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Estimation of Grain Quality Components and their Correlation of Basmati Rice (*Oryza sativa* L.)

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ABSTRACT

Variability and correlation for twelve grain characters (before cooking) and eight characters (after cooking) on distinct six lines viz. S1, S2, S5, 42(i), 42(ii) and 44(i) of Basmati rice were studied. Before cooking, the maximum hulling (%), milling outturn (%) and head rice recovery were recorded in S2 genotype. The highest kernel length and breadth of rice were also found in S2, whereas the highest kernel length and breadth ratio (L/B) of brown, rough and milled rice were observed in S2, S1 and S5 genotypes, respectively. After cooking, the highest kernel length and breadth were recorded in S2, while the highest length and breadth ratio was noted in 42(ii) genotype. The highest kernel elongation ratio and volume expansion were recorded in S5. The maximum alkaline spreading value and the minimum cooking time were found in S2. The L/B ratio of rough rice exhibited significant positive relationship with L/B of brown, milled and cooked rice.

Keywords: Variability, correlation, grain quality components, Basmati rice

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INTRODUCTION

Rice (*Oryza sativa* L.; 2n=24) belonging to the family Gramineae is one of the important cereal crops. Bangladesh is the fourth largest producer and consumer of rice in the world, with annual production of 33.834 million metric tons (BBS, 2013). It occupies 74.77% of total cropped areas and it alone constitutes about 90% of the total food grain produced annually in the country (BBS, 2010).

Consumer demand for the fine rice varieties is high due to its good nutritional quality, palatability, aroma and taste. The demand of basmati rice has been increasing in Bangladesh as the country is approaching more prosperous in rice production (BRRI, 2004). The climatic condition of Bangladesh is also suitable to produce quality Basmati rice. Besides yield, the grain quality of rice is the most important factor for deciding the profitability of the farmers as the grain quality decides the price in the market. Juliano and Duff (IRRI, 1991) reported that grain quality is second after yield as the major breeding objective for crop improvement. Quality of rice may be considered from the view point of size, shape and appearance of grain, milling quality and cooking properties (Dela Cruz & Khush, 2000). Quality of rice mainly depends on its intended end use by the consumers. All consumers want the best quality that they can afford. Traditionally, plant breeders concentrated on breeding for high yields. The quality of rice grain is not only dependent on the variety or genotype, but it also depends on the crop production environment, harvesting, processing and milling systems. As for example, the rice millers prefer varieties with high milling whereas consumers consider physicochemical characteristics (Meca & Juliano, 1981). The amylose content of rice is considered as the main parameter of cooking and eating quality (Juliano, 1972). Intermediate to high amylose rice with low to intermediate gelatinization temperature is preferred. Therefore, grain quality should be acceptable to farmers. However, there is very few information on qualitative data on before and after cooking in rice.

Conceiving the above scheme in mind, the research work has been undertaken in order to study the milling, cooking and eating quality and grain appearance of different advance lines of Basmati rice.

