

INTERRELATIONSHIP AND CAUSE-EFFECT ANALYSIS OF BASMATI RICE (*ORYZA SATIVA* L.) GENOTYPES

UMESH*, H. K. JAISWAL, SHOWKAT A. WAZA, T. SRAVAN AND MUKH RAM

Department of Genetics and Plant Breeding,

Institute of Agricultural Sciences, Banaras Hindu University, Varanasi - 221 005, Uttar Pradesh, INDIA

e-mail: umesh7155@gmail.com

INTRODUCTION

Rice is the staple food for two thirds of the Indian population. It contributes 43 per cent of caloric requirement and 20-25% of agricultural income. The area grown under rice (45.5 million hectares) in India is the largest among all the rice growing countries and it ranks second in production after China (MOA & FCI, 2011). Keeping in mind the future demand of rice as a food for mankind, there is a continuous need to evolve new varieties, which should exceed the existing varieties in yield. The knowledge of patterns of genetic variation of a crop species in any given region or country is very important for planning future germplasm collection missions and for efficient utilization of collected germplasm in crop improvement programmes (Nagi *et al.*, 2013). The basic objective of most of the crop improvement programs is to realize a marked improvement in crop yield. But yield is a complex character which is controlled by association of various characters. Before placing strong emphasis on breeding for yield improvement, the knowledge on the association between yield and yield attributes will enable the breeder to improve this trait. The correlation coefficient may also help to identify characters that have little or no importance in the selection programme (Singh *et al.*, 2013). The existence of correlation may be attributed to the presence of linkage or pleiotropic effect of genes or physiological and development relationship or environmental effect or in combination of all (Oad *et al.*, 2002). The information on association of yield attributes and their direct and indirect effects on grain yield are of paramount significance. Hence, path analysis is of much importance in any plant breeding program. Path analysis permits the partitioning of the correlation coefficient into its components, one component being the path coefficient that measures the direct effect of a predictor or variable upon its response variable; the second component being the indirect effect (s) of a predictor variable on the response variable through another predictor variable (Dewey and Lu, 1959). In agriculture, path analysis has been used by plant breeders to assist in identifying traits that are useful as selection criteria to improve crop yield (Dhanwani *et al.*, 2013; Surek and Beser, 2003). The present study was conducted to find out the genetic association among different plant traits, direct and indirect contribution of these parameters towards grain yield and to identify better combinations as selection criteria for developing high yielding rice genotypes.

MATERIALS AND METHODS

The present study entitled "Interrelationship and cause-effect analysis in basmati rice (*Oryza sativa* L)" was carried out during *kharif* 2013 at Agricultural Sciences research farm, Banaras Hindu University, Varanasi, Uttar Pradesh. The experiment was laid out in a Randomized Block Design (RBD) with three replications. The experimental material was planted in three blocks. Each block consisted of twenty four genotypes randomized and replicated within each block. Twenty five days

ABSTRACT

A study of interrelationship and cause-effect analysis of grain yield and its component traits was carried out using twenty four rice genotypes. Grain yield per plant had significant positive correlation with spikelets per panicle, effective tillers per plant, flag leaf length, spikelet fertility, main panicle length and it shows negative significant association with plant height. Path analysis revealed that the maximum direct effect for yield was observed for days to 50% flowering followed by effective tillers per plant and spikelets per panicle. Days to 50% flowering and effective tillers per plant had high significant overall effect on yield. There is not a single quality trait significantly contributing to the yield although some traits had positive indirect effect. The overall effect of days to 50% flowering on yield per plant is more than the direct effect. It is due to positive indirect effects via days to maturity, effective tillers per plant and spikelet per panicle. Thus these are important plant traits which should be considered when any breeding program for higher yield in rice is to be planned.

KEY WORDS

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*Corresponding author

old seedlings were transplanted 20 cm apart between rows and 15 cm within the row. All necessary precautions were taken to maintain uniform plant population in each treatment per replication. All the recommended package of practices was followed along with necessary prophylactic plant protection measures to raise a good crop. Observations were recorded and the data was subjected to statistical analysis. Statistical analyses were done following Singh and Chaudhary (1985) for correlation coefficient and Dewey and Lu (1959) for path analysis.

