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Analysis of Yield Components and Aroma of Small Grain Aromatic Rice *(Oryza sativa* L.) in Bangladesh

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Abstract

The study was conducted to evaluate the extent of variability among the small grain aromatic (SGA) rice *(Oryza sativa* L.) genotypes for yield and yield components. Twenty four popular SGA rice genotypes were evaluated for yield and yield contributing characters in BRAC Agricultural Research and Development Centre, Gazipur, Bangladesh. BRRI dhan34 was used as check variety. Highest grain yield per plant was observed in Chinikanai-1, which was followed by Kalijira PL-9, Kalijira PL-3 and Badshabhog. Chinikanai-1 had the highest number of grains per panicle. Correlation analysis revealed that the number of panicles per plant (r = 0.646) and number of grains per panicle (r = 0.525) had the positive contribution to grain yield. Based on sensory test, it was found that 18 genotypes were scented and six were lightly scented. After evaluation of yield components, four genotypes namely Chinikanai-1, Kalijira PL-9, Kalijira PL-3 and Badshabhog were selected as outstanding genotypes, which can be used as potential breeding materials for sub-tropical environment of Bangladesh.

Keywords: Aromatic rice, grain yield, yield component, small grain rice

1. Introduction

Aromatic rice *(Oryza sativa* L.) is preferred by consumers all over the world due to its flavor and palatability. Small grain aromatic (SGA) rice has been the chief ingredients for preparation of many fabulous dishes in Bangladesh and Eastern India. The important feature of this group of rice is its palatable aroma which has been considered as a high value trait for rice. Grain quality of rice plays an important role in consumers' acceptability and after yield, it is the second major breeding consideration (Jewel *et al.*, 2011). Low yield is a common character of aromatic rice and consequently rice breeders are trying to develop the agronomic traits to gain better grain yield. The success stories on the improvement of SGA rice is very much limited except BRRI dhan34. The weaknesses are photoperiod sensitivity, poor yield potential, susceptibility to lodging, pests and diseases, and severe lodging (Golam *et al*., 2011). Agronomic value of rice depends on increase grain yield and its associated traits such as panicles per plant, grains per panicle, and thousand grain weight.

Genotypic evaluation of yield components has identified their relationship with grain yield and it is helpful to identify superior SGA genotype(s) for improvement (Tahir *et al.*, 2002). Correlation analysis of characters can be used as tool for indirect selection. Correlation studies help the

plant breeders during selection and provide an understanding of yield components. Therefore, this study was conducted to evaluate the extent of variability among the SGA rice genotypes for yield and its contributing traits.

2. Materials and Methods

Twenty four small grain aromatic rice genotypes including a standard check variety (BRRI dhan34) were grown at BRAC Agricultural Research and Development Centre (BARDC), Gazipur, Bangladesh during Aman season 2012. The experiment was laid out in a Randomized Complete Block Design with three replications. The climatic condition was hot and humid with frequent rain during vegetative phase, and cold and dry during the reproductive and ripening phase (Table 1).

Seeding was done on 05 August 2012 and 30 days old seedlings were transplanted. Twenty cm distance was maintained between the rows and 15 cm between the plants. Single seedling was used for transplanting and unit plot size was 3.24 m^2. TSP and MoP were applied at the rate of 100 Kg/ha and 60 Kg/ha, respectively during final land preparation. Urea was applied at the rate of 120 Kg/ha in two splits at 10 and 30 days after transplanting. A hand weeding was done at 25 days after transplanting.

Data on days to 50% flowering was recorded. Five plants were randomly selected excluding border rows and any missing plants in a plot for data on plant height (cm), tillers per plant, panicle per plant, panicle length (cm), grains per panicle, sterility percentage, thousand grain weight (g), spikelet length (mm), spikelet breadth (mm) and grain yield per plant (g). Thousand grain weight and grain yield per plant were adjusted to 14% moisture.

Grain aroma was assessed by a panel consisting of three members following the procedure described in the Thirteenth International Fine Grain Aromatic Rice Observational Nursery of the International Network for Genetic Evaluation of Rice (INGER) coordinated by IRRI (IRFAON, 2012). In brief, few grains were de-hulled, then carefully crushed between the teeth and inhaled the smell slowly to detect the presence and intensity of aroma. Then all the SGA varieties were scored for aroma intensity based on the scale of the Standard Evaluation System for Rice (IRRI, 2002).

Data were analyzed using PLBSTAT Version 2N (Utz, 2007) and Microsoft Excel. Analysis of variance was used to test the significance of variance sources, while DMRT test ($p = 0.05$) was employed to compare the differences among treatment means. The correlation coefficient analysis was conducted to find the relationship of different traits.

