

Estimation of Phenotypic and Genotypic Correlation and Path Coefficients in Rainfed Upland Rice (*Oryza sativa* L.) Genotypes at Guraferda, Southwest Ethiopia

Abayneh Kacharo Kampe*, Addis Alemayehu Tassew and Altaye Tiruneh Gezmu

South Agricultural Research Institute, Bonga Agricultural Research Center Bonga, Ethiopia

*Corresponding author: Abayneh Kacharo Kampe, South Agricultural Research Institute, Bonga Agricultural Research Center Bonga, Ethiopia, Tel: +251934820424; E-mail: abaynehkacharo@gmail.com

Received date: 18 March, 2018; Accepted date: 06 July, 2018; Published date: 10 July, 2018

Copyright: © 2018 Kampe AK, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Abstract

A field experiment was conducted with the objective of determining the magnitude of association between yield and yield component characters. Fifteen rainfed upland rice genotypes were evaluated in randomized complete block design in three replications for two consecutive years (2014 and 2015) in southwest Ethiopia. Correlation coefficient analysis of grain yield showed positive and significant association with days to 85% maturity and number of fertile tillers per plant at both phenotypic and genotypic levels. At phenotypic level, thousand seed weight displayed positive and significant correlation with grain yield, while at genotypic level, panicle length and plant height exhibited positive and significant relationships. Thus, these traits could play pivotal role in the development of high yielding rainfed upland rice genotypes. Separation of correlation coefficients into direct and indirect effects of component traits on grain yield revealed that days to 85% maturity and number of fertile tillers per plant exerted the maximum positive direct effect on grain yield at both genotypic and phenotypic levels. The direct contribution of days to 85% maturity supported indirectly by panicle length and thousand seed weight at phenotypic level. At genotypic level, panicle length assisted the direct contribution of days to 85% maturity to the grain yield. Therefore, while making selection these characters would be reliable criteria for improving grain yield of upland rice genotypes at south-western Ethiopia.

Keywords: Direct and Indirect effect; Positive and negative correlation; Rice; Rainfed; Yield component traits

Introduction

Rice (*Oryza sativa* L. and *Oryza glaberrima* Steud) belongs to the family Poaceae, is the most significant food crops of the world and assists as a chief food basis for more than 50% of the world population [1]. It offers a wealth of material for genetic studies because of its wide ecological distribution and enormous variation encountered for various qualitative and quantitative characters. It is predominantly a self-pollinated crop, but up to 3% natural out crossing may occur depending on the cultivar and the environment [2].

In Ethiopia, the cultivation of rice is of a recent history, however, its use as a food crop, income source, employment opportunity and animal feed have been well recognized [3]. In the past few years it was considered as a strategic food security crop that have received due emphasis in promotion of agricultural production and as such it is considered as the “millennium crop” expected to contribute in ensuring food security in Ethiopia. Volume of rice production in Ethiopia is also on move with national average productivity rise of 1.8 ton per hectare [4] to 2.8 ton per hectare [5] at on-farm level. According to Seck et al. [6]; the number of participant farmers and the demand for improved rice technologies is also highly increasing from time to time from different stakeholders and the country planned to meet the projected average productivity increase of 5.1 tons/ha in 2019.

In Ethiopia rainfed rice is cultivated in Amhara, Tigray, Oromia, South Nation Nationalities and Peoples Region (SNNPR), Gambella and Benshangul Gumuz Regions [7]. The total cultivated area at

national level has increased from 33,819.65 in 2013-2014 to 45,454.2 hectares in 2015-2016. The cultivated area has increased in 2015-16 as compared to 2013-2014 by about 37.33% nationally with considerable difference across regions. Accordingly, rice production has increased from a total of 92,362.7 tons, in 2013-14 to 1,268,064.47 tons in 2015-16. Similarly, productivity has also increased from 2.7 in 2013-14 to 2.8 tons per hectare in 2015-16.

Despite the country's immense potential for growing this crop, production, productivity and expansion of the rice has been challenged by lack of improved varieties, lack of recommended crop management practices for different rice ecosystems, lack of pre and post-harvest management technologies and lack of awareness on its utilization [7,8-10]. As a result, rice yield remains progressively low with average national productivity of 2.8 tons/ha [11], which is very much lower than the average yield of rice in the world that accounts 4.54 tons per hectare [12]. Among the determining factors for the reduced productivity of rice in Ethiopia, lack of improved high yielding varieties takes the lion share [13,14].

