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Studies on the Inter-relationship among Various Morpho-physiological Characters with Reference to Yield in Rice (*Oryza sativa* L.)

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A B S T R A C T

The cultivated rice (*Oryza sativa* L.) belongs to the family Poaceae, is the most important food for a large part of the world's population, especially in East, South and South East Asia. The present investigation involving forty-five genotypes was undertaken to assess correlation coefficient and path coefficient analysis. All the forty-five rice genotypes were evaluated in randomized complete block design with three replications during *Kharif* 2017. Observations were recorded for morphological traits *viz.*, days to 50% flowering, days to maturity, plant height, number of reproductive tillers per plant, panicle length, number of grains per panicle, biological yield per plant, harvest index, test weight and grain yield per plant. Analysis of variance revealed substantial amount of variability among the genotypes for all the characters under study, indicated wide spectrum of variability among the genotypes. Correlation and path analysis indicated that effective improvement in grain yield may be obtained by improving number of reproductive tillers per plant, number of grains per panicle, biological yield per plant, harvest index and test weight also can be considered as guidelines for further breeding work to develop desired plant type.

Introduction

Rice is a cereal crop belonging to genus *Oryza* of the subfamily *Pooideae* in the grass family *Gramineae* (*Poaceae*). The genus *Oryza* has twenty-two wild and two cultivated species *viz*., *Oryza sativa* and *Oryza glaberrima*. The germplasms found in Asia, America and Europe belong to *Oryza sativa*, while those in West Africa belong to *Oryza glaberrima*. *Oryza sativa* is a cultivated diploid species having 24 chromosomes of AA genome. The Asian rice complex comprises a perennial wild species, *O. rufipogon*, an annual wild species, *O. nivara* and the annual cultivated species *O. sativa* and its subspecies and weedy rice *O. spontanea*. Both *O. sativa* and *O. glaberrima* are believed to have evolved independently from different progenitors

viz., *O. nivara* and *O. barthii*, and got domesticated in South or South-East Asia and tropical West Africa, respectively. Wide spread dispersal of Asian cultigens led to the formation of three eco-geographic races: *indica*, *japonica* and *javanica* (Chang, 1976).

Rice grain quality is a major factor from consumer as well as marketing point of view. Grain aroma is the most desirable characteristic of high grain quality rice. The agronomic value of a variety depends on many characteristics (Huang *et al.,* 1991) and the most important characteristics are high yielding ability, resistance to diseases and pests, resistance to undesirable environmental factors and high quality of the products. But, the final aim is to increase the grain yield of rice (Swaminathan, 1999). Yield component characters show association among themselves and also with yield. Plant Breeder has to find significant correlations among yield and yield component traits, and effect of yield component traits on grain yield to predict the superior cross combinations and to select ideal plant type with increased yield. Since, a simple correlation analysis is not able to provide detailed and actual knowledge in the relation between dependent variable and predictor variables, path analysis was employed in the most of causation relationships. This method was developed by Wright (1921) as a statistical tool enables to study complex relationships between traits. It has been used to organize the effect and present the causal relationships between the predictor variables and response variables through a path diagram based on experimental results or on a priori grounds (Samonte *et al*., 1998). In the most studies involving path analysis, researchers considered entire characters as the first order variables to analyse their effects on a dependent variable such as yield. Therefore, the present investigation was undertaken to examine the relationships between heat tolerant traits and yield under late sowing conditions.

Materials and Methods

The present investigation was carried out during Kharif 2017 at Crop Research Centre, Chirori, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.), situated at an elevation of about 297 meters above mean sea level with 29.01˚’N latitude and 77.75˚E longitude, representing the North Western Plain Zone. The experimental material comprised of 45 diverse genotypes of rice (*Oryza sativa* L.) procured from various sources. The details of experimental material presented in Table 1. Each breeding line was grown in a plot comprising 3 rows of 3 meter long maintaining inter and intra row spacing of 20 x 15 cm. Twenty days old seedling was transplanted manually. Five plants from each plot in each replication were randomly selected for recording observations on ten characters viz., Days to 50 per cent flowering, Days to maturity, Plant height, Number of reproductive tillers per plant, Panicle length (cm), Number of grains per panicle, Biological yield per plant (g), Harvest index (%), Test weight 1000 Seed weight (g) and Grain yield per plant (g). Averages of data from the sampled plants of each plot with respect to different characters were used for various statistical analyses. The test of significance of differences between the genotypes means for various characters as per procedure out lined by Panse and Sukhatme (1969). Correlation was estimated as the association between various character pairs. The correlation at genotypic and phenotypic levels was estimated from the analysis of variance and covariance as suggested by Searle, (1961). The analysis of path coefficient was estimated by following the procedure as suggested by Sewall Wright, (1921) and as elaborated by Dewey and Lu, (1959).