3. Results and Discussion

3.1. Plant height

Plant height varied significantly among the genotypes (Table 2). Coefficient of variation for plant height was 3.53% (Table 2). Similar result was reported by Kole and Hasib (2008). Plant height ranged between 92 to 133 cm (Table 3). Robin and Saha (2015) recorded slightly higher plant height for Kalijira (127 cm). This is possibly due to late seeding of the SGA genotypes. Minimum plant height was recorded in Sakkorkhora, while maximum height was observed in Chinikanai-1.

3.2. Number of tillers per plant

Genetic differences were significant at 1% level among rice genotypes in respect of number of tillers per plant (Table 2). Coefficient of variation for number of tillers per plant was 20.09% (Table 2). The number of tillers per plant ranged from 7 to 14 (Table 3). Minimum and maximum number of tillers was observed in Begun bichi and Tilkapur, respectively.

3.3. Number of panicles per plant

There were significant variations among the genotypes for number of panicles per plant (Table 2). Coefficient of variation for number of panicles per plant was 20.84% (Table 2).

Table 1. Meteorological data recorded at the experimental site during the study period

Month	Air temp (%)		Rainfall (mm)	Relative humidity (%)		Sunshine (hrs/day)	Cloudy (hrs/day)	Solar radiation (gm/cal/cm^2/day)
	Max	Min		9 am	2 pm			
Aug-2012	32.4	26.7	18.18	85.39	73.72	5.80	7.10	351.14
Sep-2012	32.4	26.9	15.51	84.13	77.53	4.15	8.05	276.94
Oct-2012	31.9	24.0	0.73	78.06	64.29	6.70	4.79	337.78
Nov-2012	28.4	18. 6	2.39	76.07	57.63	7.08	4.29	292.18
Dec-2012	23.7	13.7	0.12	90.13	65.52	4.43	6.17	216.17

Table 2. Genotypic variations of agronomic traits in 24 SGA rice genotypes of Bangladesh

Source of variation	DF	GYP	PH	TILL	PN	PL	50F	G	S (%)	TGW	SL	SB
Genotype	23	37.99**	266.93**	11.96**	10.78**	8.06**	47.01**	3352.32**	117.11**	0.800**	0.49**	0.13**
Replication	2	27.43^{NS}	26.01^{NS}	12.60^{NS}	6.29^{NS}	7.10^{NS}	5.10^{NS}	643.76^{NS}	2.20^{NS}	0.004^{NS}	0.05^{NS}	0.01^{NS}
Error	46	10.73	15.88	4.51	3.68	2.47	0.47	495.59	31.32	0.004	0.09	0.02
Mean		15.20	113.03	11.00	9.00	24.15	78.31	155.00	15.16	11.00	6.11	2.28
CV (%)		21.56	3.53	20.09	20.84	6.51	0.88	14.32	36.92	1.830	5.00	5.96

** indicate significantly different at 1%, NS: not significant. Indicators: GYP=grain yield per plant (g), PH=plant height, TILL=tillers per plant, PN=panicles per plant, 50F=days to 50% flowering, PL=panicle length, G=grains per panicle, S (%) =grain sterility (%), TGW=thousand grain weight (g), SL=spikelet length and SB=spikelet breadth

Table 3. Mean comparison of different traits the genotypes through Duncan Multiple Range Test (DMRT)

