.606	-0.298	0.190	0.237	0.300	0.964**	0.597	0.103	1				
Sp.L	0.508	0.397	0.072	0.049	-0.266	0.082	0.233	0.789	0.976**	0.325	0.607	1			
L/B	0.093	0.742	0.402	0.465	-0.582	0.420	0.199	0.951**	0.687	0.652	0.639	0.763	1		
TGW	0.130	-0.050	0.151	0.589	0.553	-0.429	0.111	0.502	-0.223	-0.078	0.331	0.336	0.234	1	
YLD	-0.862*	-0.192	0.819	0.820	0.948**	0.641	0.163	0.755	-0.886*	-0.033	0.630	0.854*	0.409	0.980**	1

PH=Plant Height,T/H=Tillers/hill, ET/H=Effective tillers/hill, DF=Days to 50% flowering. DM=Days to maturity, PL=Panicle Length, R/P=Racillae/panicle, Sp/P=Spikelets /panicle, St.P=Sterility percentage, FLA=Flag leaf angle, FLL=Flag leaf length, Sp.L=Spikelets length, L/B=length-breadth ratio, TGW=Thousand grain weight and YLD=Yield.

**Significant at 0.05 of probability, **Significant at 0.01 of probability*

Yield is an important trait being affected by various interrelated traits. Therefore planning a protocol for increased yield might not be effective until other yield attributes influencing directly or indirectly are taken under consideration. The character association among the considered genotypes is shown in Table 3 above. Tillers hill^{-1} at the maximum vegetative stage showed the negative association with the plant height (r= -0.127). The effective tillers hill^{-1} showed the negative association with the plant height (r= -0.145). It had a significant association with the tillers hill^{-1} (r=0.909*).

The days to 50% flowering showed the negative association with the plant height (r= -0.671) and tillers hill^{-1} (r= -0.287). It had positive association with the effective tillers hill^{-1} (r=0.176).

The days to maturity showed the negative insignificant association with the plant height (r= -0.565). It had positive association with the tillers hill^{-1} (r=0.303) and effective tillers hill^{-1} (r=0.127). It showed highly positive association with the days to 50% flowering (r=0.953**).

The panicle length showed the positive association with the plant height (r=0.114), effective tillers hill^{-1} (r= 0.407) and days to maturity (r= 0.180). It had negative association with the tillers hill^{-1} (r= -0.492) and days to 50% flowering (r= -0. 373). The rachillae panicle^{-1} showed the positive association with the plant height (r= 0.255), effective tillers hill^{-1} (r= 0.389) and days to maturity (r= 0.165). It had negative association with the tillers hill^{-1} (r= - 0.407), and days to 50% flowering (r= -0.056). It showed positive association with the panicle length (r=0.832*). The spikelets panicle^{-1} showed the positive association with the effective tillers hill^{-1} (r= 0.527), days to 50% flowering (r= 0.179), days to maturity (r= 0.037), panicle length (r=0.261) and rachillae panicle^{-1} (r=0.184). It had negative association with the plant height (r= -0.429) and tillers hill^{-1} (r= - 0.749). The sterility percentage showed the positive association with the effective tillers hill^{-1} (r= 0.078), panicle length (r=0.704) and rachillae panicle^{-1} (r=0.239). It had negative association with the plant height (r= -0.558), tillers hill^{-1} (r= - 0.264), days to 50% flowering (r= -0.097), days to maturity (r= -0.131) and spikelets panicle^{-1} (r= -0.760).

Flag leaf length showed the positive insignificant association with the days to maturity (r= 0.190), panicle length (r=0.237), rachillae panicle^{-1} (r=0.300), sterility percentage (r=0.597) and flag leaf angle (r=0.103). It had negative association with the plant height (r= -0.350), tillers hill^{-1} (r= - 0.767), effective tillers hill^{-1} (r= -0.606) and days to 50% flowering (r= -0.298). It showed highly positive association with the spikelets panicle^{-1} (r= 0.964**).

1000-grain weight showed the positive association with the plant height (r=0.130), effective tillers hill^{-1} (r=0.151), days to 50% flowering (r=0.589), days to maturity (r=0.553), rachillae panicle^{-1} (r=0.111), spikelets panicle^{-1} (r= 0.502), flag leaf length (r=0.331), spikelet length (r=0.336) and length-breadth ratio (r=0.234). It had negative association with the tillers hill^{-1} (r= -0.050), panicle length (r= -0.429), sterility percentage (r= -0.223) and flag leaf angle (r= -0.078).

Yield showed the positive association with the effective tillers hill^{-1} (r=0.819), days to 50% flowering (r=0.820), panicle length (r= 0.641), rachillae panicle^{-1} (r=0.163), spikelets panicle^{-1} (r= 0.755), flag leaf length (r=0.630), and length-breadth ratio (r=0.409). It had negative association with the tillers hill^{-1} (r= -0.192) and flag leaf angle (r= -0.033). It showed highly positive association with the days to maturity (r=0.948**), spikelet length (r=0.854*) and thousand grain weight (r=0.980**). It had negative association with the plant height (r= -0.862*) and sterility percentage (r= -0.886*).

Positively correlated results indicated that increase of one trait will result in increase of the correlated trait and negative association of traits indicates that increase one character will decrease the negatively correlated character. Therefore, selection would be effective for increasing grain yield with simultaneous consideration of panicle length, spikelets panicle^{-1}, effective tillers/hill and 1000-grain weight. Previous report also indicated that harvest index, days to maturity and effective tillers hill^{-1}, 1000-grain weight; flag leaf area and panicle length should be given emphasis on the selection criteria for genetic improvement of rice yield [27].

4. CONCLUSION

The results of various characters studied in this experiment suggested that some good characters do exist in the local cultivars. Genetic variability parameters revealed that plant height, number of tillers hill^{-1}, effective tillers, days to maturity, panicle length, rachillae panicle^{-1},

spikelets panicle^{-1}, sterility percentage, flag leaf length, spikelet length, 1000-grain weight, and yield can be improved by proper selection. The desirable characters may be transfer in the modern varieties by using appropriate breeding techniques for developing superior varieties of rice and play an important role in meeting the global demand.

COMPETING INTERESTS

It is declared that the authors have no competing interests as defined by the publisher, or other interests that might be perceived to influence the results and/or discussion reported in this article.

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