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Assessment of Mean Performance, Variability, Traits Association and Path Coefficient in Transplanted Aman Rice (*Oryza sativa L.*) Landraces

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Authors' contributions

This work was carried out in collaboration among all authors. Authors MK and MFRKP performed the experiment. Authors TC, MAS and MZI conduct statistical analysis and wrote the first draft. Authors MK and ESMHR supervised the work. Author MAS harmonized and finalized the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

The study was conducted to estimate the mean performance, genetic parameters along with traits association and path coefficients from data collected on 48 Transplanted Aman (T. Aman) rice landraces. In mean performance, Manik Digha, Goirol, Jesso Balam, Dal Katra, Chinri Gushi,

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Indrasail, Sunadiga, Bad Kalamkati, Raj Mondal and Blue Stick were found as elite landraces. High heritability along with genetic advance (GA) and genetic advance in per cent of mean (GAMP) was observed for basal leaf width, plant height, culm length, filled grain/panicle, unfilled grain/panicle, days to flowering, days to maturity, test weight, grain length, grain breadth, decorticated grain length breadth ratio and yield showed high genetic advance that helped in effective and reliable selection through these characters for crop improvement. A positive and significant association was found for filled grain per panicle, days to flowering, days to maturity, grain length and decorticated grain length breadth ratio with yield/hill at both genotypic and phenotypic levels. Though days to maturity and decorticated grain length breadth ratio have a negative direct effect on yield but made the total association positive and significant. Filled grain/panicle, days to flower and grain length have a positive direct effect on yield and 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 width, plant height, culm length, filled grain/panicle, unfilled grain/panicle, days to flower, days to maturity, test weight, grain length, grain breadth, decorticated grain length breadth ratio and yield are identified as key traits for developing high yielding rice breeding lines.

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

1. INTRODUCTION

Bangladesh, a low-lying, riverine country, lies in the north-eastern part of South Asia between latitude $20^0 34'$ and $26^0 38'$ N and longitude $88^0 01'$ and $92^0 41'$ E. The country, with an area of 147,570 sq. km (56,977 sq. mi), is bounded by India on the west-north and north-east while Myanmar on the south-east and the Bay of Bengal on the south [1]. Bangladesh, predominantly an agrarian country, enjoys generally a subtropical monsoon climate. The agriculture sector contributes about 14.23% of the country's GDP and employs around 40.60% of the total labour force [2]. Rice a member of the Poaceae family is the staple food for millions across the globe including Bangladesh. 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 [3].

According to FAO [4], Bangladesh is the world's second-largest per capita rice consumption at 179.9 kg $yr.^{-1}$. BBS [1] reported that the rice sector contributes one-half of the agricultural GDP and one-sixth of the national income in Bangladesh. The recent coverage of the Aman area was 48.82 per cent and contributed 38.62 per cent of the total rice production [5]. Brolley [6] said, 'Rice security' is equal to 'Food security in Bangladesh as in many other rice-growing countries. Nath [7] claimed that rice is a political crop. In Bangladesh, more food will be required in future because of the increasing population. Kabir et al. [8] reported that the population of Bangladesh would be 215.4 million in 2050 when 44.6 MT of clean rice will be needed to feed the population.

To feed the upcoming increased population, we need to find out the sustainable yield booster genes which are tolerant to different stresses. We can achieve our target by exploring the local landraces along with their genetic studies. It's necessary to sort out the special breeding lines having high yields with short growth duration and other good agronomic traits. Yield is a polygenic trait and has a complex association with many yield-contributing traits which are stimulated by environmental factors [9]. In 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 [10-12].

The study was conducted to estimate the mean performance, variability, correlations among the traits of selected T. Aman Landraces, the association between the traits and yield, and direct and indirect effects contributed by each trait towards yield for the efficient selection of promising Landraces for the future rice breeding scheme.

2. MATERIALS AND METHODS

2.1 Materials, Design and Intercultural Operations

The experiment was carried out in T. Aman 2018 season. Forty-eight (48) entries of T. Aman rice landraces (Table 1) were collected from the genebank of Bangladesh Rice Research Institute (BRRI). The Landraces were sown in the seedbed on 23 July 2018 and raised 25 days of seedlings 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 28 August 2018. 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 (RCBD). Fertilizer doses were 60:20:40 kg NPK per hector. The recommended agronomic practices were maintained for the proper crop growth.

Data were collected from ten (10) plants randomly in each replication on behalf of ligule length (cm), basal leaf length (cm), basal leaf width (cm), plant height (cm), culm length (cm), culm diameter (mm), total tiller number, effective tiller number, panicle length (cm), filled grain/panicle, unfilled grain/panicle, days to flower, days to maturity, test weight (g), grain length (mm), grain breadth (mm), decorticated grain length breadth ratio and yield (g/hill).

