Estimation of genetic association among yield contributing traits in aromatic and non-aromatic rice (*Oryza sativa* L) cultivars

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Abstract: This study provided useful evidences about yield and its contributing components on 8 morphological traits, which were studied in 24 Asian accessions of rice (*Oryza sativa* L.). Plant yield was positively and significantly correlated with filled grains weight per panicle, number of grains per panicle, 1000-grain weight and spikelet fertility percentage at genotypic and phenotypic levels. Thus, these traits could play pivotal role in the development of high yielding rice genotypes. Path coefficient analysis recorded highest positive direct effect on yield per plant through number of grains per panicle, filled grains weight per panicle, plant height and 1000-grain weight. Hence, traits like number of grains per panicle, filled grains weight per panicle and 1000-grain weight would be useful in future breeding programs to develop superior genotypes having excellent yield potential.
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Introduction

More than 61 percent of the world's population is living in Asia and it is said that world's 90 % rice is not only produced in Asia but also consumed in this continent (Islam *et al.* 2010). Whereas, in past 40 years, 12 countries of South and Southeast Asia released more than 2000 advanced cultivars of rice. China is the leading and prime producer of rice in Asia, while 318.3 million tones rice was produced in Asia during the year 2011 (Abbas *et al.* 2014; Food and Agriculture Organization (FAO) of United Nations). Rice is basic primary staple food for 17 countries in Asia including Pacific, it is also staple food for 9 countries in Africa and contributes in 20 % of world energy, while wheat is providing 19 % and maize is providing 5 % (Ahsan *et al*., 2011; Ahsan *et al*., 2013; Ali *et al*., 2012; Ali *et al*., 2013ab; Ali *et al*., 2014abc; Laxuman *et al.* 2011) and it supplies 15 % per capita protein also (Ramezanil and Torabi, 2011). Except China, the population in Asia is increasing at 2 % rate (Tiwari *et al.* 2011) per year. This is why, one fourth of the Asian people are still poor and mostly living in Vietnam, Nepal, North Korea and Afghanistan, thus this situation is demanding more rice food. 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 pivotal role for more production in rice (Yang *et al.* 2007). If some yield contributing components are selected in order to increase grain yield, it would very important matter if the components involved are really heritable and genetically have independent characteristics or in other words these components are positively associated with each other (Yang *et al*., 2007). Correlation study provides well estimate about yield and yield related traits and also defines that how these traits are genetically correlated with each other. Moreover, correlation gives a strong measure about yield contributing components, eventually providing a helping hand to the rice breeders over selection of desirable plants. In addition to correlation, path coefficient analysis explains the association in the form of direct and indirect effects of every yield contributing character with grain yield. Furthermore, scientists can give rank to these yield components by looking their level of contribution (Dewey and Lu, 1959). This method gives magnitude about the cause and effect condition and assists in knowing the reason of relationship between two quantitative variables. The following study was taken into consideration among diverse genotypes of Asia and contribution of yield and yield related components towards grain yield and thereby to maintain proper future plant breeding strategies for the purpose of developing good yielding varieties of rice (*Oryza sativa* L.) in Asia.

Materials and methods

The following study was carried out in the research area of the Department of Plant breeding and Genetics, University of Agriculture, Faisalabad, Pakistan during the kharif season 2011-12. The germplasm was comprising 24 Asian rice genotypes

and laid out in randomized complete block design into the field with three replications for each genotype and data was recorded on (i) number of tillers per plant, (ii) plant height, (iii) number of spikelets per panicle, (iv) number of grains per panicle, (v) Spikelet fertility percentage (vi) filled grains weight per panicle, (vii) 1000-grain weight & (viii) yield per plant. Correlation study was used to reveal type and nature of association between yield and yield related components by the technique presented by Kwon and Torrie (1964). Direct and indirect effects created from partitioning of genotypic correlation coefficient were studied by using the formula Dewey and Lu, 1959.

