Original Research Article

Deciphering Genetic Variability, Traits Association, Correlation and Path Coefficient in Selected Boro Rice (*Oryza sativa* L.) Landraces

ABSTRACT

The study was conducted to evaluate the mean performance, variability along with heritability, correlation coefficient and path coefficients from data collected on 48 Boro rice landraces. Amboro 2 (Golden), Gopal Beshi, Deshi Boro, Kali Boro, Madhabsail, Jagli (Deshi Boro), Pankaich, Joya Boro and Mi-Pajang were found as elite landrace based on the mean performance. High heritability along with genetic advance (GA) and genetic advance in per cent of mean (GAMP) was observed for ligule length, basal leaf length, basal leaf width, culm length, panicle length, test weight, grain length, grain breadth and brown rice length breadth ratio. A positive and significant correlation was observed for basal leaf length, culm length, plant height and yield at both genotypic and phenotypic levels. Basal leaf length and plant height showed a positive direct effect, but culm length showed a negative direct effect at the genotypic level and the situation is just reversed at the phenotypic level for these three traits. However, all these three traits have made the total association positive and significant. Yield had significant (***p<0.001) positive correlations with filled grains number per panicle, days to flowering, days to maturity, grain length, and decorticated grain length breadth ratio. Hence, basal leaf length, culm length, plant height, days to flower and days to maturity are identified as key traits for developing advanced Boro rice breeding lines. The landraces showing a significant amount of variability for yield and its correlated traits can be used for the future breeding program by direct selection based on yield and yield contributing traits.

Keywords: Variability; traits association; correlation, path coefficient; heritability; rice landrace.

1. INTRODUCTION

Bangladesh is one of the leading rice-growing countries in the world right now and its economy and tradition largely depend on rice. Rice is nowadays not only an economical crop but political also because it maintains the social and political stability of Bangladesh [1]. In Bangladesh, rice occupies more than 96% of the land area under "Cereal Agriculture". Bangladesh is the third-largest rice producer in the world after China and India [2]. Bangladesh is the world's second-largest per capita rice consumption country at 179.9 kg $yr.^{-1}$ [3]. The growth of rice production in Bangladesh is 3.5% until recently. The cultivable lands are decreasing day by day due to industrialization [4]. Boro is considered the irrigated and high-yielding season played an important role in Bangladesh rice security. The recent coverage of the Boro area was 41.58 per cent and contributed 53.75 per cent of the total rice production [5]. The population of Bangladesh will reach 215.4 million in 2050, when 44.6 MT of clean rice will be needed to feed Bangladeshi people [6]. So, more food will be required in future because of the increasing population.

To feed the upcoming increased population, we need to emphasize Boro rice production. Though Boro rice is a long duration rice ecosystem, it is balanced by offering its yield. But it is crucial to find out the marvelous breeding lines having short duration and other good agronomic traits without compromising with yield. By exploring the local Boro landrace along with their genetic studies, we can achieve our target. Yield is a polygenic trait and has a complex association with many yield-contributing traits which are stimulated by environmental factors [7]. In a sense, high yield can be trapped by good agronomic practices, but an effective and meaningful breeding program will lead to finding out more genetic variation, selection of genotypes and advancement of selected genotypes for varietal development [8-10]. Several researchers explored morphological traits for diversity assessment and characterization of Bangladesh rice landraces [11-34]. For selection, conservation, characterization, and proper utilization of germplasms, genetic diversity is the key component of any crop production system [34]. Rice breeders are working to evaluate genetic variability by digging out desirable characters and assessing them up to which extent they are heritable, so various morphological characters have been identified that play a pivotal role in more rice production [35].

Therefore, the current study was conducted to evaluate the mean performance, variability among the traits of selected Boro rice landraces, the correlation between the traits and yield, and direct and indirect effects contributed by each trait towards yield for the efficient trait-based selection of promising rice landraces for the future rice breeding perspectives.

2. MATERIALS AND METHODS

2.1. Materials, Design and Intercultural Operations

The experiment was carried out in Boro 2018-19 season. Forty-eight (48) entries of Boro rice landraces (Table 1) were collected from the genebank of Bangladesh Rice Research Institute (BRRI). The landrace was sown in the seedbed on 29 November 2018 and raised 47 days seedling in the Genetic Resources and Seed Division farm of BRRI. The soil was silt clay, slightly acidic (pH 6.5) and very low in organic matter (0.86%). The seedlings were transplanted in the experiment field with one seedling per hill on 14 January 2019. The row-to-row and plant-to-plant distance was 20cm × 20cm. There were 30 hills for each landrace in each replication. Entries were repeated three times. The experiment was laid out in a randomized complete block design. Fertilizer doses were 80:60:40:12 kg NPKS per hectare, respectively. The recommended agronomic practices were maintained for proper crop growth.

