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Research Article
Morpho-Physicochemical Study of Jesso-Balam Rice (*Oryza sativa* L.) Accessions of Bangladesh

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Abstract

In total 28 accessions of Jesso-balam rice were characterized for 38 morpho-physicochemical characters at Bangladesh Rise Research Institute during T. Aman 2009 and 2011 seasons. The analysis of variance showed highly significant differences ($p<0.01$) among the genotypes for all the characters. The mean separations showed high degree of variations and no single duplicate was found. The culm height (cm) ranged from 99.74 (JB20)-138.53 (JB22), effective tiller number per hill from 7 (JB6)-15 (JB4, JB26), straw yield per hill (g) from 21.01 (JB26)-47.01 (JB22), panicle length (cm) from 23.49 (JB20)-29.89 (JB22), primary branch number from 9.67 (JB20)-13.67 (JB23), secondary branch number from 19.67 (JB20)-53 (JB18), grain length (mm) from 5.92 (JB26)-9.37 (JB8), 1000-grain weight (g) from 11.0 (JB26)-25.88 (JB14), protein content (%) from 5.9 (JB15)-9.9 (JB26), grain yield per panicle (g) from 1.65 (JB12)-3.37 (JB21) and grain yield per hill (g) from 16.67 (JB26)-26.4 (JB4), respectively. The high GCV and h^2_b together with high GAPM were found in 1000-grain weight, seedling height, secondary branch number, panicle exertion, effective tiller number per hill, straw yield per hill and penultimate leaf area suggested that selection may be effective for these characters in segregating generations. The simple correlation indicated that the higher the PBN, SBN, SBFGW, LBR and TGW possessed greater PL, GL and PGY. Finally, the pure lines of Jesso-balam rice germplasm offers valuable gene reservoir which need to conserve and characterize using molecular tools for validating useful genes.

Key words: Morpho-physicochemical characters, jesso-balam rice, Bangladesh

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food for nearly half of the global population especially in Asia, Africa and Latin America (Maclean *et al*., 2002; FAO., 2004). Over 90% of the world's rice is produced in Asia. Bangladesh is one of the largest producer and consumer of rice in the world with an annual production of 33.88 million Mt by occupying 77.15% of the total cropped area of the country (BBS., 2013). Presently, Bangladesh is self sufficient in rice production and even export to some extent. But in future, maintaining the increased production of rice will be the main challenge especially in the context of decreasing cultivable rice land and scarcity of irrigated water of the country. Moreover, climate changes make everything more critical especially higher rice production. Therefore, new diverse genes that govern biotic and abiotic stresses, nutritional qualities and even various attributes with indigenous or traditional values need to be considered.

Plant breeding is the art and science of changing the traits of plants in order to produce desired characteristics. Rice genetic resource is the primary material for rice breeding and makes a concrete contribution to global wealth creation and food security (Zhang *et al*., 2011). The rice germplasm is a rich reservoir of valuable genes that plant breeders can harness for crop improvement (Yadav *et al*., 2013). With an increasing global population, the demand for rice will continue to rise, which raises challenges for the breeding of high yielding rice cultivars (Zhang *et al*., 2013).

Rice is rich in genetic diversity at both inter and intra-specific levels. Knowledge regarding the extent of genetic variation and genetic relationships between genotypes are vital for designing effecting breeding and conservation strategies (Roy *et al*., 2015). Genetic diversity underlies the improvement of crops by plant breeding. Land races of rice (*Oryza sativa* L.) can contain some valuable alleles not common in modern germplasm (Pervaiz *et al*., 2010).

Genetic diversity is the foundation for an efficient choice of parents for the variety development program which require a continuous supply of new genetic inputs (genes/gene-complexes). The available diversity in the germplasm serves as an insurance against unknown future needs/conditions, thereby contributing to the stability of farming systems at local, national and global levels (Singh *et al*., 2000). Ghosal *et al.* (2010) conducted field experiment on 18 advanced breeding lines for yield contributing characters and found significant variation for all the tested characters. Parikh *et al.* (2012) characterized 71 aromatic rice germplasm and found highly significant variability among the varieties. However, Singh *et al.* (1991) stated that the genetic diversity of a collection can be reflected perfectly, only if, various kinds of traits have been evaluated compositively. But, now rice diversity in Bangladesh is threatened due to extensive cultivation of Modem Varieties (MVs) all over the country (Ahmed *et al*., 2010).

There are 28 germplasm of 'Jesso-Balam Transplant Aman Pure Line (TAPL), in Rice Genebank of Bangladesh Rice Research Institute (BRRI), Gazipur, which need to be characterized for their effective conservation and utilization. However, the Balam rice is the most popular rice in Southern regions of the country. But due to low yield compare to MV's, the cultivation area of this rice is decreasing year after year. The present study was, therefore, undertaken to assess the variability and genetic parameters of 28 Jesso-balam Pure Line (PL) rice accessions to identify potential genotypes through morpho-physicochemical characters for improving the Balam rice in Bangladesh.

MATERIALS AND METHODS

The field experiment was conducted at Bangladesh Rice Research Institute (BRRI), Gazipur during T. Aman, 2009 and 2011, seasons and laboratory experiment in the laboratory of Grain Quality and Nutrition Division (GQND) of the same during 2011. A total of 28 Jesso-balam TAPL rice accessions, collected from Genebank of BRRI were used in the experiments (Table 1). The genotypes were developed as 'Pure Lines' by 'Head to row method' in the hybridization programs of Plant Breeding Division, BRRI.

The 30 days old single seedling was transplanted per hill for each genotype in Randomized Complete Block Design (RCBD) with three replications. Space within and between

Table 1: List of the 28 Jesso-Balam TAPL rice accessions

Code name	Accession*number	Code name	Accession*number	Code name	Accession*number	Code name	Accession*number
JBPL1	2470	JBPL8	2465	JBPL15	2464	JBPL22	2472
JBPL2	2468	JBPL9	2458	JBPL16	2480	JBPL23	2477
JBPL3	2461	JBPL10	2475	JBPL17	2474	JBPL24	2473
JBPL4	2456	JBPL11	2469	JBPL18	2455	JBPL25	2466
JBPL5	2457	JBPL12	2462	JBPL19	2463	JBPL26	2454
JBPL6	2460	JBPL13	2471	JBPL20	2453	JBPL27	2459
JBPL7	2467	JBPL14	2479	JBPL21	2476	JBPL28	2478

*BRRI Rice Gene bank accession number, TAPL: Transplant aman pure line rows were 20 and 25 cm, respectively. The unit plot size was four rows each of 2.7 m length. The fertilizer dose of 60-50-40-10 kg NPKS per hectare was applied in the form of Urea, Triple Super Phosphate (TSP), Muriate of Potash (MP) and Gypsum, respectively. Total fertilizers except urea were applied before the final land preparation. Urea was applied in three installments at 15, 30 and 45 Days after Transplanting (DAT). Appropriate control measures were taken for pest and disease when necessary.

The data were statistically analyzed using MstatC software. For each character, the mean, range and standard deviation were calculated and ANOVA (Analysis of Variance) was performed. The mean values were separated by Duncan's Multiple Range Test (DMRT) as suggested by Stell and Torrie (1960). The genotypic variance ($\sigma^2 g$), phenotypic variance ($\sigma^2 p$) and heritability (h^{2b}, %) in broad sense were calculated according to Johnson *et al.* (1955), while the Genotypic Coefficient of Variation (GCV %) and phenotypic coefficient of variation (PCV %) was computed with the formula suggested by Burton (1952). The Genetic Advance (GA) was calculated according to Lush (1949) and Johnson *et al.* (1955), the Genetic Advance in Percent Mean (GAPM) by Comstock and Robinson (1952) and the simple correlation coefficients by Beale (1969).