2.2 Statistical Analysis

Mean, range and standard deviation (SD) for each character were estimated. The mean sum of the square was estimated for the calculation of genotypic and phenotypic variances [13]. Genotypic and phenotypic coefficients of variation were estimated by the formula suggested by Burton [14]. Heritability in a broad sense was estimated which was further defined by Lush (1949) by the suggested formula [13]. The expected genetic advance for different characters was calculated using the suggested formula [13,15]. Genetic advance in the percentage of mean was calculated by the given formula [16]. Phenotypic and genotypic correlations were worked out by using the suggested formulae [17]. Analysis of the path coefficient suggested [18] and modified by [19] was used to calculate the direct and indirect contribution of various traits to yield. Principal component analysis and correlations were performed using R packages [20].

3. RESULTS AND DISCUSSION

3.1 Assessment of Mean Performance

The mean performance of forty-eight (48) Landraces was shown in Table 2. In the case of plant height, most of the Landraces (25) are concentrated in >160.56 cm-180.30 cm. The cumulative mean was 159.84 cm whereas the highest plant height was found in Goirol (180.30 cm). Most of the Landraces (38) effective tiller number was under 9. Bansfol acquired the highest (13.66) effective tiller number whereas Rupsail and Sechi Amon placed with the lowest (6) effective tiller number. For the trait of panicle length, the grand mean was 25.80 cm and most of the Landraces (28) fall under the range of >24.33 cm-27.56 cm. Highest panicle length by Sunadiga (30.80 cm) and the lowest by Goirol (21.10 cm). The grand mean of filled grain was 106.68/panicle, the highest value by Jesso Balam (156.67/panicle) and the lowest by Bansfol (43.67/panicle). In days to flower maximum Landraces (21) concentrated between >100 cm-115 cm with a grand mean of more than 107 flowering days. Highest flowering days by Chinri Gushi (129 days) and lowest by Dhal Data (86.67 days). In days to maturity maximum Landraces (21) concentrated between >141 cm-157 cm with a grand mean of more than 136 maturity days. The highest maturity days are occupied by Indrasail (157 days) and the lowest by Dhal Data Bansfol (109 days). In the case of test weight, most of the Landraces (39) fall under >21.12 g-30.55 g with a mean value of 24.42 g. The highest test weight was for Sunadiga (30.55 g) and the lowest for Daudkhani (16.40 g). Thirty (30) Landraces were under a 2.43 decorticated grain length breadth ratio having a mean of 2.43. The highest decorticated grain length breadth ratio was 3.32 by Chinri Gushi and the lowest by Hashfol (1.99). Maximum Landraces (27) produced yields between >7.03 g to 16.16 g per hill with a mean of 8.35 g which is matched with the findings of [21-24] but differed with the findings of [25] in case of hilly rice and [26] in case of T. Aman rice. The highest yield was obtained by Blue Stick (16.16 g) and the lowest by Dal Katra (2.46 g).

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 basal leaf width, days to flower, days to maturity, grain breadth and decorticated grain length breadth ratio. Chakrabarty et al. [27] found the similar result. It depicts that these traits are less influenced by the environment. The highest genotypic and phenotypic coefficient of variation was found for unfilled grains per panicle which are agreed with [27] and [28]. In a broad sense, high heritability was found for all traits except for ligule length, basal leaf length, culm diameter, total tiller number, effective tiller number and panicle length. High heritability along with genetic advance (GA) and genetic advance in per cent of mean (GAMP) was observed for basal leaf width, plant height, culm length, filled grain/panicle, unfilled grain/panicle, days to flower, days to maturity, test weight, grain length, grain breadth, decorticated grain length breadth ratio and yield. It means that these traits are controlled by multiple genes with high additive gene action and this result agreed with [27] and [29].

3.3 Principal Component Analysis

Principal component analysis revealed that two major dimensions could explain around 43% of the total variability, and mainly influenced by total tiller numbers, effective tillers numbers and grain breadth, respectively (Figs. 1 and 2).

3.4 Correlations among the Measured Traits

Correlation analysis showed that there were significant correlations 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).

3.5 Assessment of Traits Association

Measurement of the association between traits indicates the positive or negative relationships either in a significant or non-significant way. In this study, the genotypic and phenotypic associations are focused on in Table 4. Selection of the elite Landraces based on the positive and significantly associated traits for the crop development otherwise significant negatively correlated trait-based selection will damage the crop improvement program. A positive and significant association was found for filled grain per panicle, days to flower, days to maturity, grain length and decorticated grain length breadth ratio with yield/hill at both genotypic and phenotypic levels. Similar results were also obtained by another authors [30-32]. Days to maturity are associated positively and significantly with filled grain/panicle whereas effective tiller number is negatively associated with panicle length meets with the findings of [27]. Test weight has a positive and significant correlation with grain length and grain breadth at both levels. Plant height has a significant negative association with days to flower and days to maturity. On the other hand, the decorticated grain length breadth ratio has a significant positive correlation with grain length but grain breadth has a significant negative association which can be authenticated by [33].

3.6 Assessment of Path Coefficient

Filled grain/panicle, days to flower and grain length has a positive direct effect and made the total association positive and significant which is described in Table 5.