Table 1. Selected Boro rice landraces from BRRI genebank

Accession no.	Landrace Name	Accession no.	Landrace Name	Accession no.	Landrace Name
149	Mi-Pajang	1705	Jagli	2191	Kali Boro 26
180	Dholi Boro	1753	Local Boro	2192	Kali Boro 41/1
257	Kumri Boro	1794	Saita	2193	Kali Boro 48/1
261	Bairagi Sail	1795	Dud Saita	2194	Kali Boro 80/3
931	Tepi Khorch	1804	Bogra Boro	2195	Kali Boro 80/5
937	Pan Kaich	1805	Deshi Boro	2196	Kali Boro 109/4
938	Boro Deshi	1806	Jagli (Deshi Boro)	2197	Kali Boro 138/2
939	Gopal Beri	1808	Boro	2198	Kali Boro 139/2
940	Borail	1809	Boro Jagli	2199	Kali Boro 200
1049	Kali Boro	1810	Jagli	2200	Kali Boro 208
1050	Sonar Geye	1815	Deshi Boro	2201	Kali Boro 259
1051	Joya Boro	1816	Boro	2202	Kali Boro 266
1473	Amboro II (Golden)	1861	Boro (Sunga)	2203	Kali Boro 576
1477	Batti Boro	1866	Jala Boro	2204	Kali Boro 600
1651	Madhar Sail	2189	Kali Boro 2/2	2205	Kali Boro 704
1704	Jagli	2190	Kali Boro 4/1	2206	Boro 6/2

Data were collected from 10 plants randomly in each replication on ligule length (cm), basal leaf length (cm), basal leaf width (cm), culm length (cm), culm diameter (mm), plant height (cm), effective tiller (%), spikelet fertility (%), panicle length (cm), test weight (g), grain length (mm), grain breadth (mm), brown rice length breadth ratio, days to flower, days to maturity and yield (g/hill).

2.2. Statistical analysis

The mean, range and standard deviation for each character were estimated. The mean sum of the squares was estimated for the calculation of genotypic and phenotypic variances [36]. Genotypic and phenotypic coefficients of variation were estimated by the formula suggested by Burton [37]. Heritability in a broad sense was estimated which was further defined by Lush [38] by the suggested formula [36]. The expected genetic advance for different characters was calculated using the suggested formula [36, 38]. Genetic advance in the percentage of mean was calculated by the given formula [36]. Phenotypic and genotypic correlations were worked out by using the suggested formulae [37]. Analysis of the path coefficient suggested [41] and modified by [42] was used to calculate the direct and indirect contribution of various traits to yield. Principal component analysis and correlations were performed using R packages [43].

3. RESULTS AND DISCUSSION

3.1. Assessment of Mean Performance

The mean performance of 48 Boro rice landrace was shown in Table 2. Most of the landrace (31) showed basal leaf length within the range of 36.20 cm-47.40 cm. For culm length, maximum accession (29) falls under the range 99.70 cm-120.60 cm. In case of plant height, most of the landrace (29) is concentrated in 124.90 cm-146.20 cm. The cumulative mean was 124.15 cm whereas the highest plant height was found in Amboro 2 (146.10 cm) which is almost matched with [25]. For effective tiller per cent, most of the landrace's (30) fall under the range of 80.95-86.9. Deshi Boro acquired the highest (92.85) effective tiller per cent whereas Kali Boro 200 placed the lowest (75%). Spikelet fertility was found highest (96.63%) for Kali Boro 139/2 and maximum (37) accession showed their fertility level under the range of 89.38%-96.68%. For the trait of panicle length, the grand mean was 23.07 cm, and the highest value was obtained by Madhabsail (26.60 cm). However, for test weight, most of the landrace (33) falls under 22.34 g-27.82 g with a mean value of 23.93 g. The highest test weight was for Jagli (Deshi Boro) (33.28 g). The highest brown rice length breadth ratio was 2.77 by Pankaich and the lowest by Borail (1.76). For days to flower, maximum landrace (35) concentrated under 123 days with a grand mean of more than 121 days. The highest flowering days were obtained by Pankaich (143 days). In days to maturity, maximum landrace (33) falls under 149 days with a grand mean of more than 148 days. The highest maturity days were occupied by Joya Boro (168 days) and the lowest by Kali Boro 80/5 (140 days). Maximum landrace (31) produced a yield between 12.14 g-17.83 g per hill with a mean of 16.19 g, matched with the findings of [24] but differed with [20, 22, 24, 26]. The highest yield was obtained by Mi-Pajang (23.51 g) and the lowest by Bairagi Sail (6.45 g).

