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Character Association Studies for Grain Yield and Related Traits in Rice Cultivars of North Bank Plain Zone of Assam

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Abstract

The phenotypic characterization of traits associated directly or indirectly with grain yield is a pre requisite for plant breeding program. With an aim to improve the existing varieties with high yielding potentials this experiment was carried out to study the association of twelve yield attributing characters with grain yield and path analysis in 64 rice genotypes of North Bank Plain Zone of Assam. Character association studies indicated that direct selection of 100 grain weight, grain length, grain breadth, biological yield and harvest index, would bring about improvement in grain yield. Path analysis at genotypic and phenotypic level showed filled grains per panicle, effective tillers per plant, 100 grain weight, panicle length, days to maturity and biological yield had positive and high direct effect on grain yield respectively. Hence selection of these traits will be effective for future breeding programs that will simultaneously contribute in improvement of yield.

***Key words*: Correlation coefficient, Path analysis, Rice, Yield, Yield attributing traits

Rice is the most important food crop in India which serves as the primary source of energy for more than 60% of the population [1]. India is the second largest producer of rice in the world. In India, rice is grown in an area of 44 m ha, with a total production of 116 million tones and productivity of 2700 kg ha^{-1} [2]. Among the rice growing regions of the country, the North Eastern region including Assam is the home to diverse traditional rice genotypes under both cultivable and wild state [3]. The North Bank Plain Zone (NBPZ) is an important rice growing region of Assam which represents a wide range of cultivated rice types under rice growing environments [4]. The phenotypic dissection of traits, directly or indirectly associated with grain yield is a pre-requisite for an effective plant breeding program targeting improvement of grain yield [5]. This is done by character association studies based on correlation and path analysis. It serves as an important tool for researchers in framing suitable criteria for obtaining improvement in yield [6]. A detail study of the character association in a set of germplasm can provide the basis for selection which in turn brings about improvement on performance in terms of grain yield. The traditional germplasm of the NBPZ have not been so far studied exclusively. Therefore, in order to arrive at a baseline understanding of the grain yield and its association with the component traits, character association study was conducted in the collected set of germplasm of NBPZ of Assam.

MATERIALS AND METHODS

A set of 64 rice cultivars comprising from farmers' fields of North Bank Plain Zone of Assam representing the entire administrative block formed the materials for the investigation. The investigation was conducted at the experimental field of Biswanath College of Agriculture, Biswanath Chariali, represented by the latitude of 26°15′N, 27°45′N, the longitude of 92°42′ E, 95°30′ E and altitude of 104 m MSL. The crop was raised during the Kharif season of 2021. The experiment was conducted following a Completely Randomized Design (CRD) with two replications. As per standard guidelines from IRRI, the germinated rice seedlings of all cultivars were first grown in well protected nursery beds and after 21 days, they were transplanted to well puddle experimental field. Each plot consisted of five rows of six meters in length with spacing 20 cm between plants and 25 cm between rows. Single seedling was transplanted per hill and the crop was raised following the recommended package of practice. Observations on 13 traits i.e. days to flowering (DF), days to maturity (DM), plant height (PH), panicle length (PL), effective tillers per plant (EF), filled grains per panicle (FG/P), 100 grain weight (GW), grain yield (GY), grain length (GL), grain width (GW), length: breadth ratio (L:B), biological yield (BY) and harvest index (HI) were recorded as per the standard evaluation system for rice by IRRI

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[7]. The estimation of correlation coefficient at genetic and phenotypic level for the 13 traits was done as described by Singh and Choudhary [8]. The direct and indirect influence of traits on yield was calculated as per the procedure of Path coefficient analysis proposed by Wright [9] and using the statistical software INDOSTAT.

RESULTS AND DISCUSSION

The analysis of variance for 13 traits revealed highly significant differences among the genotypes for all the observed characters indicating the existence of high variability among the varieties. Thus, there is an ample scope for selection of different quantitative characters for rice improvement. The appearance of a huge scale of variability might be due to the diverse type of cultivars under different agro-ecological condition in the zone. Earlier several workers, who worked on rice, have reported the presence of variability amongst the genotypes of rice for different quantitative traits [10-15].