Table 1. Selected T. Aman rice landraces from BRRI genebank

Accession no.	Landraces Name	Accession no.	Landraces Name	Accession no.	Landraces Name
2	Badkalamkati	72	Bashpul	110	Dudh Bhanalia
4	Bais Bis	84	Apchaya	111	Goirol
5	Bhasha Manik	89	Dhalkatia	112	Bhawalia Amon
6	Bansful	91	Boron	113	Hashfol
8	Blue Stick	92	Dhal Data	114	Raj Mondal
12	Chinri Gushi	94	Sechi Aman	115	Gonak Ray
13	Chitraj	98	Laksmidiga	116	Kala Mona
15	Daudkhani	99	Dal Katra	117	Belon Dhan
19	Dhola Amon	100	Chota Bhawalia	118	Shor Soira
20	Dudhlaki	101	Bhora Bhawlia	119	Gorcha
32	Indra Sail	103	Diga	120	Luta
34	Jesso Balam	104	Manik Diga	122	Sunadiga
36	Jhinga Sail	106	Bhanal Diga	123	Gabura
42	Kumari	107	Jatra Motuk	125	Khoia Motor (3)
48	Nagra	108	Bora Diga	126	Suna Digha (2)
58	Rupsail	109	Rangi Khama	130	Raj Bhawalia

Table 2. Mean performance of T. Aman rice landraces

	Range	Mean	CV	SD	SE	LSD (5%)	Highest	Lowest
Ligule Length (cm)	<1.17= 7 >1.17-1.42= 13 >1.42-1.67=28	1.40	8.12	0.18	0.03	0.06	Goirol (1.66)	Kala Mona (0.92)
Basal Leaf Length (cm)	<50.33= 7 >50.33-58.06= 27 >58.06-65.80=14	55.43	6.32	5.88	0.84	1.64	Dhal Data (65.80)	Dal Katra (42.60)
Basal Leaf Width (cm)	<1.07= 9 >1.07-1.35= 28 >1.35-1.63=11	1.22	5.03	0.17	0.02	0.04	Manik Digha (1.63)	Bansfol (0.79)
Plant Height (cm)	<140.83= 5 >140.83-160.56= 18 >160.56-180.30=25	159.84	3.99	14.48	2.09	4.09	Goirol (180.30)	Rupsail (121.10)
Culm Length (cm)	<116.26= 5 >116.26-137.72= 22 >137.72-159.20=21	134.04	4.72	14.80	2.13	4.17	Goirol (159.20)	Rupsail (94.80)
Culm Diameter (mm)	<3.78= 2 >3.78-4.85= 26 >4.85-5.91=20	4.71	7.54	0.72	0.10	0.19	Dudh Bhawalia (5.91)	Baisbis (2.71)
Total Tiller Number	<10= 38 >10-13= 9 >13-16= 1	9.12	8.93	1.59	0.23	0.45	Bansfol (15.00)	Rupsail & Sechi Amon (7.00)
Effective Tiller Number	<9= 39 >9-12= 8 >12-15= 1	8.17	9.05	1.43	0.20	0.39	Bansfol (13.66)	Rupsail & Sechi Amon (6.00)
Panicle Length (cm)	<24.33= 10 >24.33-27.56= 28 >27.56-30.80=10	25.80	3.79	2.13	0.31	0.61	Sunadiga (30.80)	Goirol (21.10)
Filled Grain/panicle	<81.34= 5 >81.34-119.01= 29 >119.01-156.67=14	106.68	5.83	21.67	3.12	6.11	Jesso Balam (156.67)	Bansfol (43.67)
Unfilled Grain/panicle	<23.67= 27 >23.67-41.34= 19 >41.34-59.00= 2	23.74	12.48	10.63	1.53	2.99	Dal Katra (59.00)	Chitraj (6.00)
Days to Flower	<100= 13 >100-115= 21 >115-130= 14	107.45	0.95	10.50	1.51	2.95	Chinri Gushi (129.00)	Dhal Data (86.67)
Days to Maturity	<125= 11 >125-141= 16 >141-157= 21	136.41	0.71	12.43	1.79	3.51	Indrasail (157.00)	Bansfol (109.00)
Test Weight (g)	<21.12= 9 >21.12 25.84= 20 >25.84-30.55= 19	24.42	0.54	3.63	0.52	1.02	Sunadiga (30.55)	Daudkhani (16.40)
Grain Length (mm)	<8.32= 31 >8.32-9.07= 11 >9.07-9.83= 6	8.26	1.82	0.57	0.08	0.15	Bad Kalamkati (9.83)	Hashfol (7.57)
Grain Breadth (mm)	<2.57= 11 >2.57-2.90= 21 >2.90-3.23= 16	2.77	2.52	0.24	0.03	0.06	Raj Mondal (3.23)	Daudkhani (2.24)
Decorticated Grain Length Breadth Ratio	<2.43= 30 >2.43-2.87= 14 >2.87-3.32= 4	2.43	3.52	0.31	0.04	0.07	Chinri Gushi (3.32)	Hashfol (1.99)
Yield(g/hill)	<7.03= 21 >7.03-11.60= 14 >11.60-16.16= 13	8.35	17.87	3.58	0.51	0.99	Blue Stick (16.16)	Dal Katra (2.46)