RESULTS AND DISCUSSION

Analysis of variance for morpho-physicochemical characters: The analysis of variance of 38 morpho-physicochemical characters, showed highly significant differences ($p<0.01$) among the genotypes for all the characters (Table 2). It indicated wide range of genetic

Table 2: Mean sum of square of 38 morpho-physico chemical characters of 28 Jesso-Balam PL rice accessions

Characters	Rep.	Variety	Error
Coleoptile length (mm)	0.57	2.54**	0.60
Seedling height (cm)	48.95	107.12**	2.37
Penultimate leaf length (cm)	11.25	102.15**	30.74
Penultimate leaf width (mm)	2.32	2.19**	0.41
Penultimate leaf area (cm^2)	85.91	148.65**	34.87
Flag leaf length (cm)	7.36	24.55**	8.01
Flag leaf width (mm)	7.01	2.43**	0.60
Flag leaf area (cm^2)	36.30	56.71**	15.81
Culm height (cm)	78.05	174.70**	45.69
Culm diameter (mm)	0.61	0.55**	0.12
Plant height (cm)	93.75	220.06**	45.06
Panicle exertion (cm)	1.47	5.21**	0.99
Effective tiller number per hill	60.04	14.16**	3.32
Straw yield per hill (g)	98.00	141.12**	31.06
Days to maturity	9.01	81.83**	0.01
Panicle length (cm)	1.55	7.51**	1.18
Grain yield per panicle (g)	0.71	0.60**	0.26
Grain yield per hill (g)	374.61	18.77**	7.75
Harvest index (%)	24.51	84.16**	24.83
Biological yield (g)	172.62	192.51**	55.22
Primary branch number	1.08	2.10**	0.89
Av. primary branch length(cm)	0.22	3.04**	0.58
Filled grain number per primary branch	0.01	0.35**	0.11
Primary branch filled grain weight (g)	0.08	0.25**	0.06
Secondary branch number	4.80	170.23**	25.08
Av. secondary branch length (mm)	0.25	14.89**	2.56
Filled grain number per secondary branch	0.08	0.22**	0.11
Secondary branch filled grain weight (g)	0.40	0.44**	0.15
Grain length (mm)	0.03	1.11**	0.02
LB ratio	0.02	0.09**	0.01
1000-grain weight (g)	3.78	20.84**	0.60
Milling out turn (%)	0.32	7.28**	0.10
Head rice out turn (%)	55.72	428.00**	0.54
Cooking time (min)	23.22	7.65**	0.05
Elongation ratio	0.03	0.05**	0.00
Imbibition ratio	0.28	0.13**	0.00
Amylose content (%)	0.13	3.30**	0.21
Protein content (%)	0.03	2.87**	0.10

**Significant at1% level of probability, PL: Pencil length variations among the pure lines of Jesso-balam. Previously, Abarshahr *et al.* (2011) studied 19 quantitative traits in 30 genotypes of rice, respectively and found highly significant differences among the genotypes. But, Dhananjaya *et al.* (1998) by studying genetic variability of 121 elite homozygous rice observed maximum variations for productive tillers per plant, number of fertile spikelet and grain yield per plant among the studied traits. Therefore, means of the studied characters were separated for further study.

Variability of Jesso-balam rice germplasm: The mean performance of 28 Jesso-balam rice accessions for 38 morpho-physiochemical characters showed that high degree of genetic variations existed among the germplasm (Table 3-6). The seedling height (cm) with the mean value of 66.47 had wide range from 50.6 (JB26)-73.71 cm (JB14). Similarly, penultimate leaf length (cm) with a mean value of 56.75, varied from 46.63 (JB7)-69.18 (JB17) cm, penultimate leaf area (cm^2) with mean 36.87 varied from 36.87 (JB8)-67.26 cm^2 (JB17), culm height (cm) with mean 118.19 varied from 99.74 (JB20)-138.53 cm (JB22), respectively. Again, plant height (cm) with mean 145.3 varied from 123.23 (JB20)-168.42 cm (JB22), effective tiller number per hill with mean 11.93 varied from 7 (JB6)-15 (JB4, JB26), straw yield per hill (g) with mean 31.62 varied from 21.01 (JB26)-47.01 g (JB22), days to maturity with mean 148.9 varied from 139 (JB16)-160 (JB22), respectively. On the other hand, panicle length (cm) with a mean value of 27.11 varied from 23.49 (JB20)-29.89 cm (JB22), grain yield per panicle (g) with mean 2.75 varied from 1.65 (JB12)-3.37 g (JB21), grain yield per hill (g) with mean 22.71 varied from 16.67 (JB26)-26.4 g (JB4), harvest index (%) with mean 33.37 varied from 21.21 (JB22)-43.2% (JB23) and biological yield (g) with mean 47.18 varied from 31.57 (JB26)-59.71 g (JB22), respectively. Moreover, primary branch number with mean 11.73 varied from 9.67 (JB20)-13.67 (JB23), average primary branch length (cm) with mean 11.67 varied from 9.67 (JB15)-13.61 cm (JB11), secondary branches number with mean 38.6 varied from 19.67 (JB20)-53 (JB18) and average secondary branch length (mm) with mean 25.52 varied from 20.06 (JB24)-28.09 mm (JB9), respectively. Again, the grain length (mm) with mean value of 8.33, showed wide range of grain length variation from 5.92 (JB26)-9.37 mm (JB8),1000-grain weight (g) with mean 20.52 varied from 11.0 (JB26)-25.88 g (JB14), milling outturn (%) with mean 71.84 varied from 69 (JB11, JB14)-75% (JB26), head rice outturn (%) with mean 84 varied from 48 (JB3)-96% (JB1, JB9), amylose

Table 3: Mean performance of seedling, leaf and culm characters of 28 Jesso-balam PL rice accessions