RESULTS AND DISCUSSION

Correlation coefficients

The result of simple linear correlation coefficients between all pairs of trait are shown in Tables 1, 2, 3 and 4 at genotypic and phenotypic level for yield and quality trait. Selection based on the detailed knowledge of magnitude and direction of association between yield and its attributes is very important in identifying the key characters, which can be exploited for crop improvement through suitable breeding programme.

Table 1: Estimation of genotypic correlation coefficient among yield and yield trait

	DTF50%	DTM	FLL	FLW	PH	MPL	ET/P	SPP	SPF	100SW	GYP
DTF50%	1.0000	1.0078	0.0451	-0.1434	-0.0425	-0.2004	0.1494	0.1383	-0.2839*	0.1559	0.0295
DTM		1.0000	0.0057	-0.1316	-0.0340	-0.2222	0.1594	0.1438	-0.2979*	0.1825	-0.0030
FLL			1.0000	0.3674**	-0.2214	0.0682	0.1657	0.4407**	0.2624*	-0.1665	0.5110**
FLW				1.0000	-0.4817**	-0.3261**	0.1449	0.4274**	-0.3363**	0.2579	-0.0431
PH					1.0000	0.2897*	-0.1173	-0.5827**	0.2734*	-0.4383**	-0.2820
MPL						1.0000	0.3653**	-0.0002	0.4215**	-0.2721	0.3666**
ET/P							1.0000	0.3399**	0.2006	-0.0900	0.5119**
SPP								1.0000	0.2583*	-0.0626	0.5650**
SPF									1.0000	-0.4122	0.5881**
100SW										1.0000	-0.1751
GYP											1.0000

** and * indicate significant at $p = 0.1$ and 0.05 , respectively; Where: DTF50% = Days to 50 % flowering, DTM = Days to maturity, FLL = Flag leaf length, FLW = Flag leaf width, PH = Plant height, MPL = Main panicle length, ET/P = Effective tiller per plant, SPP = Spikelet per panicle, SPF = Spikelet fertility, 100SW = 100-seed weight, GY/P = Grain yield per plant

Table 2: Estimation of phenotypic correlation coefficient among yield and yield trait

	DTF50%	DTM	FLL	FLW	PH	MPL	ET/P	SPP	SPF	100SW	GYP
DTF50%	1.0000	0.9686**	0.0358	-0.0734	-0.0342	-0.1373	0.1314	0.1289	-0.1390	0.1491	0.0175
DTM		1.0000	-0.0077	-0.0633	-0.0327	-0.1645	0.1277	0.1337	-0.0879	0.1694	0.0202
FLL			1.0000	0.1998	-0.2104	0.0957	0.1548	0.3969	0.1187	-0.1564	0.4651**
FLW				1.0000	-0.3054**	-0.2181	0.0760	0.2761*	-0.1061	0.1621	-0.0332
PH					1.0000	0.1843	-0.1143	-0.5770	0.1351	-0.4295**	-0.2776*
MPL						1.0000	0.2500*	0.0237	-0.0302	-0.1921	0.2670*
ET/P							1.0000	0.3261	0.1336	-0.0955	0.4989**
SPP								1.0000	0.1314	-0.0606	0.5344**
SPF									1.0000	-0.2104	0.4008**
100SW										1.0000	-0.1713
GYP											1.0000

* and ** indicate significant at $p = 0.1$ and 0.05 , respectively

Table 3: Estimation of genotypic correlation coefficient among quality traits

	KL	KB	KLAC	ASV	GT	AC
KL	1.000	0.4042**	0.7650**	0.3581**	-0.3320**	0.4080**
KB		1.000	0.6621**	0.3524**	-0.3302**	0.1235
KLAC			1.000	0.6514**	-0.6209**	0.4051**
ASV				1.000	-0.9448**	0.4844**
GT					1.000	-0.5043**
AC						1.000

* and ** indicate significant at $p = 0.1$ and 0.05 , respectively

Table 4: Estimation of phenotypic correlation coefficient among quality traits

	KL	KB	KLAC	ASV	GT	AC
KL	1.000	0.3659**	0.7555**	0.3530**	-0.3105**	0.3977**
KB		1.000	0.6064**	0.3210**	-0.3001*	0.1174
KLAC			1.000	0.6433**	-0.5941**	0.3987**
ASV				1.000	-0.9210**	0.4814**
GT					1.000	-0.4983**
AC						1.000

* and ** indicate significant at $p = 0.1$ and 0.05 , respectively;

Where, KL = Kernel length, KB = Kernel Breadth, KLAC = Kernel length after cooking, ASV = Alkali spread value, GT = Gelatinization temperature, AC = Amylose content.

