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Correlation and path analysis studies in aromatic rice germplasm of North-East region of India

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Abstract
An experiment was conducted in research fields of the department of Genetics and Plant Breeding, College of Agriculture, CAU, Imphal to study the nature and degree of association between yield and its component characters and their direct and indirect effects on grain yield in aromatic rice genotypes of North east region of India. Among the important characters studied no. of grains per plant, no. of panicles per plant, 1000 grains weight, panicle length and plant height showed high significant positive correlation with grain yield per plant. Maximum direct effect on grain yield was also observed from no. of grains yield per plant followed by no. of panicles per plant, panicle length, plant height and 1000 grains weight.

Keywords: Correlation, path analysis, aromatic rice, direct effect

Introduction
Rice (*Oryza sativa* L.) is one of the most important staple food crops consuming by more than half of the world's population, particularly in many developing countries of Asia, Africa, and Latin America. In India rice is cultivated round the year in one or the other part of the country in diverse ecologies spread over 43.38 million hectares with a production of 104.32 million tonnes during 2015-16 (Annual report, 2016-17), representing the largest area and the second highest production in the world.

Moreover, rice is the major food of most Asian countries; in particular aromatic rice also plays a vital role in global rice trading. Aromatic rices constitute a small group that is usually used for special dish preparation in festivals and special occasions rather than in common and regular purpose. In addition, it is a high value cash crop for farmers (Singh *et al*., 2000) [14]. There is a great opportunity to earn foreign currency by exporting aromatic rice, as the consumption area of aromatic rice throughout the world is large and price would be also high (Chowdhury and Bhuiyan, 1991) [3]. But the yield of aromatic rice is considerable low as compared to non-aromatic rice as they normally produce enormous spikelets of low grain weight resulting into low yield. So detail study of grain density and yield components of aromatic rice is a crucial need for yield improvement. Grain weight and grain density are the vital indicators of grain filling and mainly dependent on genetic make-up. Most of the aromatic rice varieties are low yielding because of its traditional plant type, low grain weight but with enormous spikelets. Grain density is normally higher for larger grain size; however it is also dependent on grain filling. It was also suggested that the rate and duration of grain filling in rice affect final grain traits such as weight and density. Therefore attention should be given to increase the production of aromatic rice through improvement in yield, yield attributing characters and other agro-morphological characters for breeding high yielding quality aromatic rice varieties.

Measurement of correlation coefficient helps to identify the relative contribution of component characters towards yield (Panse, 1957) [11]. Moreover, the correlation between grain yield and a component character may sometimes be misleading due to an over estimation or underestimation for its association with other characters. Thus, yield components have influence on ultimate yield both directly and indirectly (Tukey, 1954) [17]. Splitting of correlation direct and indirect effects, therefore, would provide a more meaningful interpretation of such association. Therefore, correlation in combination with path coefficient analysis will be an important tool to find out the association and quantify the direct and indirect influence of one character upon another (Dewey and Lu, 1959) [4].

Materials and Method

The experimental material consists of thirty four aromatic rice cultivars collected from different region of North-east India *viz.*: Manipur, Mizoram, Nagaland, Arunachal Pradesh, Sikkim, Tripura and Meghalaya. The field experiment was conducted during *kharif* in Randomized Block Design (RBD) with three replications, a recommended agronomic and plant protection measures were followed during the crop period. The experimental data on selected quantitative characters were recorded as per National guidelines (Rani *et al*., 2006) [12], for DUS (Distinctiveness, Uniformity and Stability) test and Minimal Descriptors (for characterization and evaluation) of Agri-Horticultural Crops, National Bureau of Plant Genetic Resources (Mahajan, 2000) [9]. Characters such as length of leaf blade, width of leaf blade, plant height, panicle length, no. of effective tillers, days to 50% flowering, days to 80% maturity, no. of grains per plant, 1000 grains weight, grain length breadth ratio, decorticated grain length width ratio and grain yield per plant were studied. Data were collected from 5 randomly selected plants from each cultivar at optimum growth stage of observation.