Recognizing the stated importance and existing potentials to boost rice production and productivity to cope up with fastest growing demand, understanding of the interaction of characters among themselves had been of great use for selection to improve productivity of rainfed upland rice. Character association and path coefficients are pre-requisites for improvement of any crop including rice for selection of superior genotypes and improvement of any trait. Knowledge of correlation between yield and its contributing characters are basic and foremost endeavour to find out guidelines for plant selection.

Character association studies have been done in upland rice genotypes in different parts of the country, however there has been no studies done by using currently used upland rice genotypes in southwest Ethiopia. The present study was conducted in order to determine the magnitude of association among component traits among themselves and with grain yield. In the view of above situations, correlation and path coefficient analysis of fifteen rainfed upland rice genotypes were studied for seven characters to evaluate the contribution of each trait towards grain yield.

Materials and Methods

Description of the experimental site, materials and procedures

The experiment was conducted at Guraferda in Bonga Agricultural Research Center experimental station for two consecutive years (2014 and 2015). The site is located at an altitude of 1235 meters above sea level, 7° 26' N and 36° 22' E latitude and longitude, respectively. It receives an annual rainfall of 1710 mm and mean monthly minimum and maximum temperature of 16.7°C and 24.0°C, respectively [15]. The experimental materials consisted of 15 rainfed upland rice genotypes (Advanced lines) obtained from Fogera National Rice Research and Training Center (FNRRTC) and Bonga Agricultural Research Center: *Hidassie* (WAB515-B-16A1-2), *Getachew* (AD01), *Andassa* (AD012), *Tana* (AD048), *NERICA-3* (WAB450-IB-P-28-HB), *SUPERICA-1* (WAB-4507), *Kokit* (IRAT-209), *NERICA-12*, *NERICA-13*, *NERICA-14*, *NERICA-15*, *NERICA-18*, *FOFIFA-4129*, *FOFIFA-3737*, *FOFIFA-3730* were used as experimental materials. The experiment was laid out in randomized complete block design in three replications. The spacing between replications, plots and rows was 1, 0.3 and 0.2 m, respectively. Seeds were drilled in rows with a rate of 60 kg per hectare. The gross and net harvestable plot size of the experiment were 6 m² (six rows of 5 m of long and 1.2 m wide) and 4 m² (four rows of 5 m long and 0.8 m wide), respectively, and four inner most central rows were used for data collection. Fertilizer was applied at a rate of 100 kg DAP and 100 kg Urea ha⁻¹. All DAP was applied during sowing whereas urea was applied in three equal splits at sowing, tillering and at panicle initiation stages. Weeding was done three times manually during the whole experimental period as required.

Data collection and analysis

Standard evaluation system developed by IRRI [16] was followed in order to collect yield and yield component data. Days to 50% heading and days to 85% maturity were computed on plot basis. Five representative plants for each genotype in each replication were randomly taken to record observations on plant height (cm), panicle length (cm), fertile or productive tillers per plant. Grain yield obtained on plot bases was converted into Kg ha⁻¹ and adjusted to 14% grain moisture content.

Phenotypic and genotypic correction coefficient analysis

Phenotypic and genotypic correlation coefficients were computed from variance and covariance components based on the method described by Singh and Chaudhury [17]. The Pearson correlation test was applied for phenotypic and genotypic correlation coefficients respectively using SAS statistical package [18].

Phenotypic and genotypic path coefficient analysis

The direct and indirect effect of component traits on yield and among themselves were estimated following the method suggested by Dewey and Lu [19] given as follows.

$$r_{ij} = P_{ij} + \sum r_{ik}p_{kj}$$

Where: r_{ij} = Mutual association between the independent trait (i) and dependent trait (j) as measured by the correlation coefficient.

P_{ij} = Component of direct effects of the independent trait (i) on the dependent variable (j) as measured by the path coefficient and, $\sum r_{ik}p_{kj}$ = Summation of components of indirect effect of a given independent trait (i) on the given dependent trait (j) via all other independent traits (k). Residual effect estimated by the formula

$$\sqrt{1 - R^2}$$

$$\text{Where: } R^2 = \sum p_{ij}^2$$

Where, R^2 is the residual factor, P_{ij} is the direct effect of yield by i^{th} trait, and r_{ij} is the correlation of yield with the i^{th} trait.

Results and Discussion

Correlation analysis

Association of grain yield and yield related traits at phenotypic and genotypic levels: Genotypic and phenotypic correlations coefficients analysis result of grain yield and yield related component traits showed both positive and negative associations (Table 1). Positive correlated result indicated that increase of one trait will result in increase of the correlated trait and negative association of traits indicated that increase of one character will decrease the negatively correlated character.