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

Table 3. Variability analysis of T. Aman rice landraces

Traits	V_g	V_p	GCV	PCV	h_b^2	GA	GAM (%)
Ligule Length (cm)	0.03	0.004	12.04	14.52	68.80	0.22	15.78
Basal Leaf Length (cm)	21.53	33.81	8.37	10.49	63.67	5.85	10.55
Basal Leaf Width (cm)	0.03	0.03	13.70	14.40	90.43	0.25	20.58
Plant Height (cm)	168.45	209.08	8.12	9.05	80.57	18.41	11.52
Culm Length (cm)	178.16	218.13	9.96	11.02	81.68	19.06	14.22
Culm Diameter (mm)	0.40	0.53	13.40	15.36	76.03	0.87	18.46
Total Tiller Number	1.86	2.53	14.95	17.42	73.71	1.85	20.29
Effective Tiller Number	1.49	2.03	14.92	17.44	73.14	1.65	20.16
Panicle Length (cm)	3.67	4.63	7.42	8.34	79.30	2.70	10.45
Filled Grain/panicle	437.61	476.27	19.61	20.46	91.88	31.68	29.70
Unfilled Grain/panicle	105.11	113.89	43.19	44.95	92.29	15.56	65.55
Days to Flower	110.81	111.84	9.80	9.84	99.08	15.56	15.41
Days to Maturity	155.75	156.68	9.15	9.18	99.40	19.66	14.41
Test Weight (g)	13.31	13.33	14.94	14.95	99.87	5.76	23.59
Grain Length (mm)	0.31	0.34	6.78	7.02	93.25	0.85	10.34
Grain Breadth (mm)	0.06	0.06	8.65	9.01	92.16	0.36	13.11
Decorticated Grain Length Breadth Ratio	0.09	0.10	12.54	13.03	92.68	0.46	19.08
Yield/hill (g)	10.80	13.03	39.34	43.21	82.89	4.73	56.59

****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*

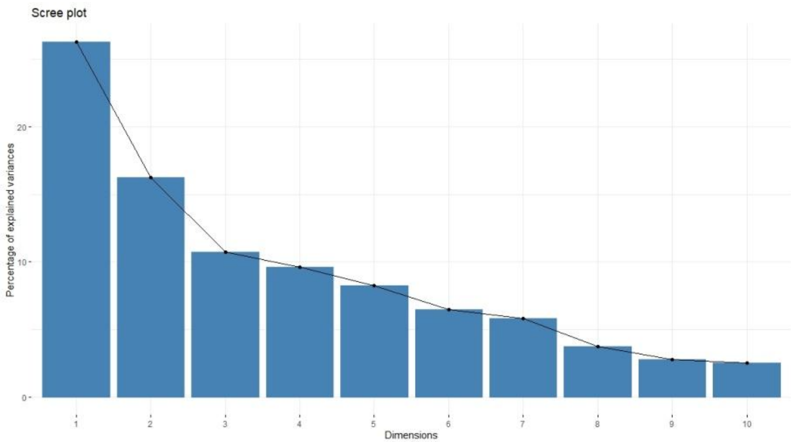

Fig. 1. Scree plot denotes contribution of different principal components of 48 T. Aman rice landraces.