MATERIALS AND METHODS

The experiment was conducted at the Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. Six different lines viz. S1, S2, S5, 42 (i), 42(ii), 44 (i) of Basmati rice and one check variety namely BRRI dhan29 were used as experimental material. The experiment was laid out in a randomized complete block design (RCBD) with three replications. A comparative laboratory analysis on quality characteristics was completed at the laboratory of Bangladesh Rice Research Institute and at the laboratory of Sher-e-Bangla Agricultural University, Bangladesh. From each entry 200 g well dried paddy was hulled in a mini “Satake Rice Machine” to get brown rice. The brown rice was passed through “Satake Rice whitening and caking machine” to obtain uniform polished grains. The polished samples were sieved to separate whole kernels from the broken ones. The samples comprising of full shape grains were used to proceed for the study. Kernels length and breadth of rough rice, brown rice, polished rice and cooked rice were measured by digital slide calipers. Ten whole kernels from each entry were used in each case. The size of polished grain was determined on the basis of average length viz. extra long (>7.50 mm), long (6.61 to 7.50 mm), medium (5.51 to 6.60 mm), short (5.50 mm to less) and shape was determined on the basis of length and breath ratio viz. slender (over 3.0), medium (2.1 to 3.0), bold (1.1 to 2.0) and round (1.0 or less) (Ahuja et al., 1995). Grain elongation ratio was computed by dividing the average length of cooked rice to the average length of raw rice. One gram milled rice kernels were used for the study of water absorption (uptake) percentage. The water absorption ratio was determined by weight of the sample was recorded before and after cooking. Volume expansion ratio was calculated as volume of cooked rice to volume of raw rice. The same procedure was repeated for each sample. For the measuring Gelatinizationtemperature sample from each entry was placed in small petriplates (5 cm wide) containing 10 ml of 1.7% potassium hydroxide (KOH) solution. The petriplates were covered and placed in an incubator maintained at 30 ± 1°c for 16 hours as suggested (Zaman, 1981). After 16 hours of incubation, the petriplates were gently taken out from the incubator. Alkali spreading values of six grains of each entry were recorded separately and mean was calculated on a seven point numerical scale viz. high (1 to 3), intermediate (3.1 to 5.9) and low (6 to 7) (Jennings et al., 1979). For determining cooking time stop watch was used. The analysis of variance for different quality characters was performed following analysis of variance technique. When F was significant at the $p < 0.05$ level, treatments means were separated using Duncan's multiple range test (Steel & Torii, 1960).

RESULTS AND DISCUSSION

From the analysis of variance, it was observed that highly significant variation existed for all the characters studied (Table 1). All the lines and check were showed clear-cut translucent endosperm appearance (Table 2). Grain appearance is largely determined by the endosperm opacity, the amount of chalkiness. IRRI (1979) classified the endosperm of rice based on endosperm opacity as waxy or non waxy. Waxy rice devoid of or have only trace of amylose content and are opaque. Non waxy rice has varying amylose level (2.1 to 32%) and are dull, hazy or translucent. Chalkiness is undesirable in all segments of rice industry. Breeders select intensively for clear, vitreous kernels. Chalky kernels break easily, reducing milling yields. The present results for quality traits are in agreement with the findings of Sandeep (2003). Grain size and shape are the first criteria for the quality of rice that breeders consider in developing new varieties for commercial production (Adair et al., 1973). All the genotypes studied were slender in shape and extra long in size (Table 2).

From the study of mean performance of quality characteristics before cooking (Table 3) the line S2 had the maximum hulling percent (76.20%), milling percent (66%) and Head Rice Recovery (HRR) percent (79.34%). The minimum hulling percent (63.85%) and milling percent (51%) were recorded in S1 line. The minimum HRR percent (63.01%) was also foud in S1. The milling per cent ranged from 51 to 66% but Ahuja et al. (1995) reported a range of 67 to 71 % for milling recovery in Basmati varieties. It assumes importance because it tells the actual yield of consumable product. A good milling quality includes high whole kernel recovery and less of broken rice. For the commercial success of a rice variety it must possess high total milled rice and whole kernel (HRR) turnout. If a variety possesses high broken percentage, its marketability will be reduced. The highest kernel length (12.61 mm) and breadth (2.63 mm) of rough rice were recorded in line S2, while the highest length and breadth (L/B) ratio was found in S1. The lowest kernel length (8.65 mm), breadth (2.19 mm) and L/B (4.13) ratio of rough rice were observed in check variety BRRI dhan29. In case of brown rice, the maximum kernel length and L/B ratio were recorded inS2 but the maximum breadth (1.92 mm) was observed in 42(i). The minimum Kernel length (6.20 mm), Breadth (1.81 mm) and

Table 1
Analysis of variance (ANOVA) for different quality traits (before and after cooking)