Table 5: Direct (diagonal) and indirect effect of component traits contributing to yield in basmati genotype at phenotypic level.

Character	DTF50%	DTM	FLL	FLW	PH	MPL	ET/P	SPP	SPF	100SW	KL	KB	KLAC	ASV	GT	AC	GYP	R value
DTF50%	0.408	-0.445	0.010	0.005	0.002	0.000	0.041	0.040	-0.032	-0.048	-0.008	-0.018	0.135	-0.173	0.087	0.012	0.017	0.0071
DTM	0.395	-0.459	-0.002	0.004	0.002	0.000	0.040	0.041	-0.020	-0.055	-0.009	-0.024	0.129	-0.156	0.081	0.012	-0.020	0.0093
FLL	0.015	0.004	0.287	-0.014	0.012	0.000	0.049	0.122	0.028	0.050	-0.014	0.008	-0.015	-0.185	0.131	-0.012	0.465	0.1335
FLW	-0.030	0.029	0.057	-0.070	0.017	-0.001	0.024	0.085	-0.025	-0.052	0.006	-0.006	0.008	-0.200	0.152	-0.028	-0.033	0.0023
PH	-0.014	0.015	-0.060	0.021	-0.057	0.000	-0.036	0.178	0.031	0.138	-0.023	0.021	-0.226	0.323	-0.287	0.052	-0.278	0.0157
MPL	-0.056	0.075	0.027	0.015	-0.010	0.002	0.078	0.007	-0.007	0.062	0.004	0.015	-0.001	0.031	0.014	0.009	0.267	0.0006
ET/P	0.054	-0.059	0.044	-0.005	0.006	0.001	0.314	0.100	0.031	0.031	-0.026	0.024	-0.027	-0.005	0.001	0.014	0.499	0.1565
SPP	0.053	-0.061	0.114	-0.019	0.033	0.000	0.102	0.308	0.031	0.019	-0.037	-0.016	0.057	-0.257	0.218	-0.008	0.534	0.1644
SPF	-0.057	0.040	0.034	0.007	-0.008	0.000	0.042	0.040	0.232	0.068	-0.016	-0.008	-0.041	0.102	-0.050	0.015	0.401	0.0931
100SW	0.061	-0.078	-0.045	-0.011	0.024	0.000	-0.030	-0.019	-0.049	-0.322	0.073	-0.097	0.431	-0.256	0.183	-0.037	-0.171	0.0551
KL	-0.029	0.038	-0.037	-0.004	0.012	0.000	-0.074	-0.106	-0.035	-0.216	0.108	-0.057	0.460	-0.205	0.140	-0.045	-0.051	-0.0055
KB	0.046	-0.070	-0.014	-0.003	0.008	0.000	-0.047	0.031	0.012	-0.199	0.039	-0.157	0.369	-0.187	0.135	-0.013	-0.050	0.0078
KLAC	0.090	-0.097	-0.007	-0.001	0.021	0.000	-0.014	0.029	-0.016	-0.228	0.082	-0.095	0.609	-0.374	0.268	-0.045	0.222	0.1351
ASV	0.121	-0.123	0.092	-0.024	0.031	0.000	0.003	0.136	-0.041	-0.142	0.038	-0.050	0.392	-0.581	0.415	-0.054	0.212	-0.1235
GT	-0.079	0.083	-0.084	0.023	-0.036	0.000	-0.001	-0.149	0.026	0.130	-0.034	0.047	-0.362	0.535	-0.451	0.056	-0.293	0.1323
AC	-0.044	0.049	0.031	-0.018	0.026	0.000	-0.039	0.023	-0.030	-0.104	0.043	-0.018	0.243	-0.280	0.225	-0.113	-0.007	0.0008

R Square = 0.8637; Residual Effect = 0.3692

Table 6: Direct (diagonal) and indirect effect of component traits contributing to yield in basmati genotype at genotypic level.