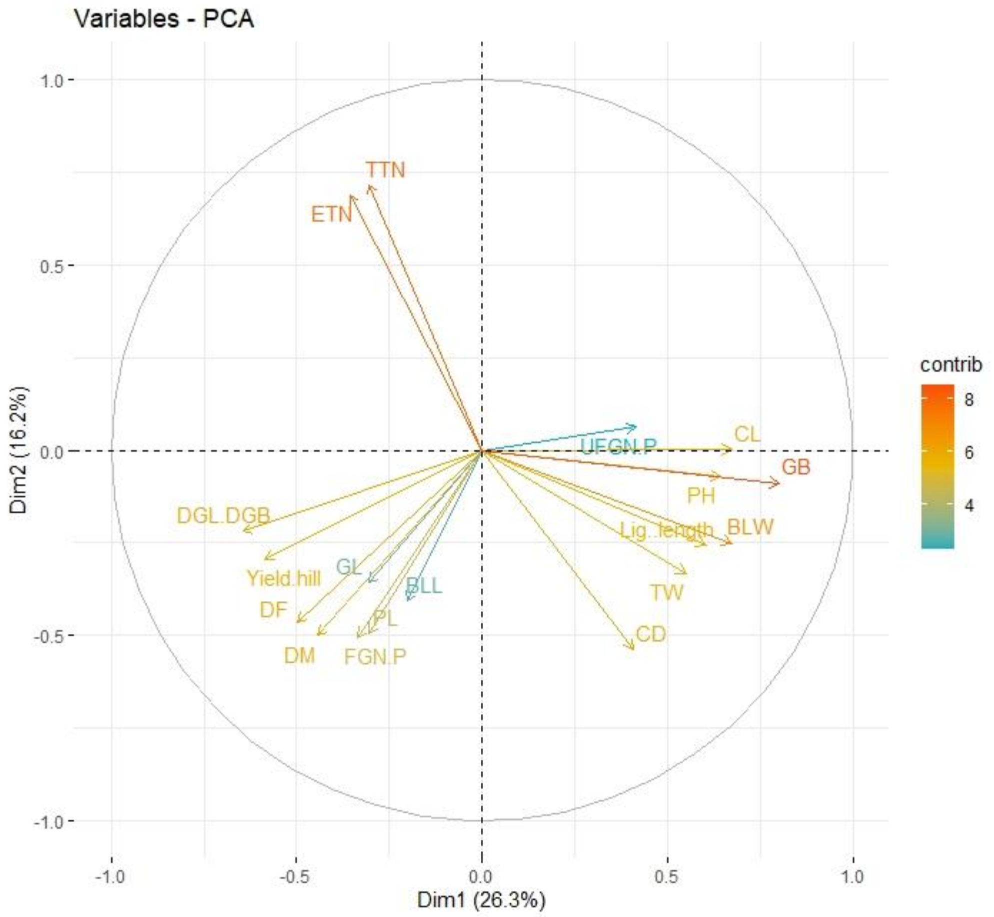

Fig. 2. Principal component analysis denotes contributing factors for variability of 48 T. Aman rice landraces.

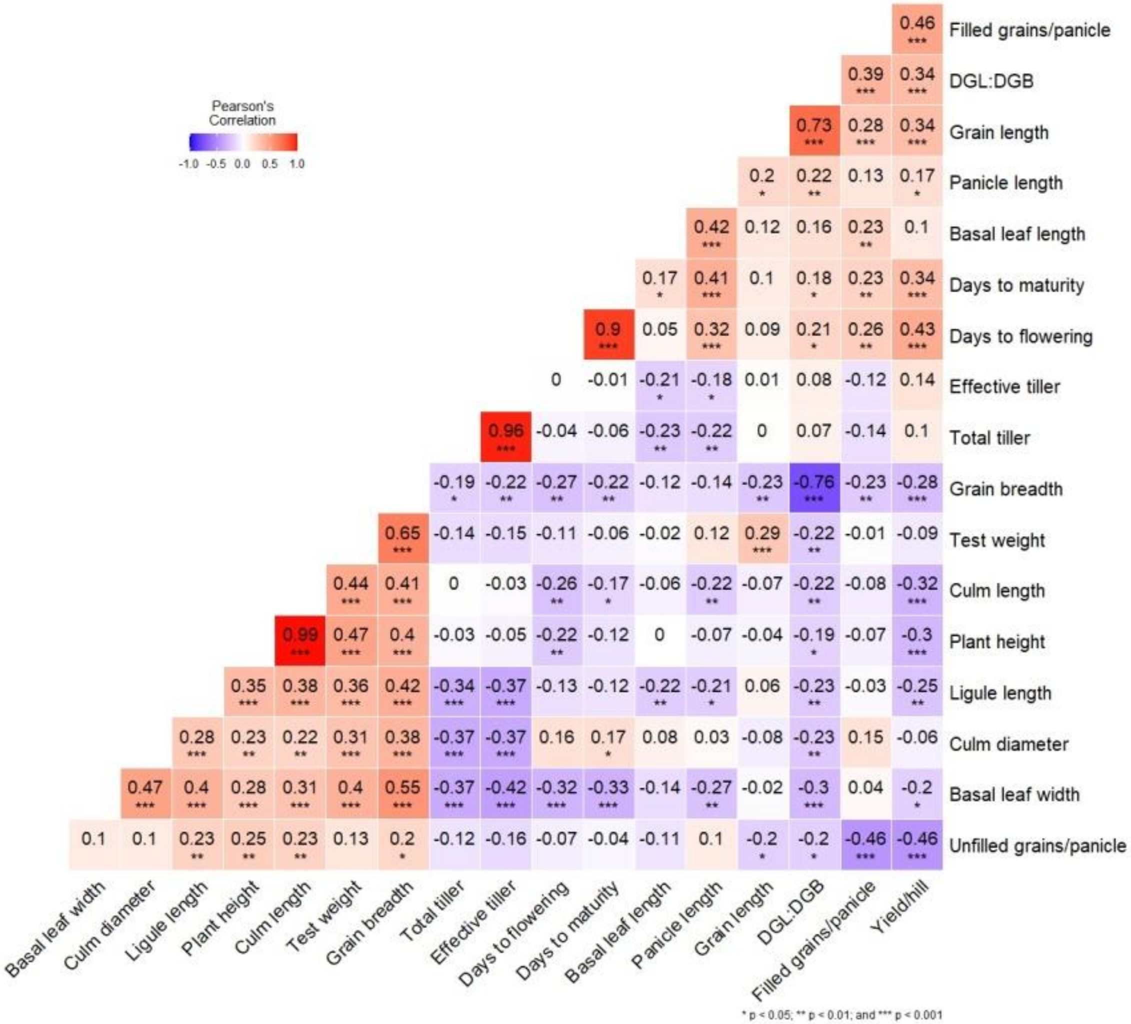

Fig. 3. Correlations among the measured traits of the 48 T. Aman rice landraces.