Table 2: Mean performance of selected Boro Rice Landraces

	Range	Mean	CV	SD	SE	LSD (5%)	Highest	Lowest
Ligule Length (cm)	<1.43= 34 ≥1.43-1.88= 11 >1.88-2.33=3	1.37	7.72	0.28	0.04	0.08	Tepi Khorch (2.33)	Kali Boro 2/2 (0.99)
Basal Leaf Length (cm)	<36.20= 14 ≥36.20-47.40= 31 >47.40-58.60= 3	39.81	6.11	6.23	0.89	1.76	Amboro 2 (Golden) (58.60)	Boro Deshi (25.00)
Basal Leaf Width (cm)	<0.84= 2 ≥0.84-1.15= 43 >1.15-1.45=3	1.03	4.55	0.14	0.02	0.04	Gopal Beshi (1.45)	Boro Deshi (0.54)
Culm Length (cm)	<78.80= 4 ≥78.80-99.70= 15 >99.70-120.60=29	101.07	4.14	14.34	2.07	4.05	Amboro 2 (Golden) (120.60)	Jala Boro (57.90)
Culm Diameter (mm)	<3.05= 1 ≥3.05-4.10= 36 >4.10-5.15= 11	3.81	8.02	0.56	0.08	0.16	Amboro 2 (Golden) (5.15)	Boro Deshi (2.00)
Plant Height (cm)	<103.60= 4 ≥103.60-124.90= 15 >124.90-146.20= 29	124.15	3.48	14.87	2.14	4.20	Amboro 2 (Golden) (146.10)	Joya Boro (82.30)
Effective Tiller (%)	<80.95= 3 ≥80.95-86.9= 30 >86.9-92.85= 15	86.27	3.10	3.45	0.49	0.97	Deshi Boro (92.85)	Kali Boro 200 (75.00)
Spikelet Fertility (%)	<82.08= 4 ≥82.08-89.38= 7 >89.38-96.68=37	91.17	3.47	5.93	0.85	1.67	Kali Boro 139/2 (96.63)	Tepi Khorch (74.78)
Panicle Length (cm)	<20.95= 4 ≥20.95-23.80= 28 >23.80-26.65=16	23.07	3.05	1.90	0.27	0.53	Madhabsail (26.60)	Boro Deshi (18.10)
Test Weight (g)	<22.34= 11 ≥22.34-27.82= 33 >27.82-33.30= 4	23.93	2.52	2.87	0.41	0.81	Jagli (Deshi Boro) (33.28)	Mi-Pajang (16.86)
Grain Length (mm)	<7.79= 25 ≥7.79-8.41= 14 >8.41-9.03= 9	7.90	1.61	0.51	0.07	0.14	Jala Boro (9.03)	1704 Jagli (7.17)
Grain Breadth (mm)	<2.91= 13 ≥2.91-3.38= 34 >3.38-3.85= 1	2.99	1.93	0.22	0.03	0.06	Dud Saita (3.83)	Mi-Pajang (2.44)
Brown Rice Length Breadth Ratio	<2.09= 15 ≥2.09-2.43= 28 >2.43-2.77= 5	2.17	2.26	0.21	0.03	0.06	Pankaich (2.77)	Borail (1.76)
Days to Flower	<123= 35 ≥123-133= 9 >133-143= 4	121.45	1.87	7.37	1.06	2.08	Pankaich (143)	Bairagi Sail (114)
Days to Maturity	<149= 33 ≥149-159= 11 >159-169= 4	148.31	1.93	7.32	1.05	2.07	Joya Boro (168)	Kali Boro 80/5 (140)
Yield(g/hill)	<12.14= 4 ≥12.14-17.83= 31 >17.83-23.51= 13	16.19	18.54	4.49	0.64	1.27	Mi-Pajang (23.51)	Bairagi Sail (6.45)