Genotypes	GYP (g)	PH (cm)	TILL (no.)	PN	PL (cm)	50F	G	S (%)	TGW (g)	SL (mm)	SB
Chinikanai-1	21.24 a	133.00 a	13ab	9 a-f	26.00 a-c	80 de	219 a	08.01 e	10.8 g	5.96 b-f	2.17 e-i
KalijiraPL-9	19.96ab	110.00 e-i	9 b-e	9 a-f	22.67 d-f	79ef	203ab	11.23 de	11.1fg	6.29 b-e	2.51bc
Kalijira PL-3	19.30 a-c	113.33 c-h	12 a-d	11 a-c	24.00 b-f	77gh	167 b-d	13.63 c-e	10.3 hi	6.11 b-f	2.45 b-d
Badshabhog	19.18 a-c	112.67 c-h	13 a-c	12 a	25.33 a-d	79 f	159 cd	11.78 de	9.8jk	5.78 c-f	2.43 b-e
BRRI dhan34	17.25 a-d	107.00 g-i	10 a-e	10 a-e	25.00 a-d	77 h	177bc	19.37 b-d	10.0ij	5.89 b-f	1.98 i
Begun bichi	07.80 g	115.67 c-f	7 e	7 d-f	21.00 f	71 kl	120 e-g	23.54 a-c	9.6 kl	5.71 d-f	2.1 g-i
Binnaful	15.74 a-e	103.33 i	9 b-e	9 a-f	21.33ef	82bc	153 c-e	19.24 b-d	11.9 d	5.95 b-f	2.42 b-e
BR5 (Dulabhog)	10.93 d-g	107.33 g-i	8 de	8 b-f	27.33 a	78 f	132 d-f	20.52 b-d	10.3 hi	6.38bc	2.02 hi
Chinikanai-2	15.11 a-f	126.00 b	8 de	6ef	25.00 a-d	82bc	201ab	09.97 de	11.6 de	5.85 b-f	2.20 d-i
Chinigura	14.15 b-f	114.67 c-g	9 c-e	8 c-f	23.67 b-f	81 c	200ab	16.98 b-e	9.4 l	5.94 b-f	2.01 hi
Chinigura PL-2	14.19 b-f	107.00 g-i	11 a-e	9 a-e	23.33 c-f	81 cd	159 cd	06.74 e	9.4 l	5.87 b-f	1.97 i
Kalijira (Normal)	18.47 a-c	106.33 hi	12 a-d	12ab	24.67 a-d	82bc	180bc	16.30 b-e	8.9 m	6.27 b-e	2.26 c-h
Kalijira (Thin type)	16.60 a-d	108.00 f-i	13ab	11 a-d	23.67 b-f	78 f	146 c-f	13.06 c-e	10.9 g	6.42 b	2.38 b-f
Kalijira PL-1	16.20 a-d	117.67 cd	11 a-e	10 a-e	21.33ef	81 cd	151 c-f	12.33 de	10.9 g	6.11 b-f	2.44 b-d
Kalijira (White type)	11.04 d-g	119.00 cd	10 a-e	8 b-f	22.33 d-f	75 i	137 d-f	06.49 e	9.8jk	5.59 f	2.12 f-i
Kalijira (Late)	12.83 c-g	115.67 c-f	12 a-d	11 a-d	25.33 a-d	85 a	88 g	32.69 a	13.6 c	5.69ef	2.62ab
Kalijira PL-6	16.52 a-d	109.00 e-i	9 b-e	9 a-f	25.33 a-d	78fg	178bc	12.64 c-e	10.4 h	6.31 b-d	2.40 b-e
Kaloshailla	18.25 a-c	135.33 a	11 a-e	11 a-d	24.33 a-e	73 j	113fg	14.90 b-e	15.5 a	7.39 a	2.30 c-g
Parbatjira	13.97 b-f	102.33 i	9 c-e	8 b-f	23.33 c-f	83 b	169 b-d	19.75 b-d	9.7jk	6.08 b-f	2.09 g-i
Sakkorkhora	09.25fg	92.33 j	13ab	5 f	25.00 a-d	82bc	118 e-g	25.37ab	14.7 b	6.94 a	2.76 a
Tilkapur	16.98 a-d	116.33 c-e	14 a	12 a	23.33 c-f	80 de	120 e-g	16.05 b-e	11.4ef	5.95 b-f	2.21 d-i
Tulshimala	15.22 a-f	109.33 e-i	8 de	8 c-f	26.67ab	73 j	179bc	12.28 de	11.1fg	6.17 b-f	2.4 b-e
Tulshimala PL-1	14.96 a-f	119.67bc	11 a-e	11 a-c	25.33 a-d	71 l	117 e-g	11.20 de	11.6 de	6.15 b-f	2.19 d-i
Tulshimala PL-3	09.55 e-g	111.67 d-h	8 e	7ef	24.33 a-e	72jk	145 c-f	09.64 de	10.0 h-j	5.74 d-f	2.21 d-i
Minimum	7.80	92	7	5	21	71	88	6.49	8.9	5.59	1.97
Maximum	21.24	135	14	12	27.33	85	219	32.69	15.5	7.39	2.76
$LSD_{0.05}$	5.38	6.55	3.49	3.15	2.59	1.13	36.59	9.2	0.3	0.5	0.22

Mean followed by the same latter in a column are not significantly different from each other at 0.05 % probability level. Indicators: GYP = grain yield per plant (g), PH = plant height, TILL = tillers per plant, PN = panicles per plant, 50F = days to 50% flowering, PL = panicle length, G = grains per panicle, S (%) = grain sterility (%), TGW = thousand grain weight (g), SL = spikelet length (mm) and SB = spikelet breadth

The number of panicles per plant ranged from 5 to 12 (Table 3). Minimum number of panicles was observed in Sakkorkhora and maximum in Kalijira (Normal) and Badshabhog.