Table 4. Genotypic and phenotypic association of T. Aman Rice Germplasm

		LL	BLL	BLW	PH	CL	CD	TT	ET	PL	FGP	UFGP	DF	DM	TW	GL	GB	DGLBR
BLL	r_g	-0.24																
	r_p	-0.21*																
BLW	r_g	0.56**	-0.21															
	r_p	0.40**	-0.16*															
PH	r_g	0.45**	-0.03	0.32*														
	r_p	0.36**	-0.02	0.26**														
CL	r_g	0.47**	-0.10	0.35*	0.98**													
	r_p	0.39**	-0.08	0.30**	0.98**													
CD	r_g	0.42**	0.14	0.56**	0.32*	0.32*												
	r_p	0.29**	0.05	0.46**	0.21*	0.20*												
TT	r_g	-0.37**	-0.36*	-0.51**	-0.10	-0.05	-0.53**											
	r_p	-0.34**	-0.25**	-0.38**	-0.04	-0.01	-0.38**											
ET	r_g	-0.39**	-0.35*	-0.55**	-0.15	-0.10	-0.50**	0.98**										
	r_p	-0.37**	-0.23**	-0.43**	-0.06	-0.04	-0.39**	0.96**										
PL	r_g	-0.27	0.52**	-0.29*	-0.12	-0.26	-0.01	-0.32*	-0.28*									
	r_p	-0.21**	0.43**	-0.26**	-0.07	-0.21**	0.03	-0.21**	-0.17*									
FGP	r_g	-0.01	0.25	0.02	-0.05	-0.07	0.19	-0.17	-0.14	0.15								
	r_p	-0.02	0.23**	0.03	-0.06	-0.08	0.14	-0.13	-0.12	0.12								
UFGP	r_g	0.27	-0.18	0.11	0.27	0.25	0.12	-0.16	-0.22	0.08	-0.48**							
	r_p	0.23**	-0.13	0.09	0.24**	0.22**	0.09	-0.12	-0.17*	0.10	-0.46**							
DF	r_g	-0.15	0.058	-0.35*	-0.25	-0.29*	0.17	-0.06	-0.01	0.36*	0.26	-0.07						
	r_p	-0.13	0.05	-0.32**	-0.22**	-0.26**	0.15	-0.04	0.01	0.31**	0.25**	-0.07						
DM	r_g	-0.13	0.22	-0.36*	-0.13	-0.19	0.18	-0.08	-0.02	0.46**	0.23	-0.03	0.90**					
	r_p	-0.11	0.17*	-0.33**	-0.11	-0.17*	0.17*	-0.06	-0.01	0.41**	0.22**	-0.04	0.89**					
TW	r_g	0.42**	-0.01	0.43**	0.53**	0.50**	0.36*	-0.16	-0.17	0.13	-0.01	0.14	-0.11	-0.06				
	r_p	0.35**	-0.01	0.41**	0.48**	0.45**	0.31**	-0.14	-0.15	0.11	-0.01	0.13	-0.11	-0.06				
GL	r_g	0.05	0.16	-0.02	-0.01	-0.04	-0.09	-0.02	-0.02	0.23	0.31*	-0.22	0.09	0.11	0.29*			
	r_p	0.05	0.13	-0.01	-0.04	-0.06	-0.07	0.01	0.01	0.20*	0.28**	-0.20*	0.08	0.10	0.28**			
GB	r_g	0.51**	-0.13	0.59**	0.43**	0.44**	0.46**	-0.25	-0.28*	-0.16	-0.25	0.21	-0.27	-0.23	0.68**	-0.26		
	r_p	0.41**	-0.11	0.55**	0.40**	0.41**	0.39**	-0.19*	-0.21*	-0.14	-0.22**	0.20*	-0.26**	-0.21**	0.65**	-0.23**		
DGLBR	r_g	-0.27	0.21	-0.32*	-0.19	-0.22	-0.28	0.05	0.06	0.23	0.41**	-0.21	0.21	0.18	-0.22	0.76**	-0.78**	
	r_p	-0.23**	0.15	-0.30**	-0.19*	-0.22**	-0.23**	0.06	0.07	0.22**	0.38**	-0.20*	0.21*	0.17*	-0.21**	0.73**	-0.76**	
Yield	r_g	-0.32*	0.21	-0.24	-0.43**	-0.45**	-0.10	0.08	0.14	0.18	0.53**	-0.53**	0.46**	0.37**	-0.08	0.40**	-0.32*	0.39**
	r_p	-0.24**	0.09	-0.20*	-0.31**	-0.33**	-0.06	0.09	0.14	0.16*	0.46**	-0.46**	0.43**	0.34**	-0.08	0.30**	-0.27**	0.34**

r_g= Genotypic correlation, r_p= Phenotypic correlation, LL= Ligule length, BLL= Basal leaf length, BLW= Basal leaf width, PH= Plant height, CL= Culm length, CD= Culm diameter, TT= Total tiller number, ET= Effective tiller number, PL= Panicle length, FGP= Filled grain/panicle, UFGP= Unfilled grain/panicle, DF= Days to flower, DM= Days to maturity, TW= Test weight, GL= Grain length, GB= Grain breadth, DGLBR= Decorticated grain length breadth ratio