***** CV= Coefficient of Variation, SD= Standard Deviation, SE= Standard Error, LSD= Least Significant Difference

3.2. Assessment of Variability

Analysis of variance and heritability (Table 3) demonstrates that high differences in genotypic and phenotypic variances were present for all the studied traits except ligule length, basal leaf width, grain length, grain breadth and brown rice length breadth ratio which is matched with the findings of [25]. It depicts that these traits are less influenced by the environment. The highest genotypic and phenotypic coefficient of variation was found for yield. In the broad sense, high heritability was found for all traits except culm diameter, effective tiller, spikelet fertility and yield. High heritability along with genetic advance (GA) and genetic advance in per cent of mean (GAMP) was observed for ligule length, basal leaf length, basal leaf width, culm length, panicle length, test weight, grain length, grain breadth and brown rice length breadth ratio. Similar results were also observed by another study [44-45]. It means that these traits have high additive gene action.

Table 3: Variability Performance of selected Boro Rice Landrace

Traits	V_g	V_p	GCV	PCV	h_b^2	GA	GAM (%)
Ligule Length (cm)	0.07	0.08	19.58	21.04	86.54	0.39	28.77
Basal Leaf Length (cm)	32.42	38.33	14.30	15.55	84.58	8.27	20.78
Basal Leaf Width (cm)	0.02	0.02	12.94	13.72	88.99	0.20	19.29
Culm Length (cm)	190.83	208.35	13.67	14.28	91.59	20.89	20.67
Culm Diameter (mm)	0.23	0.33	12.67	15.00	71.41	0.65	16.92
Plant Height (cm)	205.57	224.25	11.55	12.06	91.67	21.69	17.47
Effective Tiller (%)	4.95	12.10	2.58	4.03	40.93	2.25	2.61
Spikelet Fertility (%)	25.61	35.64	5.55	6.55	71.85	6.78	7.43
Panicle Length (cm)	3.19	3.69	7.74	8.32	86.55	2.63	11.38
Test Weight (g)	8.04	8.40	11.85	12.11	95.68	4.38	18.31
Grain Length (mm)	0.25	0.27	6.33	6.53	93.92	0.77	9.69
Grain Breadth (mm)	0.05	0.05	7.31	7.56	93.50	0.33	11.16
Brown Rice Length Breadth Ratio	0.04	0.05	9.68	9.94	94.84	0.32	14.89
Days to Flower	50.07	55.22	5.83	6.12	90.68	10.65	8.77
Days to Maturity	45.71	53.91	4.56	4.95	84.78	9.84	6.63
Yield (g/hill)	11.02	20.04	20.49	27.64	54.98	3.89	24.01

*****Vg= Genotypic variance, Vp= Phenotypic variance, GCV= Genotypic coefficient of variation, PCV= Phenotypic coefficient of variation, h_b^2= Heritability (Broad sense), GA= Genetic advance, GAMP= Genetic advance in per cent of mean

3.3. Principal Component Analysis

Principal component analysis revealed that two major dimensions could explain around 43% of the total variability, and were mainly influenced by total tiller numbers, effective tillers numbers and grain breadth, respectively (Fig. 1 and 2). Our findings differed with findings of Kimwemwe et al. [46] where the first three principal components accounted for 36.3% of the total variation of the studied rice genotypes.

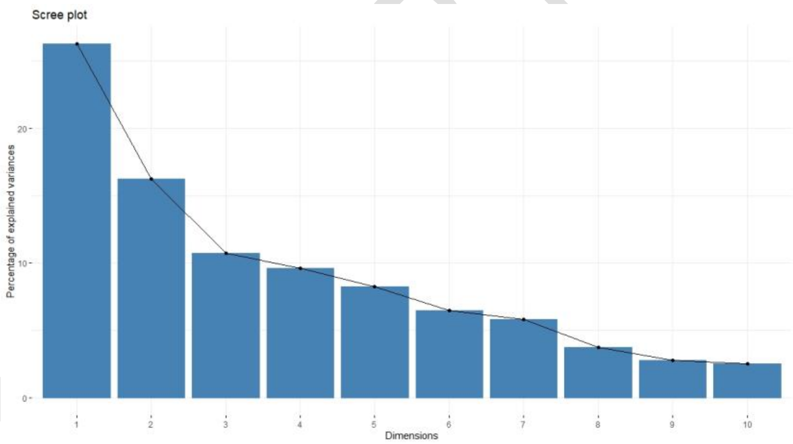

Fig. 1. Scree plot denotes contribution of different principal components of 48 Boro rice landraces.

