Genetic Variability Study of Rice Germplasm Accessions under Aerobic Condition

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Potential challenge to rice is water scarcity. Water saved in rice cultivation, will help increase cultivable areas of rice and cultivation of other crops. Aerobic cultivation is one of such systems where rice is cultivated under arid conditions with minimal water. Seventy-four rice genotypes were studied under aerobic condition manifested high GCV, PCV and narrow differences in PCV and GCV for test weight, days to fifty percent flowering, plant height, grain yield per plant, plant height, panicle length, decorticated grain length& width, number of tillers, number of productive tillers, grain width. This suggested the presence of negligible influence of external factors for those traits. Present study revealed highest heritability with genetic advance as per cent means for all the traits including yield (72.28%, 57.82) except grain length & flag leaf length indicating the presence of considerable variation and additive gene effects. Hence, improvement of these characters could be effective through phenotypic selection under aerobic condition. Better performing lines from the study would be the better source for developing drought tolerant rice also saline tolerant rice under aerobic condition.

Introduction

Rice, the important staple food crop of the world feeds over half global population. Rice producing people of Asian continent are getting a major proportion of required energy from rice crop and the rice demand is expected to increase by 38% within 30 years.

However, the rate of increase of rice production is slowing down and if the trend is not reversed, severe food shortages will occur in near future. To meet the food demand, it is necessary to increase rice production either by increasing the yield per unit area or by increasing the cultivated areas (Ray and Islam, 2008). Rice is also among the crops that consume large share of irrigation water. Water saved in rice cultivation, will help increase cultivable areas and cultivation of other crops.

Aerobic condition is one of such systems where rice is cultivated under arid conditions with minimal water without transplanting and puddling, potentially reducing most of the

pest and disease incidence. As the cultivating conditions changes, there will be changes in the soil microenvironment, pH, composition etc. Recent findings also suggest a greater number of beneficial micro-organisms dwell in aerobic condition (Shashidhar, 2007).

Drought is the first most widespread soil problem in rice growing countries which considers as a serious constraint to increased rice production worldwide. The cost effective and easiest way of addressing drought and also salinity is by development of a drought tolerant variety. For varietal development, the first important step is to screen the existing rice germplasms to identify breeding materials. Landraces are currently exploited as potential donors of drought and salinity traits due to their adaptation to local conditions (Roy *et al.,* 2011).

Aerobic rice has one of the challenges of salinity issue, as chances of salts coming in contact with the rhizosphere increases because of less moisture content in the soil. Salts which would have accumulated across so many years will come up due to capillary force and pose threat to the crop plant under aerobic condition. Addressing this challenge of salinity in case of aerobic rice stays unattended and needs to be addressed by keeping the future scope of the aerobic cultivation.

Enhancing abiotic stress tolerance in crop plants, it is very important to find sufficient variation and to devise such screening techniques which are reliable to identify tolerant genotypes. Variation for abiotic stress tolerance has been reported in many crop species, both between and within plant species of rice (Alam *et al.,* 2004) and other crop plants.

Keeping these points in view, present study was conducted to see the variation among the genotypes under aerobic condition, for development of drought and salinity tolerant variety.

Materials and Methods

The experiment was carried out during *Kharif* seasons of 2016 at Department of Plant Biotechnology, University of Agricultural Sciences, GKVK campus, Bangalore, India located at the latitude of 12° 58' North; longitude 77° 35' East and altitude of 930 meters above mean sea level (MSL).

Total 74 germplasms lines (including five checks) were studied using Augmented RCBD design with the spacing of 30 X 10 cm under aerobic condition. List of the genotypes used in the present study are given in the Table 1. Five checks namely ARB-6, AM-143, Pokkali L, IR-64 and Chittimuthyalu were used. Sowing was done in Augmented RCBD design, with 10 blocks comprising of 7 germplasm lines and five checks repeated in each block.

Three plants from all genotypes were used for recording observation and mean values ofthe traits were used for statistical analysis. The characters observed for eliciting the information under field are days to fifty percent flowering, plant height at maturity, total number of tillers, number of productive tillers at maturity, panicle length, flag leaf length, grain length, grain width, decorticated grain length and width, biomass, grain yield per plant and test weight.

Statistical analysis

The mean values of three plants used for recording the observations were analysed using R statistical package.