Results and Discussion

Analysis of variance showed significant differences for all the characters included in the present study. The data is presented in Table 2. Phenotypic and genotypic correlations were worked out on yield and yield contributing characters in forty-five genotypes. In general, genotypic correlations were found to be higher than phenotypic correlations. With respect to genotypic correlation, Grain yield per plant was highly significant and positively correlated with biological yield per plant (0.674**), number of grains per panicle (0.448**), harvest index (0.359**), test weight (0.334**) and number of reproductive tillers per plant (0.235**) and significant and positive correlated with was not found for none of the character. Positive and non-significant correlation was observed with grain yield per plant for plant height (0.156), and panicle length (0.103). Negative and non-significant genotypic correlation was observed for days to maturity (-0.028) and days to 50% flowering (-0.021). With respect to phenotypic correlation, Grain yield per plant was highly significant and positive correlated with biological yield per plant (0.659**), number of grains per panicle (0.444**), harvest index (0.357**) and test weight (0.325**). Positive and significant correlation was observed with reproductive tillers per plant (0.217*). Positive and non-significant correlation of grain yield with plant height (0.148) and panicle length (0.080) were obtained. Negative and non-significant correlation was observed with grain yield per plant for days to maturity (-0.025) and days to 50% flowering (-0.021). Estimation of genotypic and phenotypic correlation coefficient for different character combinations are furnished in table 3 and 4.

Correlation gives only the relation between two variables whereas path coefficient analysis allows separation of the direct effect and their indirect effects through other attributes by partitioning the correlations (Wright, 1921). Partitioning of the correlation coefficient of the various characters under study was done with the help of the path coefficient analysis to express the direct and indirect effect of all these characters on grain yield. The results obtained at phenotypic level and genotypic levels are presented in table 5 and 6 respectively. Partitioning of the path coefficient in to direct and indirect effects was done at the genotypic level results is presented in table-4.5. A critical perusal of result in the table revealed that biological yield per plant had the maximum direct positive effect (1.078) followed by harvest index (0.863), days to 50% flowering (0.051) and panicle length (0.039). At genotypic level also the estimates of direct and indirect effects were generally similar to those observed at phenotypic level with little variation in magnitudes. The magnitudes of residual effects at both phenotypic and genotypic levels were estimated to be low. The residual effect was obtained (0.0924) and (0.1309) at genotypic and phenotypic level of respectively.

Selection which is the basis of every breeding programme operates only on variation which is genetic nature (Johanssen, 1909). A wide range of variation present in any crop always provides the better chances of selecting desired types (Vavilov, 1951). Grain yield in rice like any other crop is highly variable and complex character which is cumulative effect of many contributed traits which are interrelated. Therefore, direct selection for yield may not be very effective. Owing to the complexity of the trait, the significance of component approach in formulating a successful breeding programme aimed at yield improvement has been emphasized. It has also been suggested that there may not be specific genes, for yield as such, but for its various components that is available. Falconer, (1960)

while studying the genetic mechanism of association between two characters, however, suggested that the linear association may be due to complete linkage or pleiotropy. Correlation resulting from linkage or pleiotropy is the overall effect of the gene that affects both the characters (positive correlation) whereas increasing one decreases the other (negative correlation). In the present investigation, the correlation coefficients were estimated among ten characters at phenotypic and genotypic levels. The genotypic correlation coefficients were in general, observed to be higher than that of phenotypic correlation coefficients, indicating the existence of strong inherent association for the various characters studied as also observed earlier by Chakraborty et al., (2010), Nandan et al., (2010), Wattoo et al., (2010), Ambili and Radhakrishnan (2011), Vanisree et al., (2013), Rashid et al., (2014) and Sritama et al., (2015).