Genotypes	Coleoptile length (mm)	Seedling height (cm)	Penultimate leaf length (cm)	Penultimate leaf width (mm)	Penultimate leaf area (cm^2)	Flag leaf length (cm)	Flag leaf width (mm)	Flag leaf area (cm^2)	Culm height (cm)	Culm diameter (mm)
JBPL1	12.39^{a}	72.30^{ab}	55.55^{c-h}	11.27^{c-g}	47.15^{d-i}	36.04^{a-e}	13.4^{b-d}	36.35^{b-f}	118.99^{b-e}	5.45^{a-c}
JBPL2	9.42^{hi}	71.27^{a-c}	49.53^{f-h}	11.2^{c-g}	41.7^{f-i}	32.9^{d-g}	13.33^{b-d}	32.93^{d-h}	113.81^{c-e}	5.62^{ab}
JBPL3	10.19^{e-h}	70.59^{b-d}	55.13^{c-h}	12.17^{a-d}	50.24^{b-g}	31.9^{e-g}	14.3^{b-d}	34.27^{b-h}	122.66^{b-d}	5.65^{ab}
JBPL4	9.69^{gh}	57.25^{j}	63.56^{a-d}	11.8^{b-f}	56.22^{b-e}	36.3^{a-e}	14.02^{b-d}	38.22^{b-f}	114.2^{c-e}	5.88^{ab}
JBPL5	10.31^{d-h}	59.80^{i}	53.08^{d-h}	11.48^{c-f}	46.11^{e-i}	33.17^{d-g}	14.1^{b-d}	35.08^{b-h}	122.2^{b-d}	5.26^{b-e}
JBPL6	11.23^{a-f}	68.06^{d-g}	52.40^{e-h}	11.37^{c-g}	44.6^{e-i}	37.37^{a-e}	13.97^{b-d}	39.12^{b-e}	121.94^{b-d}	5.47^{a-c}
JBPL7	9.56^{gh}	70.09^{b-d}	46.63^{h}	11.7^{b-f}	41.14^{f-i}	28^{g}	13.57^{b-d}	28.48^{gh}	117.39^{b-e}	5.84^{ab}
JBPL8	10.69^{c-h}	68.37^{d-f}	48.27^{gh}	10.2^{gh}	36.87^{i}	34^{b-f}	13.2^{cd}	33.64^{c-h}	117.77^{b-e}	5.73^{ab}
JBPL9	11.44^{a-f}	71.80^{ab}	62.27^{a-e}	11.2^{c-g}	52.26^{b-f}	38.2^{a-d}	14.03^{b-d}	40.24^{b-d}	126.47^{bc}	5.48^{a-c}
JBPL10	10.61^{c-h}	65.73^{e-h}	56.00^{b-h}	10.87^{e-g}	45.62^{e-i}	35.4^{a-f}	13.47^{b-d}	35.82^{b-g}	106.42^{ef}	4.73^{d-f}
JBPL11	11.31^{a-f}	72.55^{ab}	58.22^{b-g}	11.27^{c-g}	49.21^{b-h}	33.99^{b-f}	13.57^{b-d}	34.58^{b-h}	124.67^{b-d}	5.76^{ab}
JBPL12	9.94^{f-h}	71.66^{ab}	48.90^{gh}	11.97^{a-e}	43.95^{f-i}	34.53^{b-f}	13.53^{b-d}	34.99^{b-h}	117.51^{b-e}	6.01^{a}
JBPL13	11.03^{a-g}	65.55^{f-h}	56.28^{b-h}	11.23^{c-g}	47.34^{d-i}	32.74^{d-g}	12.93^{d}	31.63^{e-h}	130.47^{ab}	5.47^{a-c}
JBPL14	11.81^{a-d}	73.71^{a}	65.38^{a-c}	$10.6f^{g}$	52.03^{b-f}	39.5^{ab}	13.9^{b-d}	41.09^{a-c}	115.01^{c-e}	5.43^{a-c}
JBPL15	10.5^{c-h}	65.33^{gh}	54.81^{c-h}	11.07^{d-g}	45.54^{e-i}	35.26^{a-f}	13.33^{b-d}	35.32^{b-h}	116.53^{c-e}	5.48^{a-c}
JBPL16	11^{f-h}	66.39^{e-h}	65.17^{a-c}	12.37^{a-c}	60.48^{ab}	38.13^{a-d}	14.63^{a-c}	41.87^{ab}	124.69^{b-d}	5.68^{ab}
JBPL17	11.67^{a-e}	73.61^{a}	69.18^{a}	13.03^{a}	67.26^{a}	34.95^{a-f}	16^{a}	42.21^{ab}	114.2^{c-e}	5.92^{ab}
JBPL18	11.64^{a-e}	56.13^{j}	66.60^{ab}	11.77^{b-f}	58.99^{a-c}	38.1^{a-d}	13.9^{b-d}	39.84^{b-d}	113.88^{c-e}	5.34^{a-d}
JBPL19	10.69^{c-h}	70.15^{b-d}	53.97^{d-h}	12.73^{ab}	51.74^{b-g}	33.34^{d-g}	14.77^{ab}	37^{b-f}	117.23^{b-e}	5.56^{ab}
JBPL20	10.53^{c-h}	55.47^{j}	52.33^{e-h}	10.2^{gh}	40.08^{g-i}	33.13^{d-g}	13.07^{d}	32.54^{d-h}	99.74^{f}	4.35^{f}
JBPL21	10.25^{e-h}	66.60^{e-h}	56.20^{b-h}	11.17^{c-g}	47.06^{d-i}	34.33^{b-f}	13.67^{b-d}	35.26^{b-h}	122.03^{b-d}	5.46^{a-c}
JBPL22	11.86^{a-c}	64.34^{h}	59.34^{f-h}	11.7^{b-f}	51.97^{b-f}	33.54^{d-f}	14^{b-d}	35.26^{b-h}	138.53^{a}	5.58^{ab}
JBPL23	10.42^{c-h}	63.88^{h}	60.40^{a-f}	10.83^{e-g}	49.04^{b-h}	38.13^{a-d}	13.43^{b-d}	38.42^{b-f}	112.2^{de}	4.82^{c-f}
JBPL24	10.70^{c-h}	68.50^{c-e}	59.34^{f-h}	13.07^{a}	58.16^{a-d}	40.19^{a}	15.87^{a}	47.83^{a}	117.07^{c-e}	5.81^{ab}
JBPL25	10.58^{c-h}	71.83^{ab}	50.13^{f-h}	11.37^{c-g}	42.67^{f-i}	30.2^{fg}	13.67^{b-d}	30.87^{f-h}	121.8^{b-d}	5.87^{ab}
JBPL26	8.17^{i}	50.60^{k}	54.97^{c-h}	9.17^{h}	37.83^{hi}	33.73^{c-f}	11^{e}	27.86^{h}	113.07^{c-e}	4.69^{ef}
JBPL27	12.28^{ab}	64.96^{h}	60.09^{a-f}	10.67^{fg}	48.08^{c-i}	34.77^{a-f}	14.03^{b-d}	36.57^{b-f}	122.27^{b-d}	5.26^{b-e}
JBPL28	10.81^{b-h}	64.64^{h}	55.30^{c-h}	10.93^{d-g}	45.63^{e-i}	39.3^{a-c}	13.63^{b-d}	40.01^{b-d}	106.67^{ef}	4.62^{ef}
Mean	10.74	66.47	56.75	11.37	48.53	35.04	13.80	36.33	118.19	5.44

In column, means followed by a common alphabetical small letter are not statistically different att he 5% level by DMRT

Table 4: Mean performance of morpho-physiological characters of 28 Jesso-Balam PL rice accessions