Result and Discussion

Correlation Coefficient

In general the genotypic correlation coefficient was higher than the corresponding phenotypic correlation. Grain yield per plant exhibited significant positive correlation with no. of grains per panicle (G=0.78** and P=0.63**), no. of panicles per plant (G=0.68** and P=0.55**), 1000 grains weight (G=0.48** and P=0.39*), panicle length (G=0.46** and P=0.36*) and plant height (G=0.44** and P=0.37*) both at genotypic and phenotypic level. No. of grains per panicle had a significant positive correlation with panicle length (G=0.83** and P=0.74**), no. of panicles per plant (G=0.79** and P=0.78**) and plant height (G=0.51** and P=0.49**). Similar reports were given by Karim *et al*., (2014) [7] and Lakshmi *et al*., (2017) [8].

In the present study length of leaf blade was significantly positively correlated with width of leaf blade (G=0.47** and P=0.48**) and plant height (G=0.53** and P=0.50**). Plant height had significant positive association with panicle length (G=0.47** and P=0.41*) and no. of panicles per plant (G=0.36* and P=0.34). A significant positive correlation was also observed between no. of panicles per plant and panicle length (G=0.44** and P=0.38**). A positive correlation between no. of panicles per plant and panicle length was reported by Ahmed Mustafa and Yassir Elsheikh (2007) [1].

Days to 50% maturity showed high significant positive correlation with days to 80% maturity (G=0.94** and P=0.95**). While, significant negative correlation coefficient was observed between grain yield per plant with days to 50% flowering days (G=-0.05 and P=-0.03) to 80% maturity (G=-0.9** and P=-0.08). This result implies that early maturing genotypes produce lower grain yield. The genetic reason for this type of negative association may be linkage or pleiotropy (one gene influencing one or more seemingly unrelated phenotypic traits). Such negative association of grain yield per plant with 50% flowering and 80% maturity was also reported by Osundare *et al*., (2017) [10] at both genotypic and phenotypic level, while Lakshmi *et al*., (2017) [8], Gayathri and Padmalatha (2018) [5] reported negative association of 50% flowering with grain yield per plant at both the levels. Width of leaf blade was also found to exhibit a significant negative correlation with no. of panicles per plant (G=-0.44** and P=-0.42**). On the contrary, positive correlation of 50% flowering and 80% maturity with grain yield per plant was reported by Sarkar *et al*., (2014) [13] and Venkata Lakshmi *et al*., (2014) [16] at both genotypic and phenotypic levels. While, positive association between 80% maturity and grain yield per plant was also reported by Karim *et al*., (2014) [7]. This contradiction can be due to the genotype or the environmental influence.

Path analysis

Maximum positive direct effect on grain yield per plant was observed from no. of grains per panicle (G=0.45 and P=1.83), followed by no. of panicles per plant (G=0.03 and P=1.48), panicle length (G=0.04 and P=1.35), plant height (G=0.07 and P=1.26), 1000 grains weight (G=0.03 and P=0.95) and length of leaf blade (G=0.26 and P=0.33). Since these characters were also found to have a significant positive correlation with grain yield per plant, priority should be given to these traits while making selection for crop improvement. Similar findings were also reported by Lakshmi *et al.*, (2017) [8], Sowmiya and Venkatesan (2017) [15] and Gayathri and Padmalatha (2018) [5].

No. of grains per panicle was also found to have high positive indirect effects via no. of panicles per plant (G=0.06 and P=1.16) and 1000 grains weight (G=0.07 and P=0.24) at both genotypic and phenotypic level. While, at the same time zero indirect effect of no. of grains per panicle was observed via days to 50% flowering and days to 80% maturity. No. of panicles per plant had positive indirect effect via no. of grains per panicle (G=0.11 and P=1.43) at both levels. Its indirect effects via width of leaf blade (G=-0.004 and P=0.20), plant height (G=-0.1 and P=0.43) and panicle length (G=-0.04 and P=0.51) were found to be positive only at phenotypic level.