Estimation of genetic variability parameters like Phenotypic and Genotypic coefficient of

variation (PCV and GCV) were done using formula given by Burton and Dewane (1953) for low moisture stress. PCV and GCV with 0-10 per cent was considered as low, 10-20 per cent as moderate and 20 per cent and above as high.

Broad sense Heritability (h^2) estimate as per cent mean was calculated using the formula given by Hanson *et al.,* 1956 where, 0-30 per cent was considered as low, 30-60 per cent was considered as moderate and 60 per cent and above as high. Genetic advance and Genetic Advance means (GAM) were also calculated where 0-10 per cent was considered as Low, 10-20 per cent as moderate and 20 per cent and above as high.

Results and Discussion

Analysis of variance

Highly significant differences were observed for all the yield attributing traits indicating presence of sufficient amount of variability among the genotypes studied (Table 2). The accessions are the diverse germplasms which serve as a good source of variability, resulted many better yielding germplasm lines under Aerobic condition. Better performing accessions would be the better source for studying salinity and drought under aerobic condition.

Mean performance of genotypes

The mean value in 74 rice genotypes for 12 characters (Table 3) are briefly described below. The range of variation for days to 50 per cent flowering was 82 days to 119 days with an average value of 98.92 days. Plant height was varied from 43.32cm to 133.65cm with an average of 75.36 cm. The variation for number of tillers per plant was ranging from7.92 to 36.82 with an average value of 23.88. Variation for number of tillers per

plant was from 5.63 to 31.23 with an average value of 19.24. Flag leaf length was ranged from 12.45 cm to 33.43 cm with an average value of 20.25 cm. Panicle length was fluctuated from 9.34 cm to 25.01 cm with an average value of 16.92 cm. Test weight was ranged from 9.59 g to 28.66 g with an average value of 18.73 g.

Highest grain length was 11.1 mm, and the lowest was 5.80 mm with an average of 7.54 mm. Grain width range was from 1.51 - 3.32 mm with a mean of 2.54 mm. 1.54 mm to 8.08 mm was the range of variation for decorticated grain length and the mean was 4.66 mm. After decorticating the grain, the shortest width was 1.43mm, and the highest was 2.72 mm with an average of 2.15 mm was observed. The variation range for grain yield per plant was from 0.11 g to 6.01 g with an average value of 2.55 g.

The mean performance of seventy- four genotypes used in the present study indicated that no single rice genotype was superior for all the traits studied. Highly significant differences among the genotypes were observed for all the observations representing presence of diversity among the seventy-four genotypes studied.

The analysis of variance data manifested highly significant variance (at 0.1%) due to treatment (genotype is considered as treatment), showing inherent genetic difference among the genotypes. Significant genetic variation in various component characters exhibited by these genotypes indicated the efficiency of selection these characters.

Variability, heritability and genetic advance

The existence of genetic variability and heritability highly influences the

improvement of a plant trait. In any breeding program, prior knowledge on the estimates of variability in the population and heritable components of the trait are useful tools. Attempts to improve a character by selection would be more difficult unless a major portion of the variation is heritable.

Thus, information on both phenotypic and genotypic coefficient of variation and heritability of the character would be advantageous to breeding. Hence, the co-efficient of variation expressed at phenotypic and genotypic levels were used to compare the variability observed among different characters.

The variability parameters *viz*., mean, minimum, maximum, standard error, standard deviation, estimates of genotypic co-efficient of variation (GCV), phenotypic co-efficient of variation (PCV), environmental co-efficient of variation (ECV), heritability in broad senseh^2 and genetic advance as per cent mean with respect to yield and yield attributed traits (Table 3)are briefly described below.

Days to fifty per cent flowering

Days to fifty percent flowering exhibited moderate GCV (11.18 %) and PCV (11.67%) and ECV (6.79 %) along with the high heritability and high genetic advance as per cent mean of 91.72 % and 22.05 respectively.

Plant height

Plant height exhibited moderate GCV (23.86 %) and PCV (24.37 %) ECV (4.96 %) along with the high heritability value of 84.37 % and high GAM of 26.74.

Total number of tillers per plant

Number of tillers per plant exhibited high GCV (27.66%,) and PCV (34.45 %) and ECV

(20.52 %) along with the high heritability value of 64.50 % and high GAM of 45.85.

Number of productive tillers per plant

Number of productive tillers per plant exhibited high GCV (31.02 %), PCV (37.16%) and ECV (20.45 %), along with the high heritability value of 69.70 % and high GAM of 53.44.