Table 5. Genotypic and Phenotypic path coefficient of selected T. Aman Rice Germplasm

		LL	BLL	BLW	PH	CL	CD	TT	ET	PL	FGP	UFGP	DF	DM	TW	GL	GB	DGLBR	Yield
LL	P_g	**-0.42**	-0.10	0.21	0.79	-0.87	-0.16	0.22	-0.21	0.18	-0.01	0.06	-0.14	0.05	0.07	0.09	-0.73	0.63	-0.33*
	P_p	**-0.12**	0.01	0.00	0.54	-0.63	-0.02	0.02	-0.04	0.04	-0.01	-0.05	-0.07	0.03	-0.02	0.02	-0.03	0.08	-0.25**
BLL	P_g	0.10	**0.41**	-0.08	-0.06	0.20	-0.05	0.21	-0.19	-0.35	0.16	-0.04	0.05	-0.09	0.00	0.26	0.18	-0.50	0.22
	P_p	0.03	**-0.04**	0.00	-0.04	0.14	0.00	0.01	-0.03	-0.08	0.07	0.03	0.03	-0.04	0.00	0.06	0.01	-0.05	0.10
BLW	P_g	-0.24	-0.09	**0.37**	0.57	-0.65	-0.21	0.31	-0.30	0.20	0.01	0.02	-0.31	0.14	0.07	-0.04	-0.84	0.74	-0.24
	P_p	-0.05	0.01	**-0.01**	0.40	-0.48	-0.02	0.02	-0.05	0.05	0.01	-0.02	-0.16	0.07	-0.02	0.00	-0.04	0.10	-0.21*
PH	P_g	-0.19	-0.01	0.12	**1.75**	-1.80	-0.12	0.06	-0.08	0.08	-0.03	0.06	-0.22	0.05	0.09	-0.02	-0.62	0.44	-0.44**
	P_p	-0.05	0.00	0.00	**1.48**	-1.58	-0.01	0.00	-0.01	0.01	-0.02	-0.05	-0.11	0.03	-0.02	-0.02	-0.03	0.07	-0.31**
CL	P_g	-0.20	-0.04	0.13	1.73	**-1.82**	-0.12	0.03	-0.06	0.18	-0.04	0.05	-0.26	0.08	0.09	-0.07	-0.63	0.51	-0.45**
	P_p	-0.05	0.00	0.00	1.46	**-1.60**	-0.01	0.00	0.00	0.04	-0.02	-0.05	-0.13	0.04	-0.02	-0.03	-0.03	0.07	-0.33**
CD	P_g	-0.18	0.06	0.21	0.57	-0.58	**-0.37**	0.32	-0.27	0.01	0.12	0.03	0.16	-0.07	0.06	-0.14	-0.66	0.64	-0.10
	P_p	-0.04	0.00	0.00	0.31	-0.32	**-0.05**	0.02	-0.04	-0.01	0.04	-0.02	0.08	-0.04	-0.02	-0.03	-0.03	0.08	-0.07
TT	P_g	0.16	-0.15	-0.19	-0.18	0.10	0.20	**-0.59**	0.54	0.22	-0.11	-0.03	-0.06	0.03	-0.03	-0.04	0.36	-0.14	0.09
	P_p	0.04	0.01	0.00	-0.06	0.01	0.02	**-0.05**	0.11	0.04	-0.04	0.03	-0.02	0.01	0.01	0.00	0.01	-0.02	0.10
ET	P_g	0.16	-0.15	-0.21	-0.27	0.20	0.19	-0.58	**0.55**	0.19	-0.09	-0.05	0.00	0.01	-0.03	-0.03	0.40	-0.15	0.14
	P_p	0.05	0.01	0.00	-0.10	0.07	0.02	-0.05	**0.11**	0.03	-0.03	0.03	0.00	0.00	0.01	0.01	0.02	-0.03	0.14
PL	P_g	0.11	0.22	-0.11	-0.21	0.48	0.00	0.19	-0.16	**-0.67**	0.09	0.02	0.32	-0.18	0.02	0.37	0.23	-0.54	0.18
	P_p	0.03	-0.02	0.00	-0.10	0.34	0.00	0.01	-0.02	**-0.18**	0.04	-0.02	0.16	-0.09	-0.01	0.09	0.01	-0.07	0.17*
FGP	P_g	0.00	0.11	0.01	-0.09	0.13	-0.07	0.10	-0.08	-0.10	**0.62**	-0.10	0.23	-0.09	0.00	0.48	0.36	-0.96	0.53**
	P_p	0.00	-0.01	0.00	-0.10	0.13	-0.01	0.01	-0.01	-0.02	**0.29**	0.09	0.13	-0.05	0.00	0.12	0.02	-0.13	0.47**
UFGP	P_g	-0.11	-0.08	0.04	0.48	-0.47	-0.04	0.10	-0.12	-0.05	-0.30	**0.21**	-0.07	0.01	0.02	-0.34	-0.31	0.48	-0.54**
	P_p	-0.03	0.00	0.00	0.36	-0.36	0.00	0.01	-0.02	-0.02	-0.13	**-0.20**	-0.04	0.01	-0.01	-0.09	-0.02	0.07	-0.46**
DF	P_g	0.07	0.02	-0.13	-0.44	0.54	-0.07	0.04	0.00	-0.24	0.16	-0.02	**0.87**	-0.35	-0.02	0.15	0.39	-0.50	0.47**
	P_p	0.02	0.00	0.00	-0.33	0.42	-0.01	0.00	0.00	-0.06	0.07	0.01	**0.50**	-0.19	0.01	0.04	0.02	-0.07	0.43**
DM	P_g	0.06	0.09	-0.14	-0.23	0.35	-0.07	0.05	-0.01	-0.31	0.15	-0.01	0.79	**-0.39**	-0.01	0.16	0.33	-0.43	0.38**
	P_p	0.01	-0.01	0.00	-0.17	0.28	-0.01	0.00	0.00	-0.07	0.07	0.01	0.45	**-0.22**	0.00	0.04	0.02	-0.06	0.34**
TW	P_g	-0.18	-0.01	0.16	0.94	-0.92	-0.14	0.10	-0.10	-0.09	-0.01	0.03	-0.10	0.03	**0.17**	0.46	-0.96	0.52	-0.09
	P_p	-0.04	0.00	0.00	0.71	-0.73	-0.02	0.01	-0.02	-0.02	0.00	-0.03	-0.06	0.01	**-0.05**	0.12	-0.05	0.07	-0.09
GL	P_g	-0.02	0.07	-0.01	-0.02	0.08	0.03	0.02	-0.01	-0.16	0.19	-0.05	0.08	-0.04	0.05	**1.55**	0.37	-1.74	0.40**
	P_p	-0.01	0.00	0.00	-0.06	0.11	0.00	0.00	0.00	-0.04	0.08	0.04	0.04	-0.02	-0.01	**0.43**	0.02	-0.24	0.34**
GB	P_g	-0.22	-0.05	0.22	0.77	-0.82	-0.17	0.15	-0.16	0.11	-0.16	0.05	-0.24	0.09	0.12	-0.41	**-1.41**	1.81	-0.33*
	P_p	-0.05	0.00	0.00	0.60	-0.67	-0.02	0.01	-0.02	0.03	-0.06	-0.04	-0.13	0.05	-0.03	-0.10	**-0.07**	0.25	-0.28**
DGLBR	P_g	0.12	0.09	-0.12	-0.34	0.40	0.10	-0.04	0.04	-0.16	0.26	-0.05	0.19	-0.07	-0.04	1.18	1.11	**-2.29**	0.39**
	P_p	0.03	-0.01	0.00	-0.29	0.36	0.01	0.00	0.01	-0.04	0.11	0.04	0.11	-0.04	0.01	0.31	0.06	**-0.33**	0.34**