3.4. Days to 50% flowering

A significant variation was observed among the genotypes and coefficient of variation for days to 50% flowering was 0.88% (Table 2). Days to 50% flowering ranged from 71 to 85 days as the SGA genotypes under this study were strongly photoperiod sensitive (Table 3). The minimum days to 50 % flowering were observed in Begunbichi and Tulshimala PL-1, while the maximum value was recorded in Kalijira (Late). Weiya *et al.* (2008) also observed variations in heading days among several genotypes and they identified a regulatory gene responsible for this variation.

3.5. Panicle length

Significant variation was observed in length of panicle among the genotypes at 1% levels (Table 2). Coefficient of variation for panicle length was 6.51 % (Table 2). Panicle length displayed moderate values for coefficient of variation. Kole and Hasib, (2008) also showed the similar results. The data for panicle length ranged from 21.0 to 27.3 cm (Table 3). The minimum panicle length was recorded in Begunbichi while maximum panicle length in BR5 (Dulabhog). Ifftikhar *et al.* (2009) studied genetic variability for various traits and found that this trait is under the genetic control and could be used in the selection process of some desirable traits.

3.6. Grains per panicle

Significant genetic variation among genotypes was found for number of grains per panicle at 1% level (Table 2). Coefficient of variation for filled grains per panicle was 14.32% (Table 2). Higher coefficient of variation for filled grain was also observed by Golam *et al.* (2011). Number of filled grains per panicle ranged from 88 to 219 (Table 3). The least number of filled grains per panicle was observed in the genotype Kalijira (Late), while the maximum was in Chinikanai-1.

3.7. Grain sterility (%)

A significant genetic variation was observed among the genotypes for the trait (Table 1). Coefficient of variation for grain sterility was 36.92% (Table 2). The grain sterility ranged from 6.49 to 32.69 (Table 3). Minimum and maximum grain sterility were observed in Kalijira (White) and in Kalijira (Late), respectively. The reason for 32.69% grain sterility of Kalijira (Late) was the prevailing low night temperature during flowering and grain filling stage.

3.8. Thousand grain weight

Significant variation was observed among the tested genotypes for thousand grain weight (Table 2). Coefficient of variation for 1000 grain weight was 1.83% (Table 2). The thousand grain weight ranged from 8.9 g to 15.5 g (Table 3). Minimum thousand grain weight was recorded in Kalijira (Normal), while maximum in Kaloshailla.

3.9. Spikelet length

Sspikelet lengths varied significantly among the genotypes (Table 2). Coefficient of variation for spikelet length was 5.00% (Table 2). Spikelet length ranged between 5.59 to 7.39 mm (Table 3). Minimum spikelet length was recorded in Kalijira (White type), while maximum was observed in Kaloshailla.

3.10. Spikelet breadth

Genetic differences were significant at 1% level among rice genotypes for spikelet breadth (Table 2). Coefficient of variation for this trait was 5.96% (Table 2). Spikelet breadth ranged from 1.97 to 2.76 mm (Table 3). Minimum and maximum spikelet breadth was observed in Chinigura PL-2 and Sakkorkhora, respectively.

3.11. Grain yield per plant

The genotypes were significantly different for this trait at 1% level (Table 2). Coefficient of variation for grain yield per plant was 21.56% (Table 2) which indicates considerable variations among the genotypes. Higher coefficient of variation was also recorded for grain yield per

plant (Kole and Hasib, 2008). Grain yield per plant ranged from 7.80 to 21.24 g (Table 3). Robin and Saha (2015) found grain yield of 8.59 g per plant in Kalijira genotype which was much lower than that in the present findings. Minimum grain yield per plant was recorded in Begun bichi and maximum was recorded in Chinikanai-1. Begun bichi showed least grain yield per plant due to higher spikelet sterility (23.54%) and lower thousand grain weight (9.6 g).

3.12. Comparison of agronomic characters

SGA rice varieties showed significant differences in respect of 11 characters (Table 3). This was expected because these are landraces and are grown in different areas of Bangladesh. As compared with the check variety BRRI dhan34; Chinikanai-1, Kalijira PL-9, Kalijira PL-3 and Badshabhog were observed as the four top yielders (Table 3). The yield potential of these genotypes can be explained based on the larger number of panicles (Badshabhog), grains per panicle (Chinikanai-1 and Kalijira Pl-9) and increased panicle length (Chinikanai-1). Kalijira is a popular and a well accepted Bangladeshi aromatic rice variety. Comparison of agronomic characters of four selected outstanding genotypes along with standard check BRRI dhan34 is presented in Table 3.