Genotypes	Plant height (cm)	Panicle exertion (cm)	Effective tiller No. per hill	Straw yield per hill (g)	Days to maturity	Panicle length (cm)	Grain yield per panicle (g)	Grain yield per hill (g)	Harvest index (HI)	Biological yield (BY)
JBPL1	146.53^{c-e}	1.55^{g}	13.67^{a-c}	42.4^{ab}	157^{b}	27.54^{c-g}	2.56^{a-f}	25.17^{a-c}	23.6^{d-f}	55.57^{ab}
JBPL2	141.19^{c-f}	1.88^{e-g}	9.33^{e-h}	30.45^{d-i}	147^{k}	27.38^{c-h}	2.94^{a-d}	22.65^{a-d}	34.66^{ab}	46.75^{f-h}
JBPL3	149.21^{b-d}	2.97^{c-g}	9.33^{e-h}	26.84^{e-i}	148^{j}	26.54^{d-i}	2.78^{a-e}	21.85^{a-e}	32.15^{b-d}	39.42^{c-h}
JBPL4	141.0^{c-f}	4.27^{b-d}	15^{a}	37.12^{a-e}	151^{g}	26.8^{d-i}	3.12^{a-c}	26.4^{a}	36.04^{ab}	58.75^{a}
JBPL5	149.85^{b-d}	4.73^{bc}	11.33^{b-g}	22.5^{hi}	147^{k}	27.66^{c-f}	2.52^{a-f}	24.03^{a-d}	38.69^{ab}	36.74^{e-h}
JBPL6	151.73^{bc}	3.75^{b-e}	7^{h}	22.62^{hi}	146^{l}	29.79^{ab}	3.01^{a-d}	20.39^{b-e}	34.36^{ab}	34.54^{gh}
JBPL7	145.6^{c-e}	1.69^{g}	9^{f-h}	28.6^{d-i}	147^{k}	28.21^{a-e}	3.11^{a-c}	23.6^{a-d}	36.88^{ab}	45.28^{a-h}
JBPL8	142.79^{c-f}	3.01^{c-g}	10.33^{c-h}	33.77^{b-g}	153^{e}	25.02^{ij}	2.79^{a-d}	24.72^{a-d}	30.62^{b-e}	48.71^{f-h}
JBPL9	152.57^{bc}	4.26^{b-d}	11^{b-g}	31.51^{b-i}	151^{h}	26.1^{e-i}	2.93^{a-d}	20.11^{c-e}	32.24^{b-d}	46.33^{f-h}
JBPL10	135.02^{ef}	3.66^{b-f}	14.33^{ab}	32.25^{b-h}	152^{f}	28.6^{a-d}	2.94^{a-d}	25.9^{ab}	34.92^{ab}	49.62^{a-f}
JBPL11	152.09^{bc}	1.8^{e-g}	15^{a}	41.55^{a-c}	157^{b}	27.42^{c-g}	3.24^{ab}	21.57^{a-e}	24.41^{c-f}	55.16^{ab}
JBPL12	143.9^{c-f}	1.77^{fg}	9.67^{d-h}	25.15^{f-i}	146^{l}	26.39^{e-i}	1.65f	21.41^{a-e}	39.39^{ab}	41.44^{b-h}
JBPL13	159.61^{ab}	3.33^{b-g}	11.33^{b-g}	39.09^{a-d}	156^{c}	29.14^{a-c}	2.84^{a-d}	19.29^{de}	22.5^{ef}	50.6^{a-e}
JBPL14	143.66^{c-f}	4.37^{bc}	11^{b-g}	33.95^{b-g}	150^{i}	28.64^{a-d}	3.04^{a-d}	26.00^{a}	37.27^{ab}	53.59^{a-d}
JBPL15	141.22^{c-f}	3.68^{b-f}	13^{a-d}	33.56^{b-g}	154^{d}	24.69^{ij}	2.28^{b-f}	21.71^{a-e}	30.51^{b-e}	48.04^{f-h}
JBPL16	152.46^{bc}	4.53^{bc}	8.33^{gh}	26.07^{e-i}	139^{p}	27.76^{b-f}	3.13^{a-c}	20.27^{c-e}	33.18^{b-d}	39.1^{d-h}
JBPL17	139.47^{c-f}	3.48^{b-g}	10.33^{c-h}	36.03^{b-f}	154^{d}	25.27^{h-j}	3.14^{a-c}	19.94^{c-e}	34.51^{ab}	54.91^{ab}
JBPL18	140.41^{c-f}	4.7^{bc}	12.33^{a-f}	36.69^{b-e}	147^{k}	26.53^{d-i}	2.06^{d-f}	23.63^{a-d}	32.4^{b-d}	53.71^{a-d}
JBPL19	143.64^{c-f}	2.04^{e-g}	12^{a-f}	35.83^{b-f}	147^{k}	26.4^{e-i}	2.97^{a-d}	23.42^{a-d}	33.51^{a-c}	53.91^{a-c}
JBPL20	123.23^{g}	3.65^{b-f}	12.67^{a-e}	23.14^{g-i}	140^{o}	23.49^{j}	1.79^{ef}	19.4^{de}	34.7^{ab}	35.08^{f-h}
JBPL21	149.94^{b-d}	4.36^{bc}	12^{a-f}	32.55^{b-h}	150^{i}	27.91^{a-f}	3.37^{a}	21.26^{a-e}	33.04^{b-d}	48.57^{f-h}
JBPL22	168.42^{a}	5.08^{b}	13.67^{a-c}	47.01^{a}	160^{a}	29.89^{a}	2.4^{a-f}	22.72^{a-d}	21.21^{f}	59.71^{a}
JBPL23	138.05^{d-f}	2.05^{e-g}	13^{a-d}	21.01^{i}	144^{n}	25.85^{f-i}	2.59^{a-f}	22.93^{a-d}	43.2^{a}	37^{e-h}
JBPL24	143.36^{c-f}	2.4^{d-g}	13^{a-d}	36.20^{b-e}	156^{c}	26.29^{e-i}	2.85^{a-d}	26.09^{a}	35.67^{ab}	56.28^{a}
JBPL25	149.93^{b-d}	1.82^{e-g}	13^{a-d}	31.05^{c-i}	146^{l}	28.13^{a-e}	2.98^{a-d}	24.26^{a-d}	40.01^{ab}	51.77^{a-d}
JBPL26	142.48^{c-f}	6.88^{a}	15^{a}	21.01^{i}	145^{m}	29.41^{a-c}	2.55^{a-f}	16.67^{e}	33.27^{b-d}	31.57^{h}
JBPL27	149.04^{b-d}	4.12^{b-d}	14^{ab}	33.69^{b-g}	146^{l}	26.77^{d-i}	3.33^{a}	26.21^{a}	31.74^{b-d}	49.45^{a-f}
JBPL28	$132.1f^{g}$	2.14^{e-g}	14.33^{ab}	23.79^{g-i}	144^{n}	25.43^{g-j}	2.14^{c-f}	24.28^{a-d}	39.69^{ab}	39.31^{c-h}
Mean	145.30	3.36	11.93	31.62	148.98	27.11	2.75	22.71	33.37	47.18

In column, means followed by a common alphabetical small letter are not statistically different at the 5% level by DMRT, PL: Pencil length

content (%) with mean 24.54 varied from 22.6 (JB17)-26.5% (JB24) and protein content (%) with mean 7.34 varied from 5.9 (JB15)-9.9% (JB26), respectively. Therefore, it can be said that in this collection of germplasm, one can find wide range of variation of different important morpho-physicochemical characters. Moreover, the identified potential genotypes can be selected and utilized for developing new variety of Jesso-balam rice.

Earlier, Parikh *et al.* (2012) characterized 71 aromatic rice germplasm and found the highest plant height, panicle length, hundred seed weight and head rice recovery as 146.05, 26.9 and 2.99 g and 73.7%, respectively by evaluating 22 morphological and agronomical traits. Chakravorty *et al.* (2013) observed the highest leaf length as 61 cm, leaf breadth as 2.20 cm, plant height as 43 cm, days to maturity as 172 days, panicle length as 30.50 cm, primary branch per panicle as 16, grain length as 11.2 mm, 1000-grain weight as 29.91 g and grain per panicle as 334 etc., in 51 rice landraces of West Bengal. Thus, desirable characteristics with high potentiality of similar and duplicate named rice germplasm under study can be utilized as beneficial gene pool in developing varieties to maintain rice diversity as well as its sustainable production.