At phenotypic level, days to 85% maturity ($r=0.23^{**}$), thousand seed weight ($r=0.31^{**}$) and number of fertile tillers per plant (0.22^*) displayed positive and significant association with grain yield ha⁻¹, directing that grain yield of upland rice genotypes could be improved by selecting genotypes having higher performance for these traits. The detected positive and significant correlation of grain yield ha⁻¹ with these traits indicated that as days to 85% maturity, thousand seed weight and number of fertile tillers per plant simultaneously increased, grain yield ha⁻¹ will also increase. Similar results have been earlier reported by Mulugeta et al. [20] in rainfed upland rice genotypes. Plant height exhibited negative and significant association with grain yield ha⁻¹. This result indicated that any increase in plant height could result in decrease in grain yield ha⁻¹ that could be related with tallness in rice reduces the grain yield due to high accumulation of photosynthates on elongation of vegetative parts rather than reproductive parts. Therefore, selection is devised on semi dwarf genotypes would result in increased grain yield. Satheeshkumar and Saravanan [21] and Ukaoma et al. [22] found negative association of plant height with grain yield. On the contrary, Mulugeta et al. [20] detected significant and positive association of plant height and non-significant association of days to 50% heading with grain yield.

At genotypic level, plant height ($r=0.07^*$), panicle length ($r=0.19^{**}$), number of fertile tillers per plant ($r=0.67^{**}$) and days to 85% maturity showed significant and positive association with grain yield ha⁻¹. Days to 50% heading ($r=-0.07^*$) displayed negative and significant correlation with grain yield ha⁻¹ (Table 1). This result indicated that any increase in days to 50% heading could result in decrease in grain

yield ha⁻¹. Presence of early heading genotypes is important for climate mitigation as drought escape mechanism for areas with marginal rainfall. However, under a favourable growing condition too early heading does not permit production of sufficient assimilates for grain

filling and finally ends up with low grain yield [23,24]. Therefore, selection for early to medium heading upland rice genotypes could be effective in increasing grain yield in the study area.

Traits	DH	DM	PL	PH	NFTP	TSW	GY
DH		0.77**	0.19	0.40**	-0.25	0.05	0.014
DM	0.90**		0.26	0.47**	-0.31*	0.15	0.23**
PL	0.23	0.32		0.65**	-0.04	-0.05	0.01
PH	0.47	0.63**	0.68**		0.04	0.02	-0.32**
NFTP	-0.45	-0.48	-0.33	-0.26		-0.11	0.22*
TSW	0.02	0.05	-0.11	-0.02	0.03		0.31**
GY	-0.07*	0.11*	0.19**	0.07*	0.67**	-0.2	

* =Significant at P < 0.05; ** =significant at P < 0.01; ns=non-significant., DH=Days to 50% Heading; DM=Days to 85% Maturity; PL=Panicle Length; PH=Plant Height; NFTP=Number of Fertile Tillers per Plant; TSW=housand Seed Weight; GY=Grain Yield (kg/ha).

Table 1: Phenotypic (above diagonal) and genotypic (below diagonal) correlation coefficients of six yield and yield component traits on 15 rainfed upland rice genotypes.

Correlation among yield related traits at phenotypic and genotypic levels: Remarkable associations were observed among yield related traits at both phenotypic and genotypic levels (Table 1). Days to 50% heading showed positive and significant association with days to 85% maturity (0.77**) and plant height (0.40**), but with all other yield related traits it showed non-significant correlation. Days to 85% maturity displayed positive and significant correlation with plant height (0.47**) and negative and significant association with number of fertile tillers per plant. Similarly, panicle length also registered positive and significant association plant height at phenotypic level. This result suggested that as plant height increases, panicle length, also ultimately increases. Similar result was reported by Singh et al. [25] for the association between plant height and panicle length. Moosavi et al. [26] and Mishu et al. [27] also reported positive significant association of plant height with panicle length at phenotypic level.

At genotypic level traits like, days to 50% heading, days to 85% maturity and panicle length, exhibited significant association with other component traits. Days to 50% heading exhibited strong positive

and significant correlation with days to 85% maturity (r=0.91**). This characteristic indicates that increasing of days to 50% heading would lead to increase in the days to 85% maturity which might be attributed due to pleiotropic gene effects and linkage between genes for these traits. Association between days to 85% maturity showed strongly positive and significant with plant height The trend of relationship between panicle length with plant height was significantly positive with value of (r=0.68**) at genotypic level.