Sl. no.	Characters	df		Mean sum of square	
		Genotypes	Error	Genotypes	Error
	Before cooking				
1.	Hulling (%)	6	12	49.865**	7.56
2.	Milling outturn (%)	6	12	63.719**	9.667
3.	Head Rice Recovery (%)	6	12	95.862**	9.667
4.	Grain length of rough rice (mm)	6	12	5.661**	0.042
5.	Grain breadth of rough rice (mm)	6	12	0.084**	0.009
6.	Grain length/breadth ratio	6	12	0.556**	0.031
7.	Grain length of brown rice (mm)	6	12	3.312**	0.006
8.	Grain breadth of brown rice (mm)	6	12	0.005^{ns}	0.003
9.	Grain length/breadth ratio of brown rice	6	12	0.778**	0.013
10.	Grain length of milled rice (mm)	6	12	1.530**	0.021
11.	Grain breadth of milled rice (mm)	6	12	0.015**	0.001
12.	Grain length/breadth ratio of milled rice	6	12	0.490**	0.011
	After cooking				
1	Length of cooked rice (mm)	6	12	12.522**	0.098
2	Breadth of cooked rice (mm)	6	12	0.236**	0.041
3	Length/breadth ratio of cooked rice	6	12	1.762**	0.058
4	Cooking time (minutes)	6	12	5.857*	1.286
5	Elongation index	6	12	0.032*	0.009
6	Water uptake (%)	6	12	2913.714**	329.33
7	Volume expansion (%)	6	12	0.065**	0.008
8	Alkali spreading value	6	12	0.195**	0.024

* Significant at 5% level, ** Significant at 1% level, ns-non significant

Table 2
Endosperm appearances, size, shape, Alkali spreading value (ASV), Gelatinization Temperature (GT) of six advanced lines of basmati rice and check variety

Lines/ check	Endosperm appearance	Shape	Size	ASV	Alkali digestion	GT types
S1	Translucent	Slender	Extra long	6.00	High	Low
S2	Translucent	Slender	Extra long	7.00	High	Low
S5	Translucent	Slender	Extra long	4.25	Intermediate	Intermediate
42 (i)	Translucent	Slender	Extra long	4.59	Intermediate	Intermediate
42 (ii)	Translucent	Slender	Extra long	4.25	Intermediate	Intermediate
44 (i)	Translucent	Slender	Extra long	4.25	Intermediate	Intermediate
BRRI dhan29	Translucent	Slender	Extra long	3.83	Intermediate	Intermediate

Table 3
Mean performance of quality characteristics before cooking in different lines and check

				Rough rice			Brown rice			Milled rice (uncooked rice)		
Lines/ check	Hulling (%)	Milling (%)	Head Rice Recovery (%)	Length (mm)	Breadth (mm)	L/B ratio	Length (mm)	Breadth (mm)	L/B ratio	Length (mm)	Breadth (mm)	L/B ratio
S1	63.85 d	51.00 c	63.01 d	12.25 a	2.24 cd	5.48 a	8.57 d	1.85 ab	4.64 b	7.25 c	1.59 c	4.57 ab
S2	76.20 a	66.00 a	79.34 a	12.61 a	2.63 a	4.79 c	9.48 a	1.90 ab	5.00 a	8.05 a	1.79 a	4.50 b
S5	67.30 cd	56.00 bc	65.82 bcd	12.43 a	2.43 b	5.11 bc	9.06 b	1.87 ab	4.84 a	7.77 b	1.64 bc	4.75 a
42 (i)	69.20 bc	56.75 bc	67.50 bcd	12.27 a	2.34 bc	5.25 ab	8.73 c	1.92 a	4.55 b	7.60 b	1.69 b	4.49 b
42 (ii)	69.00 bc	56.50 bc	73.18 ab	11.45 b	2.25 bcd	5.08 bc	8.43 d	1.89 ab	4.45 bc	7.26 c	1.66 b	4.39 b
44 (i)	69.45 bc	56.93 bc	65.07 cd	11.66 b	2.31 bc	5.04 bc	8.19 e	1.91 ab	4.29 c	7.22 c	1.58 c	4.56 ab
BRRI dhan29	73.80 ab	60.50 ab	71.05 bc	8.65 c	2.19 d	4.13 d	6.20 f	1.81 b	3.43 d	5.82d	1.66b	3.51 c
Range	63.85-76.20	51-66	65.07-79.34	12.61-8.65	2.19-2.63	4.13-548	6.20-9.48	1.81-1.92	3.43-5.00	5.82-8.05	1.58-1.79	3.51-4.75
Mean	69.83	57.67	69.28	11.62	2.33	4.98	8.38	1.88	4.46	7.28	1.66	4.39
CV (%)	6.94	5.39	5.57	5.77	4.10	7.54	6.89	7.80	9.54	5.98	6.95	7.37