Flag leaf length (cm)

Moderate GCV, PCV and ECV value of 3.89 %, 20.56 % and 15.15 % respectively with moderate heritability and GAM of 45.68% and 19.37 was observed for this trait.

Panicle length (cm)

Moderate GCV, PCV and ECV were observed for panicle length (15.86 %, 17.52 % and 7.44 %) with high 81.97 % broad sense heritability and 29.62 GAM was observed.

Test weight (g)

The GCV PCV and ECV was high with 25.89 %, 26.00 % and 2.39 % for test weight. Heritability and GAM were very high for this trait with 99.16% and 53.18 respectively.

Grain length (mm)

Grain length had low GCV, PCV and ECV with values of 7.09%, PCV of 9.87%, and ECV of 6.87 % also, moderate broad sense heritability was observed (51.58 %) with moderate GAM (10.51).

Grain width (mm)

Moderate GCV (13.92 %) and PCV (16.21 %%) and ECV (8.27 %) was observed for grain width with the high heritability value of 73.98 % and high GAM of 24.74.

Decorticated grain length (mm)

High GCV, PCV and ECV was exhibited by decorticated grain length with 31.42 %, 32.40 % and 7.94 % respectively. The heritability and genetic advance were also very high 94% and 62.83 respectively.

Decorticated grain width (mm)

Decorticated grain width had moderate GCV (12.69 %, and PCV (15.10 %) and ECV (8.18 %) with high heritability (70.64%) and high GAM (22.01).

Grain yield per plant (g)

High GCV, PCV and ECV of (32.97 %, 38.77 % and 20.41% respectively was observed for grain yield with the high heritability (72.28 %) and GAM (57.82).

Many of these traits had high GCV, PCV and ECV suggested that these traits are under the relatively greater influence of genetic factors and relatively less influence of the environment. Hence, these characters can be relied upon and simple selection can be practiced for further improvement. These results were in conformity with Bisne *et al.,* (2009) for grain yield per plant. Similar results were also reported for number of tillers per plant and number of productive tillers per plant (Elayaraja *et al.,* 2005) and test weight (Kumar *et al.,* 2001). Grain length exhibited lower GCV, PCV and ECV indicated lower amount of variability for grain length.

Table.1 List of Genotypes used for the study under Aerobic condition

Sl. No.	Genotypes	Sl. No	Genotypes	Sl. No	Genotypes	Sl. No	Genotypes
1	Kagga	21	Kari mundaga	41	Ratan sagara	61	Rajamudi
2	Mullu Bhatta	22	Kari dadi	42	Ratnachudi	62	Alur sanna
3	Masuri Bhatta	23	Kempudooddi	43	Ratnagiri-24	63	Chiman Sali
4	BantwalaKempu Bhatta	24	Kerekallumutugya	44	MTU-1001	64	Azucena
5	Bile kalavi	25	Kirwana	45	Saratiga	65	GulwadiSannakki
6	Champakali	26	Kyasari	46	Sarjan	66	Halaga Bhatta
7	Dambersali	27	Farm valya	47	Selumsanna	67	KanadaTumba
8	Doddamullare	28	Tanu	48	Waner-1	68	Doddiga
9	Murnavami Bhatta	29	Bidar local-1	49	Wari Mysore sanna	69	NMS-2
10	Gandhasali	30	Mobane	50	Yadakmuki	70	Kara Bhatta
11	Gopal Dodiga	31	Murukata Bhatta	51	Matta kara	71	Pokkali C
12	Hegge	32	Mutalaga	52	Sannavalya	72	Ezhome 1
13	Holesalichipiga	33	Prassanna	53	ChittiMutyalu	73	Ezhome 2
14	Honasu	34	PusaSughandi	54	Jyothi	74	Hemavati
15	Honnekattu	35	Pushpaka	55	Tanu	C1	ARB-6
16	Chippiga	36	Putta batta	56	Bangarakovi	C2	AM 143
17	HakkalaSali	37	Rajkamal	57	Bangaru sanna	C3	Pokkali L
18	Jigguvaratiga	38	Rajmani	58	Medisali	C4	IR64
19	KagiSali	39	Rani	59	Ambemohar-2	C5	Chittimuthyalu
20	Kari kantiga	40	Rasi	60	Mallige		

Table.2 Analysis of variance (mean sum of squares) for 12 different characters in rice genotypes Aerobic condition (n = 74)