3.13. Correlations analysis

Out of 11 characters, only three viz. number of tillers per plant, number of panicles per plant and grains per panicle showed positive and significant correlations with grain yields (Table 4). Positive relation of grain yield with panicles per plant was also reported by Golam *et al.* (2011). Negative correlation between panicles per plant and grain yield was reported by Zia-ul-qamar *et al.* (2005), which do not support the present findings. Although significant negative correlation was observed between grain sterility (%) and grains per panicle. Plant height had no significant correlation with grain yield. However, number of tillers per plant, panicle length, spikelet length and spikelet breadth showed positive correlation with yield. However, no significant correlation was observed between the above mentioned traits and yield in this study although their trend was positive. Golam *et al.* (2011) reported positive contribution of grains per panicle towards grain yield, which supports the present finding.

Table 4. Correlation coefficients among the agronomic traits using genotypes means

Traits	PH	TILL	PN	50F	PL	G	%S	HSW	SL	SB
TILL	0.042									
PN	0.219	0.616**								
50F	-0.291	0.333	0.066							
PL	0.045	0.136	0.027	-0.047						
G	0.058	-0.196	-0.163	0.207	0.098					
%S	-0.364	0.03	-0.083	0.316	0.032	-0.503*				
HSW	0.194	0.295	-0.058	0.029	0.144	-0.493*	0.369			
SL	-0.016	0.231	0.018	-0.096	0.220	-0.171	0.121	0.632**		
SB	-0.221	0.398	0.064	0.226	0.020	-0.226	0.295	0.590**	0.347	
YIELD	0.327	0.454*	0.646**	0.19	0.132	0.525**	-0.377	-0.022	0.165	0.128

** indicate significant at 1% level of probability, * indicate significant at 5% level of probability, ns: not significant. Indicators: GYP=grain yield per plant (g), PH=plant height, TILL=tillers per plant, PN=panicles per plant, 50F=days to 50% flowering, PL=panicle length, G=grains per panicle, S (%) =grain sterility (%), TGW=thousand grain weight (g), SL=spikelet length and SB=spikelet breadth

Table 5. Aroma score of 24 SGA genotypes based on sensory test

Genotypes	Aroma Score	Remarks
Chinikanai-1	2	Scented
Kalijira PL-9	2	Scented
Kalijira PL-3	2	Scented
Badshabhog	2	Scented
BRRI dhan34	2	Scented
Begun bichi	1	Lightly scented
Binnaful	1	Lightly scented
BR5 (Dulabhog)	2	Scented
Chinikanai-2	1	Lightly scented
Chinigura	2	Scented
Chinigura PL-2	2	Scented
Kalijira (Normal)	2	Scented
Kalijira (Thin type)	2	Scented
Kalijira PL-1	2	Scented
Kalijira (White type)	1	Lightly scented
Kalijira (Late)	2	Scented
Kalijira PL-6	2	Scented
Kaloshailla	1	Lightly scented
Parbatjira	1	Lightly scented
Sakkorkhora	2	Scented
Tilkapur	2	Scented
Tulshimala	2	Scented
Tulshimala PL-1	2	Scented
Tulshimala PL-3	2	Scented

3.14. Grain aroma

Grain aroma test revealed that all the genotypes possessed scent. On the basis of intensity of aroma, the SGA varieties were grouped in two viz, scented and lightly scented. Within the 24 SGA genotypes, only six were lightly scented and 18 were scented (Table 5). The highest yielding four SGA genotypes - Chinikanai-1, Kalijira Pl-9, Kalijira Pl-3 and Badshabhog were in scented group. Jewel *et al*. (2011) also found different aroma intensity in the genotypes.

4. Conclusions

Some of the 24 SGA rice genotypes performed better in terms of aroma score and yield related traits. Correlation analysis revealed that two agronomic traits such as number of panicles per plant (0.646) and grains per panicle (0.525) had the positive contribution to grain yield. Days to 50% flowering, plant height, panicle length, spikelet length, and spikelet breadth had positive correlation with yield. The varieties Chinikanai-1, Kalijira PL-9, Kalijira PL-3 and Badshabhog were identified as high yielders among the genotypes. The selected rice genotypes can be used as potential breeding materials to develop aromatic quality rice in Bangladesh and even for other sub-tropical countries.

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