Results and discussion

Correlation analysis

The value of phenotypic and genotypic correlation provides the information about the relationship between the two or more than two independent variables. In plant breeding and genetics through correlation analysis can be used to estimate the value of different traits (Ahmad *et al*. 2012).The genotypic correlation of number of tillers per plant with plant height and spiekelet fertility percentage was positive and significant with values of (0.304*) and (0.190*), respectively and rest of the 4 traits had negative and non-significant genotypic correlation with tillers per plant. Positive and significant phenotypic correlation of tillers per plant was found with plant height with values of (0.304**) and negative but significant correlation with number of spikelets per panicle, number of grains per panicle and yield per plant with values of (-0.335**), (-0.240*) & (-0.287*), respectively. Spikelet fertility percentage showed no phenotypic correlation with this trait and rest of the traits had negative and non-significant phenotypic correlations. Selvaraj *et al*. (2011) found similar types of results about tillers per plant and plant height. Zahid *et al*. (2006) results coincide with the correlation between tillers/ plant & grains/panicle only at phenotypic level. Babu *et al*. (2012) found similar results about tillers/plant & 1000-grain weight. Zahid *et al*. (2006) agreed with correlation between tillers/plant & yield per plant (Table 1). Genotypic correlation of plant height with spikelet fertility percentage was positive and significant in the form of (0.328*), while rest of the traits showed negative and non-significant genotypic correlations with plant height. There was negative and significant phenotypic correlation with filled grain weight per panicle, number of spikelets per panicle and number of grains per panicle with values of (-0.394**), (-0.320**), (-0.289*), respectively. Spikelet fertility percentage showed no association with plant height while rest of the traits showed negative and non-significant phenotypic correlation with plant height. Similar types of results were given by Khan *et al*. (2009) about plant height and spikelet fertility %. Zahid *et al.* (2006), Babu *et al.* (2012) Ahmad *et al.* 2012 and imran *et al*. (2014) got similar results about plant height & yield per plant (Table 1). Spikelets per panicle showed positive and significant genotypic correlation with traits such as number of grains per panicle, filled grain weight per panicle, yield per plant, 1000-grain weight and spikelet fertility percentage with values of (0.933*), (0.760*), (0.273*), (0.229*) & (0.029*), respectively. Number of spikelets per panicle also had positive and significant phenotypic correlation with number of grains per panicle, filled grain weight per panicle and yield per plant in the form of (0.931**), (0.745**) & (0.270*), respectively. Correlation of spikelets/panicle with number of grains/panicle & yield per plant is similar with the results of Rangare *et al*., (2012). Rangare *et al*. (2012) and Seyoum *et al*. (2012) concluded similar results about spikelets/panicle and yield per plant. Because, yield per plant and number of spikelets per panicle were positively and significantly associated with each other, therefore grain yield in rice can be increased if more number of spikelets are produced (Table 1). Genotypic correlation of grains per panicle with filled grain weight per panicle, yield per plant, spikelet fertility percentage and 1000-grain weight was positive and significant with values of (0.850*), (0.400*), (0.381*) & (0.315*), respectively. These four traits also showed significant and positive phenotypic correlation with number of grains per panicle having values of (0.832**), (0.397**), (0.384**) & (0.313**), respectively. Similar types of results were reported by Zahid *et al*. (2006) about grains/panicle and 1000-grain weight. Khan *et al.* (2009), Ullah *et al*. (2011) and Seyoum *et al*. (2012) concluded similar types of results about the correlation of grains/panicle and yield/plant. Many scientists have suggested that number of grains per panicle is very important trait and it is mostly found positively associated with grain yield that mean if number of grains is improved then high yielding genotypes can be produced.

Positive and significant genotypic correlation was observed between spikelet fertility percentage and grain yield per plant, filled grain weight per panicle and 1000-grain weight with values of (0.426*), (0.405*) & (0.293*), respectively. These three characters also had significant and positive phenotypic correlation with spikelet fertility percentage having values of (0.414**), (0.387**) & (0.284*), respectively. Sankar *et al.* (2006) also obtained similar results about spikelet fertility % and 1000-grain weight. Haider *et al.* (2012) and Seyoum *et al.* (2012) also noticed similar types of results about spikelet fertility and grain yield/plant. Yield per plant and spikelet fertility percent being positively associated

with each other indicated that if more fertile spikelets are produced then they will contribute more towards yield (Table 1). The genotypic correlation of filled grain weight per panicle with yield per plant and 1000-grain weight was positive and significant showing values of (0.477*) & (0.330*), respectively whereas filled grain weight per panicle also had positive and significant phenotypic correlation with these two traits with values of (0.477**) & (0.323**), respectively (Table 1). It is suggested that, if grain weight per panicle is increased then yield per plant will also be improved. Thousand grain weight had positive and significant genotypic correlation and phenotypic correlation with grain yield per plant with values of (0.421*) & (0.419**), respectively. Similar types of findings were reported by Haider *et al*. (2012) and Masood *et al*., (2014abc). That means if 1000-grain weight is more in a variety then ultimately more yield will improved.

Table 1. Genotypic and phenotypic Correlation coefficients between various agronomic traits in 24 Asian rice genotypes

Traits	r	Plant height	No. of spikelets /panicle	No. of grains /panicle	Spikelet Fertility%	Filled grain weight/pancile	1000-grain weight	Grain yield/ plant
No. of tillers/ plant	G P	0.304* 0.304**	-0.338 -0.335**	-0.241 -0.240*	0.190* 0.182	-0.225 -0.221	-0.117 -0.116	-0.290 -0.287*
Plant height	G P		-0.321 -0.320**	-0.290 -0.289*	0.070* 0.065	-0.401 -0.394**	-0.223 -0.222	-0.130 -0.129
No. of spikelets/panicle	G P			0.933* 0.931**	0.029* 0.027	0.760* 0.745**	0.229* 0.228	0.273* 0.270*
No. of grains/ panicle	G P				0.381* 0.384**	0.850* 0.832**	0.315* 0.313**	0.400* 0.397**
Spikelet fertility %	G P					0.405* 0.387**	0.293* 0.284*	0.426* 0.414**
Filled grain wt. /panicle	G P						0.330* 0.323**	0.477* 0.477**
1000 grain weight	G P							0.421* 0.419**