Source of variation	df	Mean sum of square											
		PH	DFF	TNT	NPT	FLL	PL	TW	GL	GW	DGL	DGW	GY
Treatment (ignoring Blocks)	77	469***	75.73*	75.26 ***	59.9 ***	21.16**	10.95 ***	31.68 ***	2.19 ***	0.20 ***	3.66 ***	0.13 ***	1.65 ***
Treatment: Check	4	740***	129.19**	227.84 ***	135.11 ***	58.20 ***	39.60 ***	180.83 ***	24.91 ***	0.79 ***	14.74 ***	0.60 ***	13.01 ***
Treatment: Test	72	337***	560.48**	67.66 ***	56.56 ***	17.32 *	8.78 ***	23.72 ***	0.554 **	0.16 ***	2.28 ***	0.10 ***	0.98 ***
Treatment: Test vs. Check	1	8901***	124.10**	12.16 *	0.13 *	149.51 ***	52.87 ***	8.8 ***	29.72 ***	0.33 **	59.13 ***	0.04	4.56 ***
Block (eliminating Treatments)	9	9	6.34	23.70	22.87	12.85	4.57 *	0.11	0.33	0.067	0.22	0.02	0.73*
Residuals	36	14	11.04	24.02	17.13	9.41	1.58	0.2	0.26	0.04	0.14	0.030	0.27
Coefficient of Variation		5.38	3.36	20.33	20.23	15.70	7.65	2.36	6.58	8.13	7.19	8.23	21.55
Standard Error difference		4.22	4.73	5.54	4.68	3.47	1.42	0.50	0.58	0.23	0.41	0.19	0.58
CD @ 5 %		8.57	4.93	11.24	9.49	7.03	2.88	1.025	1.18	0.48	0.84	0.40	1.19

*Significant at 5%; ** Significant at 1% ***Significant at 0.1%

DFF: Days to 50 % flowering; PH: Plant height (cm); TNT: Total number of tillers per plant; NPT: Number of productive tillers per plant; FLL: Flag leaf length, GY: Grain yield per plant (g); TW: test weight (g); GL: Grain length (mm); GW: Grain width (mm); DGL; Decorticated grain length (mm); DGL; Decorticated grain width (mm)

Table.3 GCV, PCV and other genetic parameters of all the genotypes used for the study under Aerobic Condition (n=74)

Aerobic	PH	DFF	TNT	NPT	FLL	PL	TW	GL	GW	DGL	DGW	Yld
Mean	75.36	98.92	23.88	20.24	20.25	16.92	18.73	7.54	2.54	4.66	2.15	2.55
Std Error	2.08	19.97	0.97	0.89	0.48	0.32	0.55	0.10	0.05	0.17	0.04	0.12
Std Deviation	18.33	40.58	8.58	7.82	4.21	2.86	4.85	0.87	0.42	1.54	0.33	1.04
Min	43.32	82	7.29	5.63	12.45	9.34	9.59	5.80	1.51	1.54	1.43	0.11
Max	133.65	119	36.82	31.23	33.43	25.01	28.66	11.10	3.32	8.08	2.72	5.01
PV	337.13	382.78	67.66	56.56	17.32	8.78	23.72	0.55	0.17	2.28	0.10	0.98
GV	323.18	361.22	43.64	39.43	7.91	7.20	23.52	0.29	0.13	2.14	0.07	0.71
EV	13.96	24.57	24.02	17.13	9.41	1.58	0.20	0.27	0.04	0.14	0.03	0.27
GCV	23.86	11.18	27.66	31.02	13.89	15.86	25.89	7.09	13.94	31.42	12.69	32.97
PCV	24.37	11.67	34.45	37.16	20.56	17.52	26.00	9.87	16.21	32.40	15.10	38.77
ECV	4.96	6.79	20.52	20.45	15.15	7.44	2.39	6.87	8.27	7.94	8.18	20.41
h^2	95.86	91.72	64.50	69.71	45.68	81.97	99.16	51.58	73.98	94.00	70.64	72.28
GA	36.31	12.43	10.95	10.82	3.92	5.01	9.96	0.79	0.63	2.93	0.47	1.48
GAM	48.18	22.05	45.84	53.44	19.37	29.62	53.18	10.51	24.74	62.83	22.01	57.82
Skewness (p.value)	0.083	0.080	0.000	0.000	0.042	0.702	0.15	0.0008	0.007	0.012	0.063	0.742
Kurtosis (p.value)	0.863	0.009	0.001	0.001	0.653	0.210	0.026	0.003	0.854	0.386	0.146	0.750