Path coefficient analysis

Path coefficient analysis at phenotypic level: Grain yield per hectare of rice was taken as dependent variable and direct and indirect effects of the other independent variables were computed and have been showed in Table 2. Direct positive effect on grain yield of some characters indicated that selection of these traits is directly helpful for the improvement of yield. Negative indirect effects of some characters on grain yield showed that effects of such traits are indirectly affecting the grain yield in the negative direction.

Traits	DH	DM	PL	PH	NFTP	TSW	r ^{ph}
DH	-0.24	0.67	0.1	-0.4	-0.13	0.01	0.014
DM	-0.18	0.87	0.13	-0.47	-0.16	0.04	0.23**
PL	-0.04	0.23	0.51	-0.65	-0.02	-0.01	0.01
PH	-0.09	0.41	0.33	-0.99	0.02	0.01	-0.32**
NFTP	0.06	-0.27	-0.02	-0.04	0.53	-0.03	0.22*
TSW	-0.01	0.13	-0.03	-0.02	-0.06	0.3	0.31**

Residual effect=0.52; DH=Days to 50% Heading; DM=Days to 85% Maturity; PL=Panicle Length; PH=Plant Height; NFTP=Number of Fertile Tillers per Plant; TSW=Thousand Seed Weight; r^{ph} =phenotypic correlation coefficient

Table 2: Phenotypic direct (bolded) and indirect effects of six component traits on grain yield of 15 upland rice genotypes.

The path coefficient analysis result revealed that, at phenotypic level, days to 85% maturity (0.87) exerted the highest positive direct effect on grain yield ha⁻¹ followed by number of fertile tillers per plant (0.53), panicle length (0.51), and thousand seed weight (0.30). Positive direct effect of these traits on grain yield indicates a hand to hand relationship between each other and should be watched closely while practicing selection aimed at the improvement of grain yield. This result was in harmony with the findings of Karim et al. [28] and Hossian et al. [29] but, in contrary to the finding of Moosavi et al. [26]. The indirect exertion of days to 85% maturity on grain yield through all the other characters considered were negative, except for panicle length and thousand seed weight. Therefore, along with days to 85% maturity, the causal factors which had positive indirect effects on grain yield ha⁻¹ might be considered simultaneously during the process of selection for grain yield improvement program in rainfed upland rice. The indirect influences of number of fertile tillers per plant on grain yield through days to 85% maturity, panicle length, plant height and thousand seed weight were also found to be negative and it showed positive indirect effect via days to heading. Similarly, positive direct effect of panicle length and thousand seed weight on grain yield was attributed to days to 85% maturity and lowered by days to 50% heading, panicle length, plant height and fertile tillers number per plant.

Days to 50% heading (-0.24) and plant height (-0.99) exerted negative direct effect on grain yield ha⁻¹. In such situations direct selection for genotypes that took long time to head and, highest plant height might be ineffective for the improvement of grain yield in upland rice. The negative direct exertion of days to 50% heading on grain yield was nullified indirectly by days to 85% maturity, panicle length and thousand seed weight. Similarly, the direct negative influence of plant height with grain yield counterbalanced by the positive indirect effects of days to 85% maturity, panicle length, fertile tillers number per plant and thousand seed weight. The current findings suggest that improvement of grain yield of rainfed upland rice

genotypes through selection could be achieved through direct selection via positively contributed component traits to grain yield and positively exerted indirect effects to nullify or counterbalance the negative direct effects of component traits. The residual effect was (0.52), indicating that 48% of the variability in grain yield was contributed by traits considered in the path analysis. This result gives an impression that some other major characters than those involved in the present study might also contribute to grain yield.

Path coefficient analysis at genotypic level: Genotypic path coefficient analysis result (Table 3) revealed that days to 85% maturity had positive and maximum direct effects on grain yield, followed by number of fertile tillers per plant and panicle length. Positive and direct effect of days to 85% maturity with grain yield was lessened by negative and indirect effect of days to 50% heading, plant height, fertile tillers number per plant and thousand seed weight while it was supported indirectly through panicle length. Significant and positive direct effect of number of fertile tillers per plant on grain yield was attributed to days to 50% heading and plant height and but reduced by negative indirect influences of days to 85% maturity panicle length and thousand seed weight. Similarly, the positive and direct effect of panicle length (0.77) on grain yield was lowered by its indirect effect of days to 50% heading, plant height and number of fertile tillers per plant.