Path coefficient analysis

The only technique that furnishes a method by which separation of correlation coefficients becomes possible among various traits into direct and indirect influences is path coefficient analysis, which was suggested by Dewey and Lu (1959). 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 (Ashfaq *et al*. 2014). Yield per plant of rice was taken as dependent variable and direct and indirect effects of the other independent variables were computed & have been demonstrated in Table 2 and discussed as under. It was found that number of spikelets per panicle, number of tillers per plant and spikelet fertility % exerted negative direct effects on grain yield per plant with values of (-1.382), (-0.290) & (-0.152), respectively. The indirect influences of number of spikelets per panicle on yield per plant through plant height and spikelet fertility percentage were also found to be negative and rest of the traits showed positive indirect effects. Whereas, indirect effects of number of tillers per plant through numbers of grains per panicle, filled grains weight per panicle and 1000-grain weight were also found to be negative and its indirect effects through plant height and number of spikelets per panicle were positive. The indirect effects of spikelet fertility percentage through tillers per plant and number of spikelets per panicle were also negative and remaining traits exhibited positive indirect effects. Eventually, the negative directs of these characters revealed that the direct selection done on the bases of these traits would not be fruitful. Rangare *et al*. (2012); Seyoum *et al*. (2012); Dar *et al*. (2014); Ali and Ahsan (2015); Masood *et al*., (2015ab); Raza *et al*., (2015) and Zafar *et al*., (2015) concluded negative direct effect of spikelets per panicle on yield per plant. Seyoum *et al*. (2012) gave similar results about negative direct effect of tillers per plant on grain yield per plant. Gyanendra *et al.* (2011) also provided similar results regarding negative direct effect of spikelet fertility percentage on yield per plant (Table 2).

It was observed that number of grains per panicle, filled grain weight per panicle, plant height and 1000-grain weight estimated positive direct

effects on grain yield per plant in the form of (1.452), (0.420), (0.305) and (0.151), respectively. The indirect effects of grains per panicle through tillers per plant, filled grain weight per panicle and 1000-grain weight were also positive and rest of the traits had negative indirect influences. The indirect influences of filled grain weight per panicle through tillers per plant, number of grains per panicle and 1000-grain weight were found to be positive as well and remaining traits illustrated negative indirect influences. In addition, indirect effects of plant height through spikelets per panicle were positive but for all remaining characters followed negative indirect influences. The indirect influences of 1000-grain weight through number of tillers per plant, grains per panicle and filled grain weight per panicle were found to be positive and rest of the traits indicated negative indirect influences. All the desirable traits, which had positive direct influences provided useful information to develop superior genotypes having good yield potential and further to be used in future breeding programs in rice.

Table 2: Direct (Bold values) and indirect effects of some yield related traits on yield per plant

Traits	No. of Tillers/ plant	Plant height	No. of Spikelets/ panicle	No.of grains/ panicle	Spikelet Fertility %	Filled grains weight/ panicle	1000-grain weight
No. of tillers /plant	**-0.290**	0.093	0.467	-0.351	-0.029	-0.094	-0.017
Plant height	-0.088	**0.305**	0.443	-0.421	-0.010	-0.168	-0.033
No. of spiekelets/ panicle	0.098	-0.098	**-1.382**	1.356	-0.004	0.319	0.034
No. of grains/ panicle	0.070	-0.088	-1.290	**1.452**	-0.058	0.357	0.047
Spikelet fertility %	-0.055	0.021	-0.041	0.554	**-0.152**	0.170	0.044
Filled grains weight/ panicle	0.065	-0.122	-1.051	1.235	-0.061	**0.420**	0.050
1000- grain weight	0.034	-0.068	-0.317	0.457	-0.044	0.138	**0.151**

Many breeders found direct and positive effect of number of grains per panicle on grain yield per plant including (Seyoum *et al*. 2012). Few other scientists, such as Laxuman *et al*. (2011) obtained positive direct effect of filled grain weight per panicle on yield per plant. Some of the rice breeders, like Gyanendra *et al*. (2011) and Seyoum *et al*. (2012) reported similar type of results that plant height affected the grain yield per plant in direct and positive way. Direct and positive influence of 1000-grain weight on yield per plant was also noticed by Jayasudha and Sharma (2010).

Conclusion

In the light of above discussion, it could be accomplished that at both genotypic and phenotypic level, yield per plant yield had positive and significant correlation with filled grains weight per panicle, number of grains per panicle, 1000-grain weight and spikelet fertility percentage and number of grains per panicle indicated highest positive direct effect followed by filled grains weight per panicle, plant height and 1000-grain weight. The traits directly related to yield per plant (positively & significantly) and revealing direct positive effects, could therefore, be most efficient to produce high grain yield varieties in Asia.

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