PCV: Phenotypic coefficient of variance; GCV: Genotypic coefficient of variance; h^2: Broad sense heritability; GAM: Genetic advance as percent of mean DFF: Days to 50 % flowering; PH: Plant height (cm); TNT: Total number of tillers per plant; NPT: Number of productive tillers per plant; FLL: Flag leaf length, GY: Grain yield per plant (g); TW: test weight (g); GL: Grain length (mm); GW: Grain width (mm); DGL; Decorticated grain length(mm); DGL; Decorticated grain width (mm)

Table.4 Estimates of phenotypic correlations coefficients for different quantitative traits in rice genotypes under aerobic condition (n=74)

|	DFF	PH	TNT	NPT	FLL	PL	GY	TW	GL	GW	DGL
PH	-0.168	1									
TNT	0.181	-0.290*	1								
NPT	0.237	-0.258*	0.906**	1							
FLL	0.551**	-0.402	0.301*	0.265*	1						
PL	-0.037	0.077	-0.233**	-0.240**	-0.025	1					
GY	-0.295	0.379**	-0.105	-0.022	-0.273	0.047	1				
TW	-0.015	0.032	-0.024	-0.025	0.05	0.047	0.226**	1			
GL	0.048	-0.172	0.15	0.222	0.045	0.17	0.135	0.096	1		
GW	-0.272*	0.224	-0.13	-0.076	-0.419**	0.096	0.421**	0.165*	0.378**	1	
DGL	-0.281*	0.338**	-0.233	-0.179	-0.379**	0.049	0.433**	0.286**	0.643**	-0.155	1
DGW	0.23	-0.350**	0.232	0.247*	0.291*	0.066	-0.208	0.238**	-0.181	0.745**	-0.763**

* Significant at 5%, ** significant at 1 %

DFF: Days to 50 % flowering; PH: Plant height (cm); TNT: Total number of tillers per plant; NPT: Number of productive tillers per plant; FLL: Flag leaf length, GY: Grain yield per plant (g); TW: test weight (g); GL: Grain length (mm); GW: Grain width (mm); DGL; Decorticated grain length (mm); DGL; Decorticated grain width (mm)

Fig.1 Genotypic (GCV) and phenotypic co-efficient of variation (PCV) for different traits in rice genotypes under aerobic condition (n=74)
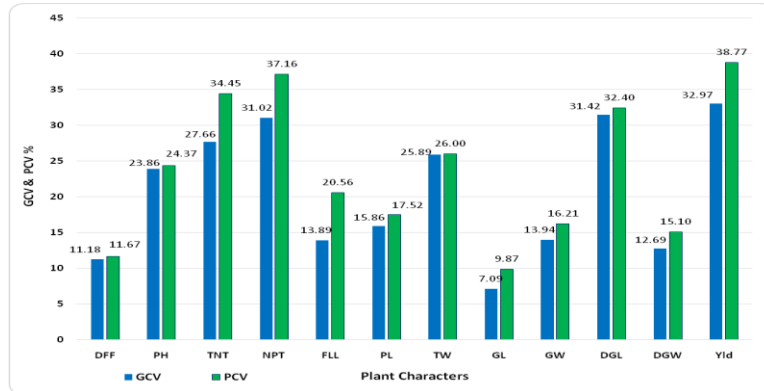
Fig.2 Heritability Broad Sense (hBS) and genetic advance as % mean (GAM) for different traits in rice genotypes under aerobic condition (n=74)
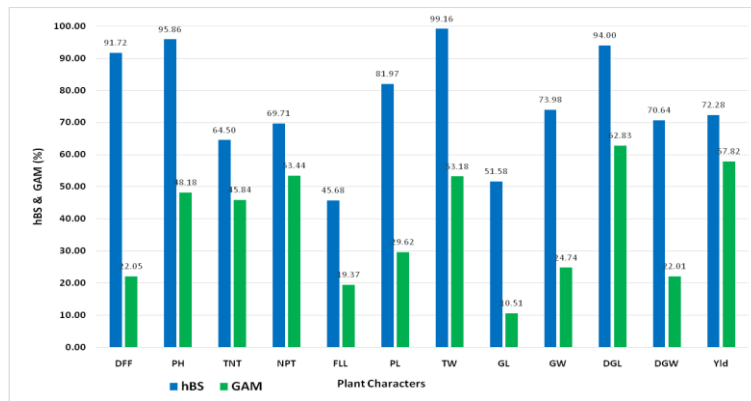
Narrow differences in PCV and GCV was recorded for test weight, days to fifty percent flowering, plant height, grain yield, plant height, panicle length, decorticated grain length& width, number of tillers, number of productive tillers, grain length, grain width (Figure 1) suggested the presence of negligible influence of external factors for these traits.