The phenotypic expression of the correlation was influenced by the environmental factors. Grain yield per plant exhibited highly significant stable and positive association with biological yield per plant, number of grains per panicle, harvest index and test weight at genotypic and phenotypic level. Whereas number of reproductive tiller per plant exhibit highly significant at phenotypic level and at genotypic level number of reproductive tillers per plant exhibit significant stable and positive association with grain yield per plant. Thus, it can be inferred that selection based on any one of these traits either alone or in combination, will result in identifying high yielding strains. In the present study number of reproductive tillers per plant, number of grains per panicle, biological yield per plant, harvest index and test weight with grain yield per plant exhibited a highly significant positive correlation, which might be due to linkage of genes determining these traits. These results are in general agreement with the finding of Chakraborty et al., (2010), Nandan et al., (2010), Wattoo et al., (2010), Ambili and Radhakrishnan (2011), Sinha and Mishra (2013), Vanisree et al., (2013), Sritama et al., (2015), Solomon and Wegary (2016) and Iqbal et al., (2018). Selection for these traits could definitely be yielded towards productivity as they exhibited correlated response with grain yield. Though even, the correlation coefficients are quite helpful in determining the components of complex traits like yield, however, an exact picture of the relative importance of direct and indirect influence of each component character is not provided by such studies. Path coefficient analysis (Wright, 1921; Dewey and Lu, 1959) under such circumstances plays an important role in partitioning of the correlation coefficients into direct and indirect effects of a set of independent variables on the dependent variable and determines the component characters on which selection can be based for improvement in yield.

The phenotypic and genotypic path coefficient revealed high direct contribution of number of reproductive tillers per plant, number of grains per panicle, biological yield per plant, harvest index and test weight towards grain yield per plant. The direct contribution of number of reproductive tillers per plant, number of grains per panicle, biological yield per plant, harvest index and test weight with grain yield per plant observed in this study is also in confirmation with the findings of Nandan et al., (2010), Babu et al., (2012), Rai et al., (2014), Islam et al., (2015), Sarawgi et al., (2016), Kalyan et al., (2017) and Kishore et al., (2018). High indirect positive contribution of harvest index mainly via number of grains per panicle was responsible for their positive association with grain yield per plant. The contribution of residual effects that influenced grain yield was very low at both genotypic and phenotypic levels indicating that the characters included in the present investigation were sufficient enough to account for the variability in the dependent trait i.e. grain yield per plant.

Table.1 List of Genotypes used in research programme

S.No.	Germplasm	Source
1.	Laldhan	J&K/IARI, New Delhi
2.	Bas 867	US Patented Line
3.	Basmati 6141	PU/DRR, Hyderabad
4.	Basmati 5874	PU/DRR, Hyderabad
5.	Basmati 138	PU/DRR, Hyderabad
6.	Basmati 217	PU/DRR, Hyderabad
7.	PDKV Shriram	MH/DRR, Hyderabad
8.	Kh. Sakani	DRR, Hyderabad
9.	Lua Nhe Den	Thailand/DRR, Hyderabad
10.	Pusa Basmati 1121	IARI/DRR, Hyderabad
11.	HBC 46	HA/DRR, Hyderabad
12.	Sathi	Pantnagar
13.	Kasturi	DRR, Hyderabad
14.	Basmati 410	PU/DRR, Hyderabad
15.	Adam Chini B	UP/DRR, Hyderabad
16.	Taroari Basmati	-
17.	IR62873-238-2-3	IARI/DRR, Hyderabad
18.	IR62873-227-1-16	IARI/DRR, Hyderabad
19.	CO ACC 167(T167)	Coimbatore
20.	IR 841-85-1-1-2	IARI/DRR, Hyderabad
21.	Binir hen	Phillipines/DRR, Hyderabad
22.	IET 22787 (RP4594-121-148-24-11)	DRR, Hyderabad
23.	Hasan Serai	Iran/DRR, Hyderabad
24.	Tarunbhog	RPR/DRR, Hyderabad
25.	Hung-mi-hsiang-ma-tsan	Vietnam/DRR, Hyderabad
26.	Chimbalate Basmati	PU/DRR, Hyderabad
27.	IR 75428-6-3	IARI/DRR, Hyderabad
28.	Vasumati	DRR, Hyderabad
29.	JGL 1798 (Jagithyal Sannalu)	JGL/DRR, Hyderabad
30.	Haryana Basmati-1	HA/NAGINA
31.	Basmati 5836	PU/DRR, Hyderabad
32.	Mahisugandha	Kota/DRR, Hyderabad
33.	Basmati Type-3	PU/DRR, Hyderabad
34.	Pusa Basmati-1	IARI/DRR, Hyderabad
35.	Karnal Local	PU/DRR, Hyderabad
36.	Bindli	Nagina
37.	IET 18033 (RP3644-9-5-3-2)	DRR, Hyderabad
38	Basmati Bahar	PU/DRR, Hyderabad
39.	Domsaih	Iran/DRR, Hyderabad
40.	UPR 2828-7-2-1	Pantnagar
41.	Yamini (Basmati CSR-30)	CSSRI/DRR, Hyderabad
42.	Ranbir Basmati	J&K/IARI, New Delhi
43.	Longku Labat	Indonesia/DRR, Hyderabad
44.	Kamini Joha	AS/DRR, Hyderabad
45.	UPR 3565-10-1-1	Pantnagar