Again, Biswas *et al.* (2001) evaluated 34 modern and local rice varieties for physico-chemical properties and found the highest grain length and L/B ratio as 6.9 and 3.6 mm, respectively. Biswas *et al.* (2001) by evaluating 34 modern and local rice varieties for physico-chemical properties and found the highest milling out turn as 72%, head rice outturn as 98%, amylose as 27% and protein content as10.5%, respectively. But Subudhi *et al.* (2012) evaluated 41 rice varieties of different ecologies and found the highest milling recovery, head rice recovery, kernel length, amylose content as 76, 68, 7.54 mm, 26.1%, respectively. As a result, different important physicochemical characters were existed among the germplasm for rice improvement. Therefore, the genetically potential genotypes with special physicochemical characters can be utilized for developing high yielding varieties with better nutritional quality.

The mean separations of 28 Jesso-balam PL rice germplasm showed highly significant differences among the genotypes (Table 3-6). No single duplicate genotype was found among the pure lines. However, the genotype JB1, JB2, JB3, JB7, JB9, JB11, JB12, JB19 and JB25 were found statistically similar for seedling height. Similarly, genotype JB10, JB13,

Table 5: Mean performance of PB and SB characters of 28 Jesso-Balam rice

Genotypes	PB number	Av.PB length (cm)	Filled grain No. per PB	PB filled grain weight (g)	SB number	Av. SB length (cm)	Filled grain No. per SB	SB filled grain weight (g)
JBPL1	10^{ef}	12.94^{a-c}	4.66^{b-f}	1.06^{b-e}	31.67^{f-h}	26.5^{a-e}	2.26^{a-e}	1.5^{a-f}
JBPL2	11.67^{b-e}	11.15^{e-i}	4.89^{b-d}	1.26^{a-d}	37.33^{d-h}	26.44^{a-e}	2.28^{a-e}	1.69^{a-f}
JBPL3	11.33^{b-f}	11.48^{c-h}	4.11^{ef}	1.01^{c-e}	38.67^{d-h}	26.43^{a-e}	2.07^{a-f}	1.77^{a-e}
JBPL4	11.33^{b-f}	12.32^{a-f}	4.61^{b-f}	1.10^{a-e}	50.0^{ab}	26.0^{a}	2.25^{a-e}	2.01^{ab}
JBPL5	12.67^{a-c}	11.18^{e-i}	5.01^{a-d}	1.39^{a-d}	31.33^{gh}	21.55^{gh}	1.98^{c-f}	1.13^{d-g}
JBPL6	10.67^{d-f}	12.86^{a-c}	4.66^{b-f}	1.25^{a-d}	33.33^{e-h}	26.58^{a-e}	2.43^{a-d}	1.76^{a-e}
JBPL7	12^{a-d}	11.63^{c-h}	4.93^{a-d}	1.32^{a-d}	41.67^{b-e}	24.71^{c-f}	2.09^{a-f}	1.8^{a-e}
JBPL8	12^{a-d}	10.43^{h-j}	5.08^{a-c}	1.58^{a}	31^{gh}	21.69^{gh}	1.64^{ef}	1.22^{c-g}
JBPL9	12^{a-d}	12.73^{a-d}	5.08^{a-c}	1.34^{a-d}	44.33^{a-d}	28.09^{a}	1.96^{c-f}	1.59^{a-f}
JBPL10	12.33^{a-d}	13.52^{ab}	5.03^{a-c}	1.2^{a-d}	49^{a-c}	27.58^{a-d}	2.05^{a-f}	1.74^{a-e}
JBPL11	12.67^{a-c}	13.61^{a}	4.36^{d-f}	1.18^{a-e}	45^{a-d}	27^{a-e}	1.98^{b-f}	2.06^{ab}
JBPL12	12^{a-d}	10.62^{g-j}	4.81^{b-d}	0.9^{de}	33.67^{e-h}	24.15^{e-g}	1.78^{d-f}	0.75^{g}
JBPL13	11^{c-f}	12.52^{a-e}	4.68^{b-f}	1.1^{a-e}	39^{d-g}	27.89^{ab}	2.55^{a-c}	1.74^{a-e}
JBPL14	11.33^{b-f}	11.66^{c-h}	4.71^{b-e}	1.52^{ab}	30.33^{gh}	26.99^{a-e}	2.19^{a-f}	1.53^{a-f}
JBPL15	11.33^{b-f}	9.67^{j}	4.94^{a-d}	1.31^{a-d}	29^{h}	22.97^{fg}	1.57^{f}	$0.97f^{g}$
JBPL16	12^{a-d}	12.36^{a-f}	4.06^{ef}	0.91^{c-e}	49^{a-c}	28.08^{a}	2.64^{ab}	2.22^{a}
JBPL17	11.67^{b-e}	11.62^{c-h}	4.94^{a-d}	1.33^{a-d}	39.67^{c-g}	24.74^{b-f}	2.3^{a-e}	1.82^{a-e}
JBPL18	11.67^{b-e}	12.12^{b-g}	4.46^{c-f}	0.1^{f}	53^{a}	27.66^{a-d}	2.24^{a-e}	1.96^{a-c}
JBPL19	11.67^{b-e}	10.94^{f-j}	4.82^{b-d}	1.4^{a-d}	37.67^{d-h}	24.51^{d-g}	1.91^{c-f}	1.58^{a-f}
JBPL20	9.67^{f}	9.932^{ij}	4.04^{f}	1.03^{b-e}	19.67^{i}	23.08^{fg}	2.3^{a-e}	0.76^{g}
JBPL21	13^{ab}	12.35^{a-f}	4.55^{b-f}	1.4^{a-c}	41.33^{b-f}	24.8^{b-f}	2.65^{a}	1.97^{a-c}
JBPL22	11.67^{b-e}	11.71^{c-h}	4.46^{c-f}	1.05^{b-e}	39^{d-g}	26.32^{a-e}	2.03^{a-f}	1.35^{b-g}
JBPL23	13.67^{a}	11.57^{c-h}	4.88^{b-d}	1.22^{a-d}	38.33^{d-h}	27.78^{a-c}	2.3^{a-d}	1.37^{b-g}
JBPL24	12^{a-d}	10.35^{h-j}	4.63^{b-f}	1.22^{a-d}	37.33^{d-h}	20.06^{h}	2.52^{a-c}	1.63^{a-f}
JBPL25	11.67^{b-e}	11.28^{d-i}	5.16^{ab}	1.29^{a-d}	37.33^{d-h}	24.94^{a-f}	2.11^{a-f}	1.7^{a-f}
JBPL26	11^{c-f}	10.95^{f-j}	5.55^{a}	0.7^{e}	49^{a-c}	$23f^{g}$	2.27^{a-e}	1.85^{a-d}
JBPL27	11.67^{b-e}	12.19^{a-f}	4.68^{b-f}	1.41^{a-c}	41.33^{b-f}	26.93^{a-e}	2.37^{a-d}	1.92^{a-c}
JBPL28	12.67^{a-c}	11.11^{e-j}	4.57^{b-f}	1.08^{b-e}	32.67^{e-h}	26.05^{a-f}	2.06^{a-f}	1.06^{e-g}
Mean	11.73	11.67	4.73	1.17	38.60	25.52	2.17	1.59