While, genotypic co-efficient of variation indicates the amount of genetic variability present in the character, the heritability estimates aid in determining the relative amount of heritable portion of variation. Heritability estimates in broad sense would be reliable when accompanied by high genetic

advance (Burton and Dewane, 1953). The broad sense heritability is the relative magnitude of genotypic to phenotypic variances for the traits and it is used as a predictive role in selection procedures.

Heritability in broad sense and GAM was high for all the characters studied except flag leaf length (45.68%) and grain length (51.58%). High heritability (> 70 %) was shown by grain yield per plant, days to first flowering, test weight, plant height, panicle length, test weight, grain width, decorticated grain length and width. These results were consistent with findings of Bastia *et al.,* (2008) and Zhang *et al.,* (2005) for 100 grains weight, grain width, Akinwale *et al.,* (2011)

for days to 50 % flowering, plant height, 100 grains weight and yield per plant and El-Malky *et al.,* (2008) for number of tillers per plant, test weight in rice.

High heritability coupled with high GAM was recorded for plant height, days to fifty percent flowering, total number of tillers per plant, number of productive tillers per plant, panicle length, grain yield per plant, test weight, grain width, decorticated grain length and decorticated grain width. Similar results were observed by Kumar *et al.,* (2001) for plant height; Akinwale *et al.,* (2011) for grain yield per plant; Bekele *et al.,* (2013)for total number of tillers per plant, Sharma *et al.,* (2004); Manjunath *et al.,* (2012); Shet *et al.,* (2012); Kiran *et al.,* (2013); Sadimantara *et al.,* (2014) for productive tillers per plant in rice.

High heritability coupled with moderate GAM was recorded for flag leaf length and grain length. However, Bidhan *et al.,* (2001) reported for high heritability coupled with high genetic advance as percent mean for grain length.

These heritability and GAM from the study (Figure 2) indicated that, these characters were not much influenced by environmental factors. So, these traits were mostly controlled by additive and /or additive × additive gene interactions and may respond to direct selection for trait improvement

Correlation studies

The study of relationship of different traits has great importance in the indirect selection of a complex trait associated with a simple trait. The correlation helps in identifying the possibility of improving yield through indirect selection of its component traits which are highly correlated. The results obtained for phenotypic correlations from the present study are presented in the Table 4 are discussed below.

Days to fifty percent flowering manifested significant positive correlation with flag leaf length (0.551) and number of productive tillers. Plant height exhibited a significant negative correlation with numbers of tillers (0.290) and number of productive tillers (0.258) and positive correlation with the panicle length and grain yield. Total number of tillers per plant has shown significant positive correlation with number of productive tillers per plant (0.906) Laxuman *et al.,* 2011 also reported similar results.

Grain length is positively significantly correlating with the grain width. Grain width is negatively correlated with days to fifty percent flowering and flag leaf length. But positively correlated with grain yield, test weight and grain length. Decorticated grain length and width are significantly positively correlating with each other.

Grain yield per plant showed negative correlation with days to fifty percent flowering. Nagesh *et al.,* (2012) reported similar results for days to days to 50 % flowering and grain yield. Highly significant and positive correlation was observed for grain yield per plant with plant height, number of productive tillers per plant and number of tillers per plant. This result was in conformity with the reports by Raju *et al.,* (2004), Shashidhar *et al.,* (2005) and Nagesh *et al.,* (2012). Grain yield also showed significant positive correlation with test weight, grain width and decorticated grain length.

In conclusion all selected 74 germplasm lines showed significant variation for the yield and its related traits under aerobic condition. The estimates of genetic variability parameters in the landraces indicated that there is a presence

of narrow difference between PCV and GCV for all the studied traits indicating the least influence of environment in expression of these traits. Correlation analysis revealed most traits except days to fifty per cent flowering manifested significant positive correlation with grain yield which suggest simultaneous improvement of these traits is possible. Overall, the present field experiment revealed high heritability coupled with high genetic advance as per cent of mean for most of the characters indicating the presence of considerable variation and additive gene effects Hence, improvement of these characters could be effective through phenotypic selection.

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