The direct influences of days to 50% heading (-0.98), plant height (-0.86) and thousand seed weight (-0.21) on grain yield were negative. The negative direct effect of days to 50% heading indicated that selection for early heading genotypes will lead to high grain yield in upland rice genotypes that helps in escaping terminal moisture stress. In contrary, Mulugeta et al. [20] found negative direct effect of days to 50% heading on grain yield in rainfed upland rice. The residual effect was (0.42), explaining that the contribution of component traits on grain yield was 58% by the characters evaluated in the path analysis, the rest 42% was the contribution of other factors.

Traits	DH	DM	PL	PH	NFTP	TSW	r ^g
DH	-0.98	1.67	0.18	-0.41	-0.52	-0.01	-0.07*
DM	-0.88	1.86	0.25	-0.54	-0.55	-0.01	0.11*
PL	-0.23	0.59	0.77	-0.59	-0.38	0.02	0.19**
PH	-0.46	1.17	0.52	-0.86	-0.3	0	0.07*
NFTP	0.44	-0.89	-0.25	0.22	1.15	-0.01	0.67**
TSW	-0.05	0.09	-0.08	0.02	0.03	-0.21	-0.2

Residual effect=0.42; DH=Days to 50% Heading; DM=Days to 85% Maturity; PL=Panicle Length; PH=Plant Height; NFTP=Number of Fertile Tillers per Plant, and TSW=Thousand Seed Weight and r^g=genotypic correlation coefficient

Table 3: Genotypic direct (bolded) and indirect effects of six component traits on grain yield of 15 upland rice genotypes.

Conclusion

It is essential to know the degree of mutual association prevailing between yield and its component traits, which forms the basis for selecting desirable genotypes. A study of correlation and path analysis will thus help in identifying suitable selection criteria for improving yield. Hence the present study was undertaken to determine the extent of correlation and path coefficients in some selected rainfed upland rice genotypes. Based on correlation analysis, days to 85% heading and

number of fertile tillers per plant influenced grain yield of upland rice genotypes at both phenotypic and genotypic levels and displayed significant and positive association with grain yield. Hence, in order to increase grain yield of rainfed upland rice genotypes, more emphasis should be placed on increasing the period of days to 85% maturity and number of fertile tillers per plant. Since, simple correlation does not partition correlation coefficients into cause and effect relationships of yield contributing traits on grain yield; path coefficient analysis is employed to predict the exact figure of direct and indirect contribution

of component traits on grain yield. Thus, days to 85% maturity and number of fertile tillers per plant exerted maximum positive direct effect on grain yield at both genotypic and phenotypic levels. The direct contribution of days to 85% maturity supported indirectly by panicle length and thousand seed weight at phenotypic level. At genotypic level, panicle length assisted the direct contribution of days to 85% maturity to the grain yield. Therefore, these characters would be reliable criteria for improving grain yield of upland rice at south-western Ethiopia.

Acknowledgement

The authors would like to acknowledge Southern Agricultural Research Institute, Bonga Agricultural Research Center and Fogera National Rice Research and Training Center for financing the study and the provision of experimental seeds.