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

L/B ratio (3.43) of brown rice were noticed in check variety BRRI dhan29. In case of milled rice, the utmost kernel length (8.05 mm) and breadth (1.79 mm) were found in line S2 whereas, the utmost L/B ratio (4.75) was observed in S5. On the other hand the minimum kernel length (5.82 mm) and L/B ratio (3.51) of milled rice were found in check variety BRRI dhan29 and the minimum breadth (1.58) of milled rice was recorded in 44(i). Grains with short to medium length break less than the long grains during milling. Thus grain size and shape have direct effect on the yield of head rice. Shobha Rani (2003) reported that bold grains give low head rice recovery because of high breakage. Viraktamath (1987) observed that kernel breadth enhanced the milling output and HRR was strongly associated with milling percentage.

From the study of mean performance of quality characteristics after cooking (Table 4) the maximum length of kernel of cooked rice (13.38 mm) was obtained from line S5 which is statically identical to line S2 (13.36 mm) and the minimum length was observed (6.68 mm) in check variety BRRI dhan29. The range of kernel length of cooked rice of studied genotype was 10.15 to 13.38 mm. Shobha Rani (2003) reported that the kernel length after cooking of nine released hybrids of India ranged from 10.2 to 12.4 mm and Soroush et al. (2005) showed that the cooked kernel length varied from 10.62 to 12.32 mm, which were almost similar with the present study. These literatures supported the present study. During cooking rice grains absorb water and increase in volume through increase in length or breadth alone or length and breadth both.

Breadth wise splitting is not desirable whereas length wise splitting (grain elongation) on cooking without increase in girth is considered trait in high quality premium rice such as basmati, which elongate almost 100 per cent on cooking (Khush et al., 1986; Sidhu, 1989). The utmost kernel breadth of cooked rice (3.12 mm) was recorded from S_2 and the shortest (2.19 mm) from BRRI dhan29. The highest ratio of kernel L/B (5.21) was found in 42(ii) and the lowest ratio (3.05) was in BRRI dhan29. Sandeep (2003) reported that kernel L/B ratio of 20 new genotypes ranged from 2.04 to 3.95 after cooking. Considering this review, the studied genotypes were more superior. The highest kernel elongation ratio (1.72) was recorded in S5 and the lowest ratio (1.14) was in BRRI dhan29. Kernel elongation was primarily influenced by the kernel shape and size. The highest water absorption (294%) was recorded in line 44(i). The lowest water absorption (210%) was found in BRRI dhan29 which was statistically identical to S1 and S2 (Table 4). Water uptake is considered an important economic attribute of rice as it gives indirect measure of volume increase on cooking. Zaman (1981) reported that the good cooking rice varieties have water absorption value ranging between 174 and 275%. This result partially supported the present finding. He also reported that the majority of those showing pasty appearance have value as high as from 300 to 570%. The high water absorption is relatively less desirable characteristics and it would be desirable to select a variety or hybrid with moderate water absorption. According to Zaman (1981) water absorption rate of line S2 and S1 (214%) were moderate. The maximum volume expansion (4.41%) was found in S5 and the minimum (4.00%) was recorded in line 44(i). Volume expansion of kernels on cooking is considered another important measure of consumer preference. More volume of cooked rice from a given quantity is a matter of great satisfaction to an average rice consumer irrespective of the fact whether the increased volume is due to length-wise or breadth-wise expansion. Volume expansion by and large is determined by water uptake, however, subject to the influence of kernel texture (Zaman, 1981). The varieties which tend to show high volume expansion are sticky and give a pasty appearance on cooking. Invariably all the pasty cooking types have been found to be associated with higher water absorption. The pasty cooking closely related to high water absorption. Therefore, hybrids with low water absorption and high volume expansion are more desirable. Statistically significant variation was also recorded for alkaline spreading value for different advanced line of basmati rice (Table 4). The highest alkaline spreading value (7.00) was found in S2 and the lowest (3.83) was recorded in BRRI dhan29. Alkali spreading value is inversely related to gelatinization temperature (GT). GT is the range of temperature within which granules begin to swell irreversibly in hot water. Rice varieties having low GT start to swell