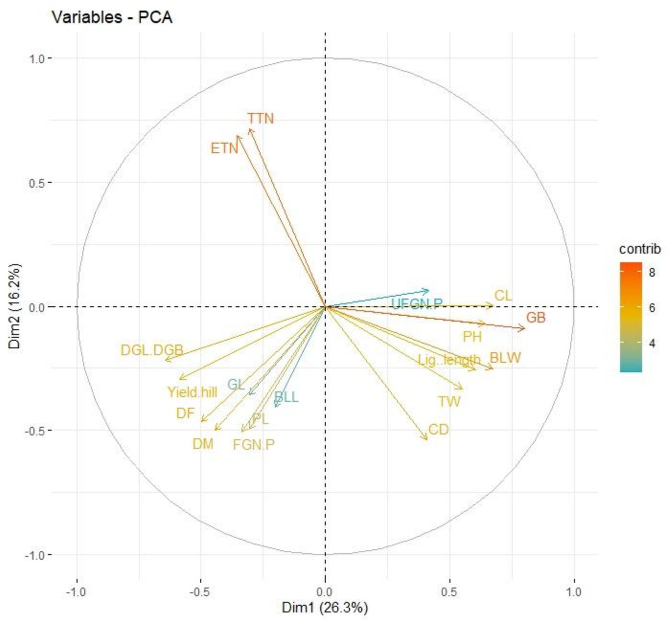

Fig. 2. Principal component analysis denotes contributing factors for variability of 48 Boro rice landraces.

3.4. Correlations Among the Measured Traits

Correlation analysis showed that there were significant correlations observed among the studied traits (Fig. 3). Yield (g/hill) had significant (***p<0.001) positive correlations with filled grains number per panicle (0.46), days to flowering (0.43), days to maturity (0.34), grain length (0.34), and decorticated grain length breadth ratio (0.34).

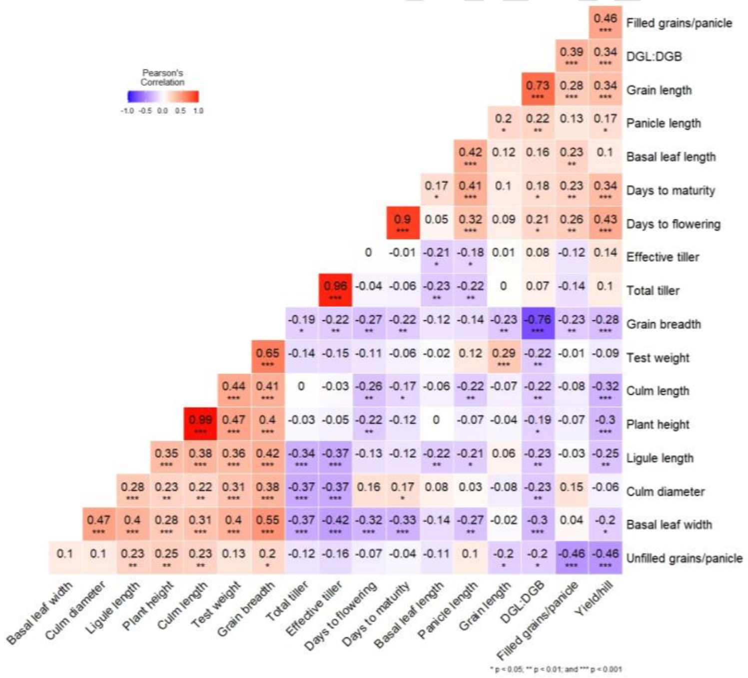

Fig. 3. Correlations among the measured traits of the 48 Boro rice landraces.

3.5. Assessment of Traits Association

Measuring the association between studied traits indicates whether we should select the landrace based on good traits or not. The correlation coefficient measures the strength between two traits. The positive and significant relationship indicates that the relationship has a positive impact on target trait-like yield. On the other hand, negative and non-significant relationships indicate that the relationship hurts the target trait. In this study, the genotypic and phenotypic associations are distributed in Table 4. Selection should be done to find out the elite landrace based on the positive and significantly associated traits for crop development. A positive and significant association was found for basal leaf length, culm length and plant height with yield at both genotypic and phenotypic levels, similar to the findings of [47-48]. Grain breadth had a negative significant relationship with a yield, so this trait should be discarded in this trait-based selection. Days to flower and days to maturity were associated positively and significantly with spikelet fertility and basal leaf length showed a significant positive association with panicle length. The results are supported by the findings of [24, 44]. Test weight had a positive and significant correlation with grain length and grain breadth at both levels. Effective tiller had a significant positive association with days to flower and days to maturity only at the phenotypic level which means that these traits are highly influenced by the environment. On the other hand, the brown rice length breadth ratio had a significant positive correlation with grain length, but grain breadth had a significant negative association which is similar with the findings of [25].