In column, means followed by a common alphabetical small letter are not statistically different at the 5% level by DMRT, PB: Primary branch, SB: Secondary branch

JB15, JB16, JB21, JB22, JB23, JB27 and JB28 were found statistically similar for the same character. Again, the genotype JB1 to JB9, JB11 to JB12, JB14 to JB19, JB21 and JB24 to JB27 were found statistically identical for seedling and plant height. In case of days to maturity, genotype JB2, JB5, JB7, JB8 and JB9 and in case of grain yield per hill genotype JB1 to JB5, JB7, JB8, JB10 to JB12, JB14, JB15, JB18, JB19, JB21 to JB25, JB27 and JB28 were found duplicate. Again, for primary branch number per panicle genotype JB1 to JB4, JB6, JB13 to JB15, JB17 to JB19, JB22, JB25 to JB27 and for secondary branch number per panicle genotype JB1 to JB3, JB5 to JB6, JB8, JB12, JB14, JB19, JB23 to JB25 and JB28 were found statistically identical. Similarly, genotype JB1 to JB4, JB7, JB9, JB12, JB13, JB16, JB18, JB20, JB23, JB25, JB27 and JB28 for grain length, genotype JB1, JB7, JB9, JB13, JB21, JB22, JB25 and JB28 for milling outturn and genotype JB1, JB8, JB9, JB13, JB15, JB18, JB19, JB24 and JB28 for cooking time were found statistically similar. Therefore, the 28 Jesso-Balam pure lines wide genetic variations were existed among them.

Hossain (2008) also observed highly significant differences among the aromatic and fine grain landraces of rice genotypes with duplicate names for all the morphological and physico-chemical characters studied. Nascimento *et al.* (2011) studied 146 accessions with same names of upland rice for 14 quantitative traits also found significance differences. However, Fukuoka *et al.* (2006) studied aromatic rice landraces and concluded that significant variation may be found among genotypes with the same name for quantitative traits. Besides, Kisandu and Mghogho (2004) studied 275 accessions from all rice growing regions of the Southern Highlands of Tanzania, reported that a large number of similar names were existed for rice cultivars. Finally, it can be concluded that wide range of genetic variation for different morpho-physicochemical characters were present among the pure lines and each line was unique and diverse from others.

Genetic parameters of Jesso-balam rice germplasm: Heritability (h^2_b %), genetic advance and Genetic Advance in Percent of Mean (GAPM), Genotypic Coefficient of Variation (GCV %) and Phenotypic Coefficient of Variation (PCV %) of 28 Jesso-balam PL rice germplasm are presented in Table 7. It was observed that the genotypic and phenotypic coefficient of variations were close to each other for seedling height as 8.9 and 9.2%, days to maturity as 3.5 and 3.5%, grain length as 7.2 and 7.4%, 1000-grain weight as 12.7 and 13.2% and L/B ratio as 5 and 5.9%, respectively indicating less environmental influence and additive gene action for the characters. But wide differences were found for filled grains weight per secondary

Table 6: Mean performance of grain characters of 28 Jesso-Balam PL rice accessions

Genotypes	Grain length (mm)	LB ratio	1000-grain weight (g)	Milling outturn (%)	Head rice outturn (%)	Cooking time (min)	Elongation ratio	Imbibition ratio	Amylose content (%)	Protein content (%)
JBPL1	8.28^{e-h}	3.1^{j}	19.72^{e-g}	73^{c}	96^{a}	16^{e}	1.5^{bc}	2.9^{c}	23.7^{g-i}	7.9^{cd}
JBPL2	8.39^{c-g}	3.18^{f-j}	21.76^{cd}	72^{d}	83^{h}	14^{g}	1.4^{cd}	2.6^{e}	24.2^{fg}	7^{e-g}
JBPL3	8.26^{e-h}	3.17^{g-j}	22.41^{cd}	70^{f}	48^{l}	19^{a}	*1.2*^{e}	3.1^{a}	23.5^{g-j}	6.4^{g-i}
JBPL4	8.39^{c-g}	3.36^{c-e}	18.83^{f-h}	69.5^{fg}	67^{j}	17.5^{c}	1.3^{de}	3.0^{b}	24.2^{e-g}	6.8^{f-h}
JBPL5	8.22^{f-h}	3.21^{d-j}	19.64^{e-g}	70^{f}	79^{l}	17^{d}	1.4^{cd}	2.9^{c}	24.7^{d-f}	7.4^{de}
JBPL6	8.64^{bc}	3.35^{c-f}	22.6^{c}	72^{d}	87^{de}	15^{f}	1.5^{bc}	2.6^{e}	24.3^{e-g}	6.9^{e-g}
JBPL7	8.36^{d-h}	3.16^{h-j}	22.08^{cd}	73^{c}	67^{j}	12i	1.3^{de}	3.1^{a}	22.8^{jk}	7.9^{cd}
JBPL8	9.37^{a}	3.52^{ab}	22.64^{c}	71^{e}	88^{d}	16^{e}	1.6^{ab}	2.6^{e}	23.3^{h-k}	6.9^{e-g}
JBPL9	8.27^{e-h}	3.34^{c-g}	19.55^{fg}	73^{c}	96^{a}	16^{e}	1.4^{cd}	2.3^{f}	24.3^{e-g}	9.3^{b}
JBPL10	7.54^{i}	3.15^{h-j}	18.29^{gh}	74^{b}	68^{j}	15^{f}	1.7^{a}	3.1^{a}	22.9^{i-k}	9.3^{b}
JBPL11	8.21^{gh}	3.16^{h-j}	19.67^{e-g}	69^{g}	93^{b}	14^{g}	1.5^{bc}	2.9^{c}	24.3^{e-g}	6^{i}
JBPL12	8.4^{c-g}	3.14^{ij}	21.92^{cd}	71^{e}	78^{i}	15^{f}	1.4^{cd}	2.9^{c}	25.4^{cd}	7.1^{ef}
JBPL13	8.27^{e-h}	3.24^{d-j}	19.61^{e-g}	73^{c}	91^{c}	16^{e}	1.6^{ab}	2.9^{c}	25.1^{c-e}	7.13^{ef}
JBPL14	9.15^{a}	3.22^{d-j}	25.88^{a}	69^{g}	90^{c}	18^{b}	1.5^{bc}	2.8^{d}	25.2^{cd}	6.3^{hi}
JBPL15	9.23^{a}	3.58^{a}	22.45^{cd}	71^{e}	93^{b}	16^{e}	1.6^{ab}	2.9^{c}	24.3^{e-g}	5.9^{i}
JBPL16	8.53^{b-e}	3.37^{b-d}	20.28^{ef}	70^{f}	90^{c}	17^{d}	1.4^{cd}	3.1^{a}	24.1^{f-h}	7.1^{ef}
JBPL17	8.76^{b}	3.2^{d-j}	23.99^{b}	72^{d}	88^{d}	18^{b}	1.3^{de}	2.6^{e}	22.6^{k}	7^{e-g}
JBPL18	8.33^{d-h}	3.34^{c-g}	19.2^{f-h}	72^{d}	86^{ef}	16^{e}	1.3^{de}	2.9^{c}	25.3^{cd}	7^{e-g}
JBPL19	8.23^{f-h}	3.2^{d-j}	21.79^{cd}	71^{e}	84^{gh}	16^{e}	1.2^{e}	2.6^{e}	23.93^{f-h}	8.2^{c}
JBPL20	8.52^{b-e}	3.45^{a-c}	21.05^{de}	74^{b}	93^{b}	18^{b}	1.2^{e}	2.9^{c}	24.6^{d-f}	6i
JBPL21	7.69^{i}	2.93^{k}	18.77^{gh}	73^{c}	95^{a}	17^{d}	1.3^{de}	2.9^{c}	25.6^{bc}	7^{e-g}
JBPL22	8.1^{h}	3.23^{d-j}	17.81^{h}	73^{c}	85^{fg}	15^{f}	1.3^{de}	3.1^{a}	23.5^{g-j}	7.9^{cd}
JBPL23	8.41^{c-g}	3.59^{a}	19.79^{e-g}	72^{d}	90^{c}	15^{f}	1.3^{de}	3.1^{a}	26.3^{ab}	8^{c}
JBPL24	8.6^{b-d}	3.32^{c-h}	21.07^{de}	72^{d}	95^{a}	16^{e}	1.4^{cd}	2.9^{c}	26.5a	7^{e-g}
JBPL25	8.34^{d-h}	3.19^{e-j}	22.13^{cd}	73^{c}	61^{k}	13^{h}	1.4^{cd}	2.6^{e}	25.8^{a-c}	7.1^{ef}
JBPL26	5.92^{j}	2.79^{k}	11^{i}	75^{a}	95^{a}	14^{g}	1.2^{e}	3.1^{a}	25.1^{c-e}	9.9^{a}
JBPL27	8.5^{b-f}	3.28^{c-i}	21.85^{cd}	71^{e}	79^{i}	17^{d}	1.3^{de}	2.9^{c}	25.8^{a-c}	7.2^{ef}
JBPL28	8.42^{e-h}	3.44^{a-c}	18.77^{gh}	73^{c}	87^{de}	16^{e}	1.4^{cd}	2.9^{c}	25.6^{bc}	7.9^{cd}
Mean	8.33	3.26	20.52	71.84	84.00	15.88	1.39	2.86	24.54	7.34