Panicle length was also observed to have a positive indirect effect through no. of grains per plant (G=0.005 and P=1.35) and 1000 grains weight (G=0.02 and P=0.27) at both levels. While, the indirect effects of panicle length via no. of panicles per plant (G=-0.05 and P=0.56) and plant height (G=-0.05 and P=0.51) were positive at phenotypic level. Plant height which had high positive direct effect on grain yield per plant was also observed to have a positive indirect effect via no. of grains per panicle (G=0.07 and P=0.90), panicle length (G=0.03 and P=0.55), no. of panicles per plant (G=0.22 and P=0.50) and 1000 grains weight (G=0.03 and P=0.11).

1000 grains weight had positive indirect effect via no. of grains per plant (G=0.01 and P=0.46) at genotypic and phenotypic level. While its indirect effects via panicle length (G=-0.01 and P=0.38) and plant height (G=-0.01 and P=0.15) were found to be positive at phenotypic level. A positive indirect effect of length of leaf blade was also observed via days to 80% maturity (G=0.03 and P=0.03), no. of grains per panicle (G=0.005 and P=0.07) and 100 grains weight (G=0.02 and P=0.07), panicle length (G=0.002 and P=0.04).

Negative direct effect on grain yield was also observed from days to 50% flowering (G=0.02 and P=-0.13) and days to 80% maturity (G=-0.003 and P=-0.13). Negative indirect effect of days to 50 % flowering was observed through length of leaf blade (G=0.07 and P=-0.07), plant height (G=-0.01 and P=-0.23), panicle length (G=0.02 and P=-0.22), days to 80% maturity (G=-0.15 and P=-0.12) and 1000 grains weight (G=-0.01 and P=-0.04). Negative indirect effects of days to 80% maturity was also recorded via length of leaf blade (G=-0.17 and P=-0.17), plant height (G=-0.02 and P=-0.03), panicle length (G=0.01 and P=-0.11), days to 50% flowering (G=0.03

and P=-0.12). The present findings were in conformity with that of Reddy *et al*., (2013), Lakshmi *et al*., (2017) [8] and Gayathri and Padmalatha (2017) and Hasan *et al*., (2010). As the characters days to 50% flowering and days to 80% maturity showed negative direct effect towards grain yield, selection for early crop duration would be beneficial for yield improvement.

Conclusion

Length of leaf blade, plant height, panicle length, no of panicle per plant, 1000 grains weight showed a positive significant correlation. Characters such as width of leaf blade, days to 50% flowering, days to 80% maturity, grain length breadth ratio and decorticated grain length width ratio showed negative correlation with yield per plant. Highest significant negative correlation was found between plant height and decorticated grain length width. So correlation studies revealed that selection based on length of leaf blade, plant height, panicle length, no of panicle per plant and 1000 grains weight would be effective for increasing grain yield. Where, width of leaf blade, days to 50% flowering, 80% maturity, grain length breadth ratio and decorticated grain length width ratio had a negative consequences on the yield.

The result of path coefficient analysis revealed that no of panicle per plant has the highest direct effect on grain yield per plant followed by 1000 grain weight, width of leaf blade, panicle length, days to 50% flowering and length of leaf blade. This result indicates that direct selection based on these characters can be effective for improving yield. On the other hand plant height, days to 80% maturity and decorticated grain length width ratio had a negative direct effect on grain yield, so direct selection based on these character will not be effective. Highest negative indirect effect was displayed by width of leaf blade via no of panicle per plant.

Table 1: Genotypic (G) and Phenotypic (P) correlation coefficient of grain yield per plant and 10 quantitative traits of 34 aromatic rice genotypes of North east region