Residual effect: Pg= 0.2287, Pp= 0.4922, Pg= Genotypic path coefficient, Pp= Phenotypic path coefficient, LL= Ligule length, BLL= Basal leaf length, BLW= Basal leaf width, PH= Plant height, CL= Culm length, CD= Culm diameter, TT= Total tiller number, ET= Effective tiller number, PL= Panicle length, FGP= Filled grain/panicle, UFGP= Unfilled grain/panicle, DF= Days to flower, DM= Days to maturity, TW= Test weight, GL= Grain length, GB= Grain breadth, DGLBR= Decorticated grain length breadth ratio

Similar findings by [21,25]. Days to maturity and decorticated grain length breadth ratio have a negative direct effect and made the total association positive and significant at both levels similar to [31]. So, direct selection based on these traits will help the breeders in planning a crop development scheme. Ligule length, culm length and grain breadth have a negative direct effect and made the total association negative and significant at both levels. Meanwhile, plant height has a positive direct effect and made the total association negative and significant at both levels whether unfilled grain/panicle and test weight has a positive direct effect at a genotypic level whereas negative direct at the phenotypic level and both of these circumstances made the total association negative and significant at both levels, authenticated by [25]. So, direct selection based on these traits should be discarded. The genotypic and phenotypic residual effect was found at 0.2287 and 0.4922 respectively which means 77.13% and 50.78% variability was counted by 18 yield contributing traits at both genotypic and phenotypic levels respectively in this study. However, 22.87% and 49.22% 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 diversed genotypes display a great heterosis than tose between closely related strains [34]. The landraces those 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 supreme 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 found for basal leaf width, plant height, culm length, filled grain/panicle, unfilled grain/panicle, days to flowerig, days to maturity, test weight, grain length, grain breadth, decorticated grain length breadth ratio and yield. It means that these T. Aman rice landraces possessed a significant amount of variability for yield and its correlated traits. Manik Digha (104), Girl (111), Jesso Balam (34), Dal Katra (99), Chinri Gushi (12), Indrasail (32), Sunadiga (126), Bad Kalamkati (2), Raj Mondal (114) and Blue Stick (8) are the elite landraces which can be used for the future breeding program by direct selection based on yield and yield contributing traits.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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