Table.2 Analysis of variance (ANOVA) for ten characters of forty-five genotypes in rice (*Oryza sativa* L.)

Source of variations	d. f.	Days to 50% flowering	Days to maturity	Plant height (cm)	Reproductive Tillers per Plant	Panicle length (cm)	Grains per Panicle	Biological yield per plant (g)	Harvest index (%)	Test weight in (gm)	Grain yield per plant
Replication	2	0.140	0.563	27.454	0.174	0.059	98.680	12.946	0.386	0.095	0.791
Treatments	44	335.575**	449.958**	1531.894**	3.091**	14.338**	1598.267**	477.238**	63.811**	16.613**	39.518**
Error	88	0.519	0.555	28.952	0.194	1.278	66.445	17.194	2.532	0.360	0.899

** Significant at 1% level

Table.3 Estimates of genotypic (G) correlation coefficients among ten characters in rice (*Oryza sativa* L.)

Characters		Days to 50% flowering	Days to maturity	Plant height (cm)	Reproductive Tillers per Plant	Panicle length (cm)	Grains per Panicle	Biological yield per plant (g)	Harvest index (%)	Test weight in (gm)	Grain yield per plant
Days to 50% flowering	G	1.000	0.818**	0.597**	-0.196*	-0.001	-0.030	0.233**	-0.323**	0.026	-0.021
Days to maturity	G		1.000	0.617**	-0.235**	-0.027	-0.064	0.247**	-0.323**	0.139	-0.028
Plant height (cm)	G			1.000	0.056	0.201*	-0.057	0.484**	-0.415**	-0.103	0.156
Reproductive tillers per plant	G				1.000	0.181*	-0.351**	0.196*	0.039	-0.019	0.235**
Panicle length (cm)	G					1.000	-0.093	0.172*	-0.135	0.011	0.103
Grains per panicle	G						1.000	0.118	0.405**	-0.230**	0.448**
Biological yield per plant (g)	G							1.000	-0.439**	0.163	0.674**
Harvest index (%)	G								1.000	0.225**	0.359**
Test weight (gm)	G									1.000	0.334**
Grain yield per plant	G										1.000

Table.4 Estimates of phenotypic (P) correlation coefficients among ten characters in rice (*Oryza sativa* L.)

Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	Reproductive Tillers per Plant	Panicle length (cm)	Grains per Panicle	Biological yield per plant (g)	Harvest index (%)	Test weight in (gm)	Grain yield per plant
Days to 50% flowering	1.000	0.816**	0.575**	-0.181*	0.001	-0.029	0.222**	-0.306**	0.027	-0.021
Days to maturity		1.000	0.594**	-0.217*	-0.031	-0.058	0.237**	-0.305**	0.135	-0.025
Plant height (cm)			1.000	0.058	0.185*	-0.056	0.445**	-0.376**	-0.093	0.148
Reproductive tillers per plant				1.000	0.149	-0.375**	0.159	0.057	-0.029	0.217*
Panicle length (cm)					1.000	-0.102	0.132	-0.114	0.017	0.080
Grains per panicle						1.000	0.144	0.360**	-0.226**	0.444**
Biological yield per plant (g)							1.000	-0.454**	0.158	0.659**
Harvest index (%)								1.000	0.209*	0.357**
Test weight (gm)									1.000	0.325**
Grain yield per plant										1.000

Table.5 Estimates of path coefficient showing direct and indirect effects of component characters on seed yield at genotypic level in rice (*Oryza sativa* L.)

Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	Reproductive Tillers per Plant	Panicle length (cm)	Grains per Panicle	Biological yield per plant (g)	Harvest index (%)	Test weight in (gm)	Correlation with seed yield (g)
Days to 50% flowering	0.051	0.042	0.030	-0.010	0.001	-0.001	0.012	-0.016	0.001	-0.021
Days to maturity	-0.041	-0.050	-0.031	0.012	0.001	0.003	-0.012	0.016	-0.007	-0.028
Plant height (cm)	-0.012	-0.012	-0.020	-0.001	-0.004	0.001	-0.009	0.008	0.002	0.156
Reproductive tillers per plant	0.007	0.008	-0.002	-0.037	-0.006	0.013	-0.007	-0.001	0.001	0.235**
Panicle length (cm)	0.001	-0.001	0.008	0.007	0.039	-0.003	0.006	-0.005	0.001	0.103
Grains per panicle	0.001	0.003	0.003	0.018	0.004	-0.052	-0.006	-0.021	0.012	0.448**
Biological yield per plant (g)	0.252	0.267	0.522	0.211	0.185	0.127	1.078	-0.474	0.176	0.674**
Harvest index (%)	-0.279	-0.279	-0.359	0.034	-0.116	0.349	-0.379	0.863	0.194	0.359**
Test weight (gm)	-0.001	-0.006	0.004	0.001	0.001	0.010	-0.007	-0.010	-0.045	0.334**

Residual Effect = 0.0924

Table.6 Estimates of path coefficient showing direct and indirect effects of component characters on seed yield at phenotypic level in rice (*Oryza sativa* L.)

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Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	Reproductive Tillers per Plant	Panicle length (cm)	Grains per Panicle	Biological yield per plant (g)	Harvest index (%)	Test weight (g)	Correlation with seed yield (g)
Days to 50% flowering	0.048	0.039	0.027	-0.008	0.001	-0.001	0.010	-0.014	0.001	-0.021
Days to maturity	-0.041	-0.050	-0.030	0.011	0.001	0.002	-0.012	0.015	-0.006	-0.025
Plant height (cm)	-0.005	-0.005	-0.009	-0.001	-0.001	0.001	-0.004	0.003	0.001	0.148
Reproductive tillers per plant	0.004	0.004	-0.001	-0.022	-0.003	0.008	-0.003	-0.001	0.001	0.217*
Panicle length (cm)	0.001	-0.001	0.007	0.005	0.038	-0.003	0.005	-0.004	0.001	0.080
Grains per panicle	0.001	0.001	0.001	0.012	0.003	-0.032	-0.004	-0.011	0.007	0.444**
Biological yield per plant (g)	0.236	0.252	0.473	0.170	0.140	0.153	1.063	-0.483	0.168	0.659**
Harvest index (%)	-0.263	-0.262	-0.323	0.049	-0.098	0.310	-0.391	0.860	0.180	0.357**
Test weight (gm)	-0.001	-0.003	0.002	0.001	-0.001	0.006	-0.004	-0.005	-0.027	0.325**

Residual Effect = 0.1309

In conclusions, correlation coefficient studies revealed the higher genotypic correlation values than the corresponding phenotypic correlation values. Grain yield revealed significant and strong positive correlation with number of grains per panicle, biological yield per plant, harvest index and test weight and at genotypic and phenotypic levels. The present study of correlation indicated that higher grain yield can be obtained by increasing number of grains per panicle, biological yield per plant, harvest index and test weight. Path coefficient analysis revealed that the traits viz., number of reproductive tillers per plant, number of grains per panicle, biological yield per plant, harvest index and test weight had positive and direct effect on grain yield per plant. The great influence of these traits reflected their importance for yield determination.

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