In column, means followed by a common alphabetical small letter are not statistically different at the 5% level by DMRT

branch as 19.6 and 31.3%, followed by panicle exertion as 35.3 and 46.1%, grain yield per panicle as 12.2 and 22.2% and filled grains number per secondary branch as 8.8 and 17.6%, respectively. Higher estimates of both GCV and PCV were found for panicle exertion (35.3 and 46.1%), followed by filled grain weight per primary branch (21.6 and 30.1%), filled grain weight per secondary branch (19.6 and 31.3%), straw yield per hill (19.2 and 26%), secondary branch number (18 and 22.2%) and effective tiller number per hill (15.9 and 22.1%), respectively indicating wide degree of variations for these traits. But very little GCV was found in days to maturity (3.5%), followed by L/B ratio (5%), plant height (5.3%), panicle length (5.4%) and primary branch number (5.4%) indicating lack inherence for these traits.

However, high h^2_b coupled with high GAPM were found for seedling height (93.6% and 17.7%), followed by 1000-grain weight (91.8% and 25%), grain length (94.8% and 14.5%), secondary branch number (65.9% and 30.1%) and panicle exertion (58.7% and55.8%), respectively suggested that they were simply inherited traits governed by a few genes with additive effects. While high h^2_b estimates with low GAPM were found for days to maturity (99.6 and 13.5%, respectively). Again, high GCV and h^{2b} together with high GAPM were observed in 1000-grain weight (12.7, 91.8 and 25%), seedling height (8.9, 93.6 and 17.7%), secondary branch number (18, 65.9 and 30.1%), panicle exertion (35.3, 58.7 and 55.8%), effective tiller number per hill (15.9, 52.1 and 23.7%), straw yield per hill (19.2, 54.2 and 29%) and penultimate leaf area (12.7, 52.1 and 18.9%), respectively.

Ghosal *et al.* (2010) conducting experiment on 18 advanced breeding lines for yield contributing characters during Boro season, observed the genotypic and phenotypic coefficient of variations close to each other for plant height, panicle length, 1000-grain weight, growth duration and yield, while some differences were found for effective tillers per square meter and spikelet sterility indicating influence of environment on the expression of these characters. Hossain and Haque (2003) stated that closer difference between the phenotypic and genotypic coefficients of variations indicating less environmental influences on the expression of the respective characters in rice. Thus, improvement of studied germplasm groups may be possible through direct selection for the characters having high GCV and PCV in segregating generations. Iftekharuddaula *et al.* (2001) by studying 24 modern rice varieties of irrigated ecosystem found high heritability coupled with high genetic advance in percentage

Table 7: Genetic parameters of 38 morpho-physicochemical characters of 28 Jesso-Balam PL rice accessions

Characters	GCV (%)	PCV (%)	H^2_b (%)	GA	GAPM(%)
Coleoptile length (mm)	7.5	10.4	51.9	1.2	11.1
Seedling height (cm)	8.9	9.2	93.6	11.8	17.7
Penultimate leaf length (cm)	8.6	13.0	43.6	6.6	11.7
Penultimate leaf width (mm)	6.8	8.8	59.1	1.2	10.7
Penultimate leaf area (cm^2)	12.7	17.6	52.1	9.2	18.9
Flag leaf length (cm)	6.7	10.5	40.8	3.1	8.8
Flag leaf width (mm)	5.7	8.0	50.4	1.1	8.3
Flag leaf area (cm^2)	10.2	14.9	46.3	5.2	14.2
Culm height (cm)	5.5	8.0	48.5	9.4	8.0
Culm diameter (mm)	7.0	9.4	54.4	0.6	10.6
Plant height (cm)	5.3	7.0	56.4	11.8	8.1
Panicle exertion (cm)	35.3	46.1	58.7	1.9	55.8
Effective tiller number per hill	15.9	22.1	52.1	2.8	23.7
Straw yield per hill (g)	19.2	26.0	54.2	9.2	29.0
Days to maturity	3.5	3.5	100.0	10.8	7.2
Panicle length (cm)	5.4	6.7	64.1	2.4	8.8
Grain yield per panicle (g)	12.2	22.2	30.4	0.4	13.9
Grain yield pe rhill (g)	8.4	14.9	32.2	2.2	9.9
Harvest index (HI) (%)	13.3	20.0	44.3	6.1	18.3
Biological yield (BY) (g)	14.3	21.3	45.3	9.4	19.9
Primary branch number	5.4	9.7	31.2	0.7	6.2
Av. primary branch length (cm)	7.8	10.1	58.6	1.4	12.2
Filled grain number per primary branch	6.0	9.2	42.1	0.4	8.0
Primary branch filled grain weight (g)	21.6	30.1	51.4	0.4	31.9
Secondary branch number	18.0	22.2	65.9	11.6	30.1
Av. secondary branch length (mm)	7.9	10.1	61.6	3.3	12.8
Filled grain number per secondary branch	8.8	17.6	25.0	0.2	9.1
Secondary branch filled grain weight (g)	19.6	31.3	39.2	0.4	25.3
Grain length (mm)	7.2	7.4	94.8	1.2	14.5
LB ratio	5.0	5.9	72.7	0.3	8.8
1000-grain weight (g)	12.7	13.2	91.8	5.1	25.0
Millin goutturn (%)	2.2	2.2	96.0	3.1	4.3
Head rice out turn(%)	14.2	14.2	99.6	24.5	29.2
Cooking time (min)	10.0	10.1	98.1	3.2	20.5
Elongation ratio	9.3	9.3	100.0	0.3	19.1
Imbibition ratio	7.3	7.3	100.0	0.4	15.0
Amylose content (%)	4.1	4.5	83.1	1.9	7.8
Protein content (%)	13.1	13.8	90.2	1.9	25.6