References

1. Wang C, Liu X, Peng S, Xu Q, Yuan X, et al. (2014) Development of novel microsatellite markers for the BBCC *Oryza* genome (Poaceae) using high-throughput sequencing technology. *PLoS one* 9: p.e91826.
2. Poehlman JM (1995) *Breeding Field Crops*. 4th Iowa State University Press. Ames, USA P, 494.
3. Teshome N, Dawit A (2011) An Overview of the National Rice Research and Development Strategy and its Implementation. Challenges and Opportunities of Rice in Ethiopian Agricultural Development, pp.1-16.
4. Central Statistical Agency (CSA) (2006) Agricultural sample survey 2005/2006. Report on area and production of major crops. Central Statistical Agency of Ethiopia, Addis Ababa, Ethiopia.
5. Central Statistical Agency (CSA) (2014) Agricultural sample survey 2013/2014. Report on area and production of major crops. Central Statistical Agency of Ethiopia, Addis Ababa, Ethiopia.
6. Seck PA, Toure AA, Coulibaly JY, Diagne A, Wopereis MCS (2013) Impact of rice research on income, poverty and food security in Africa: an ex-ante analysis. In *Realizing Africa's Rice Promise*. Pp. 390.
7. Ministry of Agriculture and Rural Development (MoARD) (2010) National Rice Research and Development Strategy of Ethiopia. Addis Ababa, Ethiopia, pp. 48.
8. Tefaye Z, Befikadu A, Aklilu A (2005) Rice Production, Consumption and Marketing on Fogera, Dera and Libokemkem Districts of Amhara Region. Bahir Dar, Ethiopia (unpublished document).
9. Mulugeta S, Sentayehu A, Kasahun B (2012) Genetic variability, heritability, correlation coefficient and path analysis for yield and yield related traits in upland rice (*Oryza sativa L.*).
10. Lakew T, Tariku S, Alem T, Bitew M (2014) Agronomic performances and stability analysis of upland rice genotypes in North West Ethiopia. *Int J Scient Res Pub* 4: 1-9.
11. Central Statistical Agency (CSA) (2016) Agricultural sample survey 2015/2016. Report on area and production of crops (Private peasant holdings, Meher season) Central Statistical Agency of Ethiopia, Addis Ababa, Ethiopia.
12. FAO Statistical Databases (United Nations) (FAOSTAT) (2016) Agriculture Organization of the United Nations Statistics Division Production [Review date: April 2015].
13. Atilaw A (2010) A baseline survey on the Ethiopian seed sector. The African seed trade association. Addis Ababa, Ethiopia.
14. Sewagegne T (2011) An Overview of Rice Research in Ethiopia. Challenges and Opportunities of Rice in Ethiopian Agricultural Development.
15. Mebratu GM, Selvaraj T, Woldeab G (2015) Assessment of disease intensity and isolates characterization of blast disease (*Pyricularia oryzae* CAV) from South West of Ethiopia. *Int J Life Sci* 3: 271-286.
16. IRRI (2013) Rice Almanac, source book for the most important economic activity on earth. Third edition. Maclean JL, Dawe DC, Hardy B, Hettel GP (editors) International Rice Research Institute, Manila, Philippines. pp. 1-253.
17. Singh RK, Chaudhary BD (1996) Biometrical methods in quantitative genetic analysis.
18. SAS Institute (2002) The SAS system for windows, V.9.0. SAS Institute, Carry, NC, USA.
19. Dewey DR, Lu K (1959) A correlation and path-coefficient analysis of components of crested wheatgrass seed production. *Agron J* 51: 515-518.
20. Bitew JM (2016) Estimation of Genetic parameters, Heritability and genetic advance for yield related traits in upland rice (*Oryza sativa L.* and *Oryza glaberrima Steud*) Genotypes in Northwestern Ethiopia. *World Scient News* 47: 340-350.
21. Satheeshkumar P, Saravanan K (2012) Genetic variability, correlation and path analysis in rice (*Oryza Sativa L.*). *Int J Curr Res* 082-085.
22. Ukaoma A, Okocha P, Okechukwu R (2013) Heritability and character correlation among some rice genotypes for yield and yield components, Federal University of Technology, Owerri, Imo State, Nigeria. *J Plant Breed Genet* 1:73-84.
23. Shavrukov Y, Kurishbayev A, Jatayev S, Shvidchenko V, Zotova L, et al. (2017) Early Flowering as a Drought Escape Mechanism in Plants: How Can It Aid Wheat Production? *Front Plant Sci* 8: 1950.
24. Yoshida S (1981) *Fundamentals of rice crop science*. 1st Edn., International Rice Research Institute, Philippines, ISBN:971-104-052-2, pp:267.
25. Singh AK, Nandan R, Singh PK (2014) Genetic variability and association analysis in rice germplasm under rainfed conditions. *Crop Res* 47: 7-11.
26. Moosavi M, Ranjbar G, Zarrini HN, Gilani A (2015) Correlation between morphological and physiological traits and path analysis of grain yield in rice genotypes under Khuzestan conditions. In *Biological Forum* 7: 43.
27. Mishu MFK, Rahman MW, Azad MAK, Biswas BK, Talukder MAI, et al. (2016) Study on Genetic Variability and Character Association of Aromatic Rice (*Oryza sativa L.*) Cultivars.
28. Karim D, Siddique NEA, Sarkar U, Hasnat Z, Sultana J (2014) Phenotypic and genotypic correlation co-efficient of quantitative characters and character association of aromatic rice. *J Biosci Agri Res* 1: 34-46.
29. Hossain S, Haque M, Rahman J (2015) Genetic variability, correlation and path coefficient analysis of morphological traits in some extinct local Aman rice (*Oryza sativa L.*). *Rice Res: Open Access*.