Table 4
Mean performance of quality characteristics after cooking in different lines and check

Lines/check	Cooked rice			Kernel	Water uptake	Volume	Alkali spreading	Cooking time
	Length (mm)	Breadth (mm)	L/B ratio	el. ratio	(%)	expansion (%)	value	(minute)
S1	11.95 c	2.96 a	4.04 b	1.64 a	214 c	4.30 a	6.01 b	17 b
S2	13.36 a	3.12 a	4.28 b	1.66 a	214 c	4.10 b	7.00 a	16 b
S5	13.38 a	2.97 a	4.50 b	1.72 a	254 b	4.41 a	4.25 d	17 b
42 (i)	12.67 b	2.44 b	5.21 a	1.67 a	250 b	4.10 b	4.59 cd	18 ab
42(ii)	10.15 d	2.39 b	4.25 b	1.39 b	260 b	4.29 a	4.25 d	17 b
44 (i)	11.80 c	2.75 ab	4.32 b	1.63 a	294 a	4.00 b	4.25 d	17 b
BRRI dhan29	6.68 e	2.19 a	3.05 c	1.14 c	210 c	4.30 a	3.83c	20 a
Range	6.68-13.36	2.19-3.12	3.05-5.21	1.14-1.72	210-294	4.00-4.41	3.83-7.00	16-20
Mean	11.57	2.792	4.18	1.55	242.27	4.214	5.026	17.429
CV (%)	5.70	7.21	5.74	8.60	7.49	6.10	5.38	6.51

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability at low temperature during cooking than the rice varieties having intermediate or high GT (Nagato & Kishi, 1966). Rice varieties having intermediate GT produces good quality cooked rice. The lowest cooking time (16 minutes) was found in line S2 and the highest (20 minutes) was recorded from BRRI dhan29. In order to find out the elongation ratio, the linear kernel elongation after cooking is compared to the original length of kernel before cooking (Irshad, 2001).