Character	DTF50%	DTM	FLL	FLW	PH	MPL	ET/P	SPP	SPF	100SW	KL	KB	KLAC	ASV	GT	AC	GYP	R value
DTF50%	0.065	0.093	0.008	-0.057	0.023	-0.070	-0.007	-0.036	-0.188	-0.006	0.034	-0.061	0.281	-0.033	-0.041	0.026	0.030	0.0019
DTM	0.065	0.093	0.001	-0.053	0.018	-0.078	-0.008	-0.038	-0.198	-0.008	0.048	-0.086	0.279	-0.031	-0.036	0.028	-0.003	-0.0003
FLL	0.003	0.001	0.175	0.147	0.120	0.024	-0.008	-0.115	0.174	0.007	0.077	0.041	-0.017	-0.036	-0.057	-0.024	0.511	0.0892
FLW	-0.009	-0.012	0.064	0.399	0.262	-0.115	-0.007	-0.112	-0.223	-0.011	-0.039	-0.029	0.031	-0.055	-0.106	-0.081	-0.043	-0.0172
PH	-0.003	-0.003	-0.039	-0.192	-0.544	0.102	0.006	0.152	0.182	0.018	0.120	0.090	-0.460	0.060	0.126	0.103	-0.282	0.1533
MPL	-0.013	-0.021	0.012	-0.130	-0.158	0.352	-0.017	0.000	0.280	0.011	-0.052	0.078	-0.013	0.009	0.002	0.028	0.367	0.1289
ET/P	0.010	0.015	0.029	0.058	0.064	0.128	-0.048	-0.089	0.133	0.004	0.139	0.110	-0.065	-0.002	-0.002	0.028	0.512	-0.0244
SPP	0.009	0.013	0.077	0.171	0.317	0.000	-0.016	-0.261	0.171	0.003	0.201	-0.066	0.108	-0.048	-0.097	-0.017	0.565	-0.1477
SPF	-0.018	-0.028	0.046	-0.134	-0.149	0.148	-0.010	-0.068	0.664	0.017	0.190	-0.037	-0.167	0.034	0.045	0.054	0.588	0.3905
100SW	0.010	0.017	-0.029	0.103	0.238	-0.096	0.004	0.016	-0.274	-0.042	-0.387	-0.424	0.890	-0.048	-0.083	-0.073	-0.175	0.0073
KL	-0.004	-0.008	-0.024	0.028	0.117	0.033	0.012	0.094	-0.225	-0.029	-0.559	-0.247	0.939	-0.038	-0.064	-0.090	-0.065	0.0362
KB	0.006	0.013	-0.012	0.019	0.080	-0.045	0.009	-0.028	0.040	-0.029	-0.226	-0.610	0.813	-0.038	-0.063	-0.027	-0.098	0.0597
KLAC	0.015	0.021	-0.002	0.010	0.204	-0.004	0.003	-0.023	-0.090	-0.030	-0.428	-0.404	1.228	-0.070	-0.119	-0.090	0.220	0.2702
ASV	0.020	0.027	0.058	0.207	0.305	-0.029	-0.001	-0.118	-0.212	-0.019	-0.200	-0.215	0.800	-0.107	-0.181	-0.107	0.227	-0.0243
GT	-0.014	-0.017	-0.052	-0.220	-0.356	0.004	0.000	0.132	0.156	0.018	0.186	0.201	-0.762	0.101	0.192	0.111	-0.321	-0.0616
AC	-0.008	-0.012	0.019	0.146	0.255	-0.044	0.006	-0.020	-0.162	-0.014	-0.228	-0.075	0.497	-0.052	-0.097	-0.221	-0.009	0.0021