Table 4: Genotypic and Phenotypic Association of Traits of Boro Rice Landrace

		LL	BLL	BLW	CL	CD	PH	ET	SF	PL	TW	GL	GB	BRLBR	DF	DM
BLL	r_g	0.26														
	r_p	0.24**														
BLW	r_g	0.25	0.53**													
	r_p	0.22**	0.50**													
CL	r_g	-0.35*	0.38**	0.2												
	r_p	-0.28**	0.35**	0.20*												
CD	r_g	0.24	0.42**	0.42**	0.28											
	r_p	0.23**	0.40**	0.35**	0.27**											
PH	r_g	-0.33*	0.45**	0.25	0.99**	0.34*										
	r_p	-0.27**	0.41**	0.24**	0.99**	0.31**										
ET	r_g	0.24	-0.08	-0.08	-0.29*	-0.15	-0.30*									
	r_p	0.15	-0.01	-0.04	-0.10	-0.07	-0.10									
SF	r_g	-0.48**	-0.20	0.15	0.53**	-0.03	0.48**	-0.04								
	r_p	-0.39**	-0.11	0.15	0.42**	0.00	0.39**	-0.05								
PL	r_g	0.04	0.64**	0.45**	0.23	0.54**	0.34*	-0.14	-0.25							
	r_p	0.05	0.57**	0.37**	0.21**	0.43**	0.33**	-0.02	-0.17*							
TW	r_g	0.09	0.00	-0.07	-0.33*	0.13	-0.32*	0.03	-0.35*	-0.06						
	r_p	0.08	0.01	-0.05	-0.30**	0.11	-0.30**	0	-0.27**	-0.06						
GL	r_g	0.37**	0.16	0.11	-0.54**	0.04	-0.52**	0.13	-0.62**	0.03	0.63**					
	r_p	0.36**	0.16*	0.10	-0.49**	0.06	-0.47**	0.05	-0.53**	0.02	0.59**					
GB	r_g	-0.10	-0.23	-0.04	-0.08	0.12	-0.10	-0.08	-0.01	-0.12	0.65**	0.07				
	r_p	-0.07	-0.20*	-0.02	-0.08	0.09	-0.09	-0.05	0.01	-0.11	0.62**	0.07				
BRLBR	r_g	0.40**	0.26	0.13	-0.41**	-0.12	-0.38**	0.16	-0.52**	0.09	0.05	0.74**	-0.57**			
	r_p	0.38**	0.24**	0.12	-0.36**	-0.07	-0.34**	0.10	-0.45**	0.08	0.04	0.73**	-0.55**			
DF	r_g	0.42**	0.47**	0.26	-0.23	0.23	-0.16	0.19	-0.45**	0.44**	-0.09	0.29*	-0.38**	0.48**		
	r_p	0.38**	0.37**	0.19*	-0.20*	0.168*	-0.14	0.16*	-0.43**	0.41**	-0.09	0.26**	-0.33**	0.43**		
DM	r_g	0.44**	0.52**	0.38**	-0.20	0.24	-0.13	0.21	-0.39**	0.49**	-0.10	0.34*	-0.35*	0.49**	0.93**	

		LL	BLL	BLW	CL	CD	PH	ET	SF	PL	TW	GL	GB	BRLBR	DF	DM
	r_p	0.37**	0.39**	0.29**	-0.18*	0.15	-0.12	0.18*	-0.34**	0.43**	-0.09	0.29**	-0.28**	0.44**	0.89**	
Yield	r_g	0.04	0.33*	0.26	0.45**	0.24	0.45**	-0.18	0.26	0.10	-0.16	0.01	-0.29*	0.17	0.10	0.09
	r_p	0.05	0.19*	0.13	0.32**	0.13	0.32**	-0.10	0.09	0.09	-0.10	-0.04	-0.24**	0.11	0.06	0.05

r_g= Genotypic correlation, r_p= Phenotypic correlation, LL= Ligule length, BLL= Basal leaf length, BLW= Basal leaf width, CL= Culm length, CD= Culm diameter, PH= Plant height, ET= Effective tiller, SF= Spikelet fertility, PL= Panicle length, TW= Test weight, GL= Grain length, GB= Grain breadth, BRLBR= Brown rice length breadth ratio, DF= Days to flower, DM= Days to maturity