The nature and extent of association between various characters pairs relating to quality attributes are presented in a sample linear correlation analysis (Table 5). Correlation study reveals that in line hulling per cent had highly significant positive relationship with milling per cent, HRR per cent and with kernel breadth of milled rice. However, a significant negative relationship was observed with the L/B ratio of rough rice. Viraktamath (1987) found a similar correlation among these traits, which supports the finding of the present study. Milling per cent showed highly significant positive relationship with HRR per cent and Kernel breadth of milled rice. HRR per cent showed highly significant positive correlation with kernel breadth of milled rice and insignificant negative association with L/B ratio of rough rice, milled rice and cooked rice. Yadav and Singh (1989) also found HRR was negatively associated with the length/breadth ratio of rough rice, which supports the present study. Kernel length of rough rice exhibited highly significant positive relationship with the kernel length of brown rice, milled rice and cooked rice and the L/B ratio of rough rice, brown rice, milled rice and cooked rice. In addition, it also showed significant positive relationships with kernel breadth of rough rice and brown rice but with a significant negative relationship with elongation ratio. The kernel breadth of rough rice showed highly significant positive linear relationships with length and L/B ratio of brown rice, milled rice and cooked rice. The kernel L/B ratio of rough rice exhibited a significant positive relationship with the length and L/B ratio of brown rice, milled rice and cooked rice, although it showed a significant negative relationship with elongation ratio. The kernel length of brown rice exhibited highly significant positive relationships with the kernel length of milled rice and cooked rice and L/B ratio of brown rice, milled rice and cooked rice, although it showed a significant negative relationship with elongation ratio. The L/B of brown rice exhibited highly significant positive relationships with the length of milled rice, cooked rice and L/B of milled rice; it also showed significant positive relationship with the L/B ratio of cooked rice. The kernel length of milled rice exhibited highly significant positive relationships with the kernel length of cooked rice, L/B ratio of milled rice and cooked rice. The L/B ratio of milled rice exhibited highly significant positive relationships with kernel length and L/B ratio of cooked rice, but it showed a significant negative relationship with elongation ratio. The kernel length of cooked rice exhibited highly significant

Table 5
Genotypic and phenotypic correlation of various quality characters

		M	HRR	KLRR	KBRR	l/b RR	KLBR	KBBR	l/b BR	KLMR	KBMR	l/b MR	KLCR	KBCR	l/b CR	WU	VE	ER	ASV
H	r_g	0.978**	0.845**	-0.345	0.345	-0.777*	-0.183	0.005	-0.215	-0.123	0.768*	-0.497	-0.21	0.249	-0.327	-0.273	-0.361	0.259	0.344
	r_p	0.921**	0.487	-0.293	0.33	-0.671*	-0.156	-0.01	-0.176	-0.118	0.562	-0.402	-0.193	0.166	-0.282	-0.194	-0.185	0.212	0.269
M	r_g		0.874**	-0.162	0.528	-0.668*	0.011	0.098	-0.015	0.070	0.837**	-0.323	-0.021	0.324	-0.199	-0.26	-0.351	0.119	0.428
	r_p		0.493	-0.136	0.499	-0.604*	0.01	-0.02	0.007	0.069	0.662*	-0.252	-0.011	0.223	-0.161	-0.243	-0.21	0.162	0.341
HRR	r_g			-0.087	0.466	-0.503	0.113	0.108	0.097	0.133	0.876**	-0.275	-0.087	0.119	-0.157	-0.347	-0.162	-0.006	0.478
	r_p			-0.077	0.331	-0.39	0.106	0.102	0.082	0.110	0.742*	-0.253	-0.07	0.093	-0.121	-0.152	-0.238	0.007	0.407
KLRR	r_g				0.731*	0.822**	0.976**	0.689*	0.966**	0.965**	0.160	0.956**	0.951**	0.024	0.862**	0.247	-0.207	-0.821**	0.311
	r_p				0.666*	0.773*	0.968**	0.469	0.939**	0.930**	0.150	0.908**	0.929**	0.026	0.817**	0.23	-0.206	-0.648*	0.31
KBRR	r_g					0.212	0.83**	0.553	0.82**	0.860**	0.657*	0.608*	0.818**	0.375	0.54	0.01	-0.301	-0.583	0.543
	r_p					0.043	0.744*	0.528	0.679*	0.742*	0.563	0.506	0.735**	0.373	0.439	0.055	-0.292	-0.312	0.467
l/b RR	r_g						0.706*	0.522	0.700*	0.663*	-0.315	0.859**	0.674*	-0.274	0.777*	0.337	-0.051	-0.702*	0.008
	r_p						0.663*	0.181	0.679*	0.610*	-0.284	0.786*	0.614*	-0.285	0.717*	0.261	-0.035	-0.603*	0.024
KLBR	r_g							0.684*	0.992**	0.994**	0.329	0.906**	0.933**	0.064	0.819**	0.184	-0.172	-0.792*	0.373
	r_p							0.451	0.976**	0.977**	0.306	0.880**	0.919**	0.056	0.784*	0.169	-0.156	-0.617*	0.365
KBBR	r_g								0.584	0.732*	0.246	0.665*	0.638*	-0.477	0.872**	0.649*	-0.660*	-0.537	-0.07
	r_p								0.249	0.419	0.076	0.401	0.434	-0.025	0.476	0.406	-0.404	-0.353	-0.038
l/b BR	r_g									0.975**	0.312	0.895**	0.926**	0.152	0.759*	0.096	-0.073	-0.789*	0.422
	r_p									0.958**	0.303	0.861**	0.892**	0.075	0.731*	0.084	-0.061	-0.589	0.405
KLMR	r_g										0.365	0.896**	0.946**	0.047	0.844**	0.233	-0.229	-0.752*	0.335
	r_p										0.342	0.885**	0.922**	0.028	0.799**	0.173	-0.18	-0.577	0.317
KBMR	r_g											-0.086	0.23	0.163	0.136	-0.42	-0.218	-0.038	0.567
	r_p											-0.134	0.184	0.011	0.164	-0.313	-0.277	0.080	0.527
l/b MR	r_g												0.902**	-0.024	0.837**	0.449	-0.141	-0.786*	0.089
	r_p												0.882**	0.022	0.762*	0.339	-0.056	-0.645*	0.073
KLCR	r_g													0.198	0.818**	0.211	-0.241	-0.702*	0.325
	r_p													0.196	0.784*	0.167	-0.208	-0.526	0.318
KBCR	r_g														-0.399	-0.537	0.166	-0.153	0.630*
	r_p														-0.443	-0.44	0.189	-0.276	0.527
l/b CR	r_g															0.491	-0.342	-0.541	-0.058
	r_p															0.425	-0.329	-0.285	-0.047
WU	r_g																-0.373	-0.169	-0.685*
	r_p																-0.408	-0.021	-0.625*
VE	r_g																	0.363	-0.18
	r_p																	0.128	-0.172
ER	r_g																		-0.517
	r_p																		-0.409