R Square = 0.8637; Residual Effect = 0.3692

Phenotypic and genotypic correlations between yield and yield components viz., days to 50 per cent flowering, plant height, flag leaf length, flag leaf width, panicle length, number of panicles per plant, number of spikelets per panicle and 100 grains weight were computed separately for rice genotypes. The results are presented in Table 1. The result revealed that the estimates of genotypic coefficients were higher than phenotypic correlation coefficients for most of the characters under study which indicated strong inherent association between the characters which might be due to masking or modifying effects of environment. Days to 50 per cent flowering registered strong and positive significant correlation with number of spikelets per panicle, days to maturity and grain yield per hill, while negative association with number of tillers per hill and number of panicles per hill. This corroborates with the findings of Reddy *et al.* (2008), Babu *et al.* (2006) and Saravanan and Sabesan (2009) for days to maturity. The association expressed by plant height with flag leaf length, flag leaf width, number of spikelets per panicle and panicle length was significant and positive at both levels (Table 1 and 2). It suggests that, priority should be given to these traits while making selection for yield improvement. A similar result for plant height association with panicle length was reported by Eradasappa *et al.* (2007) and Jayasudha and Sharma (2010). The correlation of number of spikelets per panicle exhibited positive and significant association with panicle length and biological yield per hill. Similar results were reported by Seyoum *et al.* (2012). Plant height, number of spikelets per panicle, panicle length and flag leaf length had strong and positive significant association with grain yield per plant. It indicated that grain yield can be increased whenever there is an increase in characters that showed positive and significant association with grain yield. Hence, these characters can be considered as criteria for selection for higher yield as these were mutually and directly associated with yield. Chakraborty and Chakraborty (2010), Hossain and Hoque (2003), Singh *et al.* (2002) and Biswas *et al.* (2000) reported positive significant association of panicle length with grain yield per plant. The positive significant of number of spikelets per panicle with yield was supported by Mustafa and Elsheikh (2007). Grain yield per plant recorded significant and negative correlation with plant height, whereas it showed non significant and negative correlation with 100 seed weight and flag leaf width both at genotypic and phenotypic levels. Similar negative correlation was also reported by Kole *et al.* (2008). The genetic reasons for this type of negative association may be linkage or pleiotropy. According to Ne Wall and Eberhart (1961) when two characters show negative phenotypic and genotypic correlation it would be difficult to exercise simultaneous selection for these characters in the development of a variety. Hence, under such situations, judicious selection program might be formulated for simultaneous improvement of such important developmental and component characters. Among quality traits amylose content showed significant positive association with kernel length, kernel length after cooking, alkali spreading value and showed significant negative association with gelatinization temperature at both genotypic and phenotypic levels (Table 3 and 4). Kernel length is such a quality trait that decides market price of rice so it was important to know its interaction with other quality traits. Kernel

length shows significant positive correlation with kernel breadth, kernel length after cooking, alkali spreading value, amylose content and showed significant negative association with gelatinization temperature at both levels (Table 3 & 4).

Path coefficients

Simple correlation does not provide the true contribution of the characters towards the yield; the genotypic correlations were partitioned into direct and indirect effects through path coefficient analysis. It allows separating the direct effect and their indirect effects through other attributes by apportioning the correlations (Wright, 1921) for better interpretation of cause and effect relationship. Maximum direct effect for yield was observed for days to 50% flowering followed by effective tillers per plant and spikelets per panicle. Days to 50% flowering and effective tillers per plant had high significant overall effect on yield. Spikelet fertility had significant overall effect on yield. However, there is no single quality trait significantly contributing to the yield although some traits had positive indirect effect. Positive direct effects of the traits on grain yield indicated their importance in determining this complex character and therefore, should be kept in mind while practicing selection aimed at the improvement of grain yield. These findings were also corroborated by Kole *et al.*, (2008) and Sarawgi *et al.* (2000). The indirect expressions of panicle length on grain yield through all the fore-said characters were negative except number of panicles per hill which was positive. The highest indirect expression of number of spikelets per panicle on grain yield per plant through plant height, flag leaf length had a positive effect. Based on the studies on path-coefficient analysis, it may be concluded that, Direct and indirect effects of component traits contributed to yield at phenotypic and genotypic levels (Tables 5 & 6). As residual effect was low at both phenotypic and genotypic levels it infers that maximum important characters were taken for analysis.

The overall effect of days to 50 per cent flowering on yield per plant is more than the direct effect due to positive indirect effects via days to maturity, effective tillers per plant and spikelet per panicle. At genotypic level, along with spikelet fertility, flag leaf length, flag leaf width, main panicle length, kernel length after cooking and gelatinization temperature also show significant overall effect on yield. Hence, utmost importance should be given to these characters during selection for single plant yield improvement. Similar results had been reported by Ekka *et al.* (2011). Selection of plants on the basis of these traits would certainly lead to improvement in grain yield.

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