Table 5: Genotypic and phenotypic path coefficient of Boro Rice Landrace

		LL	BLL	BLW	CL	CD	PH	ET	SF	PL	TW	GL	GB	BRLBR	DF	DM	Yield
LL	G	**0.66**	0.04	-0.07	119.26	-0.01	-117.84	-0.03	-0.61	-1.61	-0.04	0.65	0.05	-0.30	0.24	-0.35	0.04
	P	**-0.27**	-0.03	0.12	-159.37	-0.02	155.44	-0.05	0.23	3.98	-0.01	0.48	0.08	-0.70	0.21	-0.04	0.05
BLL	G	0.17	**0.16**	-0.16	-130.21	-0.02	158.62	0.01	-0.25	-28.05	0.00	0.27	0.12	-0.19	0.27	-0.41	0.33*
	P	-0.07	**-0.14**	0.28	196.20	-0.03	-238.82	0.00	0.07	42.57	0.00	0.22	0.20	-0.44	0.20	-0.04	0.19*
BLW	G	0.16	0.09	**-0.30**	-66.72	-0.02	86.37	0.01	0.18	-19.49	0.03	0.18	0.02	-0.09	0.14	-0.30	0.26
	P	-0.06	-0.07	**0.55**	115.38	-0.03	-142.95	0.01	-0.09	27.36	0.01	0.14	0.03	-0.24	0.11	-0.03	0.13
CL	G	-0.24	0.06	-0.06	**-336.80**	-0.01	347.10	0.04	0.67	-9.89	0.14	-0.94	0.05	0.31	-0.13	0.16	0.46**
	P	0.08	-0.05	0.12	**555.49**	-0.02	-570.93	0.03	-0.25	15.82	0.03	-0.65	0.08	0.67	-0.11	0.02	0.32**
CD	G	0.16	0.07	-0.13	-95.83	**-0.05**	119.87	0.02	-0.04	-23.81	-0.06	0.07	-0.07	0.09	0.13	-0.19	0.24
	P	-0.06	-0.06	0.20	151.48	**-0.07**	-183.75	0.02	0.00	32.17	-0.01	0.08	-0.10	0.15	0.09	-0.01	0.13
PH	G	-0.22	0.07	-0.07	-334.29	-0.02	**349.70**	0.04	0.61	-14.95	0.14	-0.90	0.05	0.29	-0.09	0.10	0.45**
	P	0.07	-0.06	0.14	551.10	-0.02	**-575.48**	0.03	-0.23	24.71	0.03	-0.62	0.09	0.63	-0.08	0.01	0.32**
ET	G	0.16	-0.01	0.02	100.64	0.01	-106.90	**-0.14**	-0.05	6.01	-0.01	0.23	0.04	-0.12	0.11	-0.17	-0.18
	P	-0.04	0.00	-0.03	-56.16	0.01	58.53	**-0.30**	0.04	-2.15	0.00	0.07	0.05	-0.20	0.09	-0.02	-0.11
SF	G	0.00	-0.03	-0.04	-179.95	0.00	169.04	0.01	**0.01**	10.79	0.15	-1.08	0.01	0.39	-0.26	0.32	-0.67
	P	0.11	0.02	0.08	237.97	0.00	-224.90	0.02	**-0.01**	-12.56	0.03	-0.69	-0.01	0.82	-0.24	0.03	0.09
PL	G	0.02	0.11	-0.14	-76.91	-0.02	120.71	0.02	-0.31	**-43.31**	0.03	0.05	0.06	-0.07	0.25	-0.39	0.10