H=Hulling %, M=Milling outturn%, HRR=Head rice recovery %, KLRR=Kernel length of rough rice, KBRR=Kernel breadth of rough rice, l/b RR=l/b ratio of rough rice, KLBR=Kernel length of brown rice, KBBR=Kernel breadth of brown rice, l/b BR=l/b ratio of brown rice, KLMR=Kernel length of milled rice, KBMR=Kernel breadth of milled rice, l/b MR=l/b ratio of milled rice, KLCR=Kernel length of cooked rice, KBCR=Kernel breadth of cooked rice, l/b CR=l/b ratio of cooked rice, WU=Water uptake %, VE=Volume expansion %, ER=Elongation ratio, ASV=Alkali Spreading positive relationship with the L/B ratio of cooked rice but it showed a significant negative relationship with elongation ratio at genotypic level. Chauhan et al. (1995) pointed out a significant positive correlation between cooked kernel length and kernel elongation, which is contradictory with the present study. The kernel breadth of cooked rice showed a significant positive relationship with alkali spreading value at genotypic level. Water uptake % exhibited a significant negative relationship with alkali spreading value but an insignificant negative relationship with volume expansion per cent and elongation ratio. Sood and Siddiq (1996) reported that water uptake showed positive and significant influence on volume expansion, and this finding is contradictory with the present study.

CONCLUSION

Considering overall performance in relation to cooking and eating quality point of view line S2 performed better and it can be used for further breeding purpose. From Correlation coefficient study, it can be concluded that L/B ratio of rough rice have strong positive relationship with the L/B ratio of brown rice, milled rice and cooked rice. Therefore, for the development of fine rice variety length and breadth of rough rice should be considered.

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