GCV: Genotypic coefficient of variation, PCV: Phenotypic coefficient of variation, H^2_b: Heritability, GA: Genetic advance, APM: Genetic advance in percent of mean

of mean in plant height, 1000-grain weight, spikelet per panicle and grain yield per panicle. Ghosal *et al.* (2010) documented high h^2_b estimate with high GAPM for yield, 1000-grain weight, panicle length, spikelet sterility and plant height suggested that they were simply inherited traits governed by a few major genes or additive gene effects. Akter *et al.* (2004) observed high heritability coupled with high genetic advance in percentage of mean for 1000-grain weight. Parikh *et al.* (2012) stated high heritability coupled with high genetic advance indicating preponderance of additive gene action in the expression of these characters. Shanthakumar *et al.* (1998) found high genotypic coefficient of variability together with high heritability and genetic advance for plant height, total tillers per hill, flag leaf length, panicle length,spikelet fertility, 1000-grain weight and grain yield. However, Prasad *et al.* (2001) studied eight fine rice genotypes and found that 1000-grain weight, number of effective tiller per plant, number of fertile grain per panicle and yield per plant showed high GCV and high heritability coupled with high GAPM. Therefore, selection may be effective for these characters for improving jesso-Balam rice germplasm.

Correlation of different characters for Jesso-Balam rice germplasm: Out of 24 very highly significant ($p<0.001$) estimates among the total 153 correlations obtained between 18 different character pairs, 19 correlation coefficients were found positive in nature and only 5 estimates were negative (Table 8). The result also revealed that SBFGW had the highest very highly significant positive association with PGY (0.824), followed by GL with TGW (0.816), SBN with SBFGW (0.730), GL with LBR (0.701) etc. Besides, SBN had the highest very highly

Table 8: Estimates of simple correlation coefficients between 18 agro-morphological characters of 28 Jesso-Balam PL rice

Parameters	PFLA	PH	ENT	DM	PL	PBN	APBL	PFGN	PFGW	SBN	ASBL	SFGN	SFGW	GL	LBR	TGW	PGY
PFLA	1																
PH	0.106	1															
ENT	0.008	-0.125	1														
DM	0.161	0.374***	0.255*	1													
PL	-0.108	0.491***	0.004	0.165	1												
PBN	0.080	0.041	0.038	-0.030	0.041	1											
APBL	0.184	0.256*	0.126	0.212*	0.410***	0.035	1										
PFGN	-0.186	0.020	0.139	0.088	0.126	0.009	-0.030	1									
PFGW	-0.051	0.104	-0.033	0.167	-0.007	0.254*	-0.025	0.294**	1								
SBN	0.203	0.173	0.150	0.045	0.332**	0.354***	0.559***	0.047	-0.239*	1							
ASBL	0.157	0.194	-0.009	-0.029	0.269**	0.047	0.680***	-0.186	-0.174	0.432***	1						
SFGN	0.190	0.069	-0.079	-0.143	0.148	-0.162	0.155	-0.137	-0.093	0.127	0.131	1					
SFGW	0.218*	0.178	-0.014	0.049	0.345***	0.220*	0.513***	-0.024	0.020	0.730***	0.335**	0.446***	1				
GL	0.234*	-0.080	-0.270**	0.110	-0.362***	-0.014	-0.206	-0.252*	0.298**	-0.434***	-0.036	-0.145	-0.215*	1			
LBR	0.176	-0.179	-0.033	-0.096	-0.432***	0.074	-0.267**	-0.213*	0.089	-0.265*	0.054	-0.080	-0.215*	0.701***	1		
TGW	0.183	-0.094	-0.418***	0.000	-0.275**	-0.015	-0.143	-0.146	0.419***	-0.399***	-0.057	-0.097	-0.085	0.816***	0.344***	1	
PGY	0.149	0.204	-0.029	0.135	0.276**	0.321**	0.403***	0.147	0.583***	0.458***	0.174	0.311**	0.824***	-0.006	-0.124	0.168	1
HGY	0.101	-0.011	0.328**	0.132	0.010	0.095	0.009	0.011	0.239*	- 0.000	-0.068	0.032	0.135	0.220*	0.210	0.217*	0.247*

PFLA: Penultimate and flag leaf area, PH: Plant height, ENT: Effective tiller number per hill, DM: Days to Maturity, PL: Panicle length, PBN: Primary branch number, APBL: Average primary branch length, PFGN: Filled grain number per primary branch, PFGW: Primary branch filled grain weight, SBN: Secondary branch number, ASBL: Average secondary branch length, SFGN: Filled grain number per secondary branch, SFGW: Secondary branch filled grain weight, GL: Grain length, LBR: LB ratio, TGW: 1000-grain weight, PGY: Grain yield per panicle, HGY: Grain yield per hill and ***'**'*Significant at 0.1, 1 and 5% probability levels, respectively significant negative association with GL (0.434), followed by PL with LBR (-0.432), ETN with TGW (-0.418), SBN with TGW (-0.399) etc. Therefore, these characters emerged as most important associates of grain yield in rice.

Secondly, among the 12 highly significant (p<0.01) estimates, nine correlations were positive in nature and three were found negative. The ASBL showed the highest highly significant positive association with SBFGW (0.335), followed by PL with SBN (0.332), ENT with HGY (0.328), PBN with PGY (0.321) etc. Besides, PL showed the highest highly significant negative association with TGW (-0.275), followed by ETN with GL (-0.270) etc. Therefore, these characters also emerged as important associates of grain yield in rice. Finally among the seventeen significant (p<0.05) estimates, 11 correlations were positive in nature and six were negative. The PH showed the highest significant positive association with APBL (0.256), followed by ETN with DM (0.255), PBN with PBFGW (0.254), PGY with HGY (0.247) etc. Besides, SBN showed the highest significant negative association with LBR (-0.265), followed by PBFGN with GL (-0.270) etc. Similar trend of associations between yield components were also reported earlier on rice (Chaudhary and Motiramani, 2003; Zahid *et al*., 2006; Yadav *et al*., 2011). Finally, the results indicated that the higher the PBN, SBN, SBFGW, LBR and TGW possessed greater the PL, GL and PGY, which appears logical. This also indicates high response for improving yield and yield components of studied rice germplasm. Janardhanam *et al*. (2001) also reported positive associations between different yield and yield components in rice.

CONCLUSION

Finally, each pure line of Jesso-balam rice accession offers valuable gene reservoir which needs to conserve and characterize for further improvement of Balam rice as highly significant differences among the lines were observed. The highest potentiality (positive) were found in JBPL17 for penultimate leaf area, JBPL22 for straw yield per hill, biological yield, panicle length, culm height and plant height, JBPL23 for primary branch number and harvest index, JBPL8 for grain length, JBPL26 for milling outturn, protein content and lowest TGW. Moreover, the correlation between different characters revealed that the higher the PBN, SBN, SBFGW, LBR and TGW possessed greater PL, GL and PGY. Finally, molecular approach need to apply for QTL mapping of the identified traits.

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