Characters		Length of Leaf Blade (cm)	Width of Leaf Blade (cm)	Plant Height (cm)	Panicle Length (cm)	No. of Panicle per Plant	Days to 50% flowering	Days to 80% maturity	No. of Grains per Panicle	1000 Grains Weight (g)	Grain Yield per Plant (g)
Length of Leaf Blade (cm)	G	1	0.47**	0.53**	0.04	-0.09	-0.21	-0.21	0.05	0.08	0.26
	P	1	0.48**	0.50**	0.03	-0.09	-0.20	-0.20	0.04	0.07	0.20
Width of Leaf Blade (cm)	G		1	0.32	-0.29	-0.44**	-0.13	-0.09	-0.31	-0.06	-0.10
	P		1	0.30	-0.23	-0.42**	-0.12	-0.08	-0.29	-0.06	-0.07
Plant Height (cm)	G			1	0.47**	0.36*	-0.18	-0.08	0.51**	0.12	0.44**
	P			1	0.41*	0.34	-0.18	-0.09	0.49**	0.12	0.37*
Panicle Length (cm)	G				1	0.44**	-0.18	-0.10	0.83**	0.29	0.46**
	P				1	0.38*	-0.16	-0.08	0.74**	0.28	0.36*
No. of Panicle per Plant	G					1	0.04	0.05	0.79**	0.004	0.68**
	P					1	0.04	0.06	0.78**	-0.0001	0.55**
Days to 50% flowering	G						1	0.94**	0.003	-0.04	-0.05
	P						1	0.92**	0.003	-0.04	-0.038
Days to 80% maturity	G							1	0.01	-0.10	-0.9*
	P							1	0.02	-0.09	-0.08
No. of Grains per Panicle	G								1	0.21	0.76**
	P								1	0.25	0.63**
1000 Grains Weight (g)	G									1	0.48**
	P									1	0.39*
Grain Yield per Plant (g)	G										1
	P										1

*,** : Significant at 5% and 1% level of significance

Table 2: Genotypic (G) and phenotypic (P) path coefficient of grain yield with different characters.

Characters		Length of leaf blade (cm)	Width of leaf blade (cm)	Plant height (cm)	Panicle length (cm)	No. of panicle per plant	Days to 50% flowering	Days to 80% maturity	No. Of grains per panicle	1000 Grains weight(g)	Correlation with grain yield per plant (g)
Length of leaf blade (cm)	G	0.04	0.11	-0.05	0.002	-0.05	-0.01	0.03	0.005	0.02	0.26
	P	0.33	-0.23	0.63	0.04	-0.13	0.03	0.03	0.07	0.07	0.20
Width of leaf blade(cm)	G	0.24	0.02	-0.03	-0.01	-0.24	-0.008	0.01	-0.04	-0.01	-0.1
	P	0.16	-0.49	0.38	-0.31	-0.62	0.02	0.01	-0.53	-0.06	-0.07
Plant height (cm)	G	-0.11	0.02	0.07	0.03	0.19	-0.01	0.01	0.07	0.03	0.44**
	P	0.16	-0.15	1.26	0.55	0.50	0.02	0.01	0.90	0.11	0.37*
Panicle length (cm)	G	0.08	0.001	-0.05	-0.04	0.22	-0.01	0.01	0.1	0.08	0.46**
	P	0.01	0.11	0.51	1.35	0.56	0.02	0.01	1.35	0.27	0.36*
No. of panicle per plant	G	0.57	-0.004	-0.1	-0.04	0.03	0.002	-0.01	0.11	-0.00003	0.68**
	P	-0.03	0.20	0.43	0.51	1.48	-0.01	-0.01	1.43	0.00	0.55**
Days to 50% flowering	G	0.07	-0.01	-0.03	0.02	-0.01	0.02	-0.15	0.0004	-0.01	-0.05
	P	-0.07	0.06	-0.23	-0.22	0.06	-0.13	-0.12	0.01	-0.04	-0.038
Days to 80% maturity	G	-0.17	-0.01	-0.02	0.01	-0.007	0.03	0.06	0.002	-0.03	-0.9*
	P	-0.07	0.04	-0.11	-0.11	0.09	-0.12	-0.13	0.04	-0.09	-0.08
No. of grains per panicle	G	0.14	0.002	-0.07	-0.05	0.06	0.45	0.0002	-0.003	0.07	0.76**
	P	0.01	0.14	0.62	1.00	1.16	0.00	0.00	1.83	0.24	0.63**
1000 Grains weight (g)	G	0.31	0.003	-0.01	-0.01	0.02	-0.00005	-0.002	0.01	0.03	0.48**
	P	0.02	0.03	0.15	0.38	0.00	0.01	0.01	0.46	0.95	0.39*

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