	P	-0.01	-0.08	0.21	119.49	-0.03	-193.30	0.01	0.10	**73.55**	0.01	0.03	0.12	-0.16	0.22	-0.04	0.09
TW	G	0.06	0.00	0.02	111.37	-0.01	-114.16	0.00	-0.45	2.69	**-0.42**	1.09	-0.36	-0.04	-0.05	0.08	-0.16
	P	-0.02	0.00	-0.03	-172.15	-0.01	176.84	0.00	0.16	-4.84	**-0.10**	0.77	-0.62	-0.08	-0.05	0.01	-0.11
GL	G	0.25	0.03	-0.03	183.96	0.00	-182.82	-0.02	-0.79	-1.32	-0.27	**1.72**	-0.04	-0.55	0.17	-0.28	0.01
	P	-0.10	-0.02	0.06	-276.97	0.00	275.19	-0.02	0.32	1.56	-0.06	**1.30**	-0.08	-1.34	0.15	-0.03	-0.04
GB	G	-0.06	-0.04	0.01	28.18	-0.01	-33.26	0.01	-0.01	5.08	-0.28	0.12	**-0.54**	0.42	-0.22	0.28	-0.30*
	P	0.02	0.03	-0.02	-46.33	-0.01	54.79	0.02	-0.01	-8.65	-0.06	0.10	**-0.98**	1.01	-0.18	0.03	-0.24**
BRLBR	G	0.27	0.04	-0.04	138.92	0.01	-135.03	-0.02	-0.66	-4.02	-0.02	1.28	0.31	**-0.74**	0.27	-0.39	0.17
	P	-0.10	-0.03	0.07	-204.42	0.01	198.08	-0.03	0.27	6.38	0.00	0.95	0.54	**-1.79**	0.24	-0.04	0.11
DF	G	0.28	0.08	-0.08	76.37	-0.01	-56.96	-0.03	-0.57	-19.19	0.04	0.50	0.21	-0.36	**0.56**	-0.74	0.10
	P	-0.10	-0.05	0.11	-112.93	-0.01	82.12	-0.05	0.26	30.39	0.01	0.35	0.33	-0.80	**0.54**	-0.08	0.06
DM	G	0.30	0.08	-0.12	66.07	-0.01	-44.43	-0.03	-0.50	-21.47	0.04	0.60	0.19	-0.37	0.53	**-0.80**	0.09
	P	-0.10	-0.06	0.17	-104.49	-0.01	72.11	-0.05	0.20	32.03	0.01	0.39	0.28	-0.81	0.48	**-0.10**	0.05

*Residual effect G= 0.3332, P= 0.9122

G= Genotypic path coefficient, P= Phenotypic path coefficient, LL= Ligule length, BLL= Basal leaf length, BLW= Basal leaf width, CL= Culm length, CD= Culm diameter, PH= Plant height, ET= Effective tiller, SF= Spikelet fertility, PL= Panicle length, TW= Test weight, GL= Grain length, GB= Grain breadth, BRLBR= Brown rice length breadth ratio, DF= Days to flower, DM= Days to maturity

3.6. Assessment of Path Coefficient

Basal leaf length and plant height showed a positive direct effect, but culm length showed a negative direct effect at the genotypic level (Table 5). The scenario is just reverse at the phenotypic level for these three traits, but the interesting thing is that all these three traits have made the total association positive and significant. Our findings agreed with the findings of [24, 44, 49]. Grain breadth had a negative direct effect and made the total correlation negative and significant at both levels. Spikelet fertility had a positive direct effect at the genotypic level but the negative direct effect at the phenotypic level and wholesome correlation at the genotypic level was negative but positive at the phenotypic level. So, direct selection based on these traits will affect at the genotypic level but with the help of environmental impact, the yield will be revived at the phenotypic level. Days to flower had a positive direct effect at both levels but days to maturity had a negative direct effect at both levels, hence these traits made the total association positive and non-significant, which is similar to the finding of [49]. The genotypic and phenotypic residual effect was found at 0.3332 and 0.9122, respectively, which means 66.68% and 8.78% variability was counted by these 16 yields contributing traits at both genotypic and phenotypic level, respectively in this study. However, 33.32% and 91.22% variability would be controlled by other yield subscribing traits at both genotypic and phenotypic levels, respectively which are not included in this study.

Genetic diversity plays an important role in plant breeding activities as hybrid between lines of diverged genotypes display a greater heterosis than those between closely related strains [50]. So, the landraces possessed a significant amount of variability for yield and its correlated traits can be used for the future breeding program by direct selection based on yield and yield contributing traits.

4. CONCLUSION

The existence of genotypic and phenotypic variability is the prime requirement for the self-development of economically important traits like yield. High heritability in a broad sense along with genetic advance and genetic advance in per cent of mean was observed for ligule length, basal leaf length, basal leaf width, culm length, panicle length, test weight, grain length, grain breadth and brown rice length breadth ratio. It revealed that Boro landrace has a significant amount of variability for yield and the studied agronomic traits. Tepi Khorch, Amboro 2 (Golden), Gopal Beshi, Deshi Boro, Kali Boro 139/2, Madhabsail, Jagli (Deshi Boro), Jala Boro, Dud Saita, Pankaich, Joya Boro, Mi-Pajang are the elite landraces which can be used for the future rice breeding program by direct selection based on basal leaf length, culm length, plant height, days to flower and days to maturity.

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