Correlation of grain yield with yield attributing traits

In the present investigation correlation matrix for the 13 traits were prepared at both phenotypic and genotypic levels, which are presented in (Table 1-2). Grain yield was found to be positively and significantly correlated with 100 - grain weight, grain length, grain breadth, biological yield and harvest index at both genotypic and phenotypic level. However, negative significant correlation was observed between grain yield and days to 50% flowering, days to maturity and plant height. The traits with positive significance with yield also showed positive correlation amongst them such as grain weight with harvest index and biological yield; harvest index with biological yield. Grain length and grain breadth, although showed positive association with grain yield, did not show positive correlation with other traits having positive association with grain yield. Grain length and grain width were negatively correlated, indicating selection for longer grain will yield long slender types of grains. Also, it came to light that both genotypic and phenotypic level, days to 50% flowering is positively and significantly correlated with days to maturity and filled grains per panicle which were in agreement with the findings of plant breeders working in this area [16-17]. Negative and significant correlations were observed between biological yield with days to flowering and maturity. Grain weight was also negatively associated with panicle length and effective tillers per plant. Undesirable negative association observed in grain yield with days to 50% flowering and days to maturity needs to be broken in order to further improvement of grain yield. Recombination breeding may be suggested for breaking such undesirable linkage. Panicle length, one of the important yield attributing traits, showed non-significant association with grain yield. This may be due to its negative association with other yield traits like 100-grain weight. Another important yield trait, effective tillers per plant also showed negative association with 100-grain weight and grain length, which made it to be non- significantly associated with grain yield. Filled grains per panicle exhibited non-significant association with grain yield. However, it exhibited positive association with biological yield, harvest index, grain length. In spite of having associated positively with them, its non- significant association with grain yield might be due to its positive association with days to flowering and maturity, which in turn exhibited negative association with grain yield.

Table 1 Genotypic correlation matrix for grain yield and other traits in 64 rice genotypes

	DF	DM	PL HT	PL	ET	FG	100GW	GY	GL	GW	L:B	BY	HI
DF	1												
DM	0.992**	1											
PL HT	-0.049^{NS}	-0.064^{NS}	1										
P L	-0.067^{NS}	-0.030^{NS}	0.386**	1									
ET	-0.026^{NS}	0.007^{NS}	-0.114^{NS}	0.080^{NS}	1								
FG	0.186*	0.178*	-0.072^{NS}	0.037^{NS}	-0.110^{NS}	1							
100 GW	-0.093^{NS}	-0.074^{NS}	0.087^{NS}	-0.202*	-0.320**	-0.05^{NS}	1						
GY	-0.233**	-0.212*	-0.011^{NS}	0.048^{NS}	0.071^{NS}	0.050^{NS}	0.300**	1					
GL	0.003^{NS}	0.008^{NS}	0.163^{NS}	0.087^{NS}	-0.187*	0.198*	0.13^{NS}	0.205*	1				
GW	-0.133^{NS}	-0.123^{NS}	-0.159^{NS}	-0.065^{NS}	0.163^{NS}	-0.17^{NS}	0.00^{NS}	0.295**	-0.857**	1			
L:W	0.325**	0.296**	-0.053^{NS}	-0.091^{NS}	-0.059^{NS}	0.293**	-0.02^{NS}	-0.10^{NS}	0.009^{NS}	-0.093^{NS}	1		
BY	-0.238**	-0.197*	0.071^{NS}	0.204*	0.085^{NS}	0.295**	0.232**	0.205*	0.109^{NS}	-0.012^{NS}	-0.50**	1	
HI	0.075^{NS}	0.088^{NS}	-0.006^{NS}	0.059^{NS}	0.277**	0.733**	0.224*	0.182*	0.080^{NS}	-0.018^{NS}	0.274**	0.313**	1

Table 2 Phenotypic correlation matrix for grain yield and other traits in 64 rice genotypes

	DF	DM	PH	PL	ET	FG	100Gw	GY	GL	GB	L:B	BY	HI
DF	1												
DM	0.977**	1											
PH	-0.05^{NS}	-0.06^{NS}	1										
PL	-0.06^{NS}	-0.03^{NS}	0.328**	1									
ET	-0.01^{NS}	-0.02^{NS}	-0.11^{NS}	0.071^{NS}	1								
FG	0.174*	0.172^{NS}	-0.06^{NS}	0.034^{NS}	-0.090^{NS}	1							
100Gw	-0.09^{NS}	-0.07^{NS}	0.047^{NS}	-0.16^{NS}	-0.261**	-0.060^{NS}	1						
GY	-0.217*	-0.194*	0.001^{NS}	0.054^{NS}	0.066^{NS}	0.032^{NS}	0.296**	1					
GL	0.009^{NS}	0.003^{NS}	0.151^{NS}	0.077^{NS}	-0.125^{NS}	0.171^{NS}	0.126^{NS}	0.189*	1				
GB	-0.13^{NS}	-0.12^{NS}	-0.14^{NS}	-0.05^{NS}	0.116^{NS}	-0.152^{NS}	0.013^{NS}	0.306**	-0.858**	1			
L:B	0.319**	0.291**	-0.04^{NS}	-0.08^{NS}	-0.043^{NS}	0.294**	-0.023^{NS}	-0.101^{NS}	0.003^{NS}	-0.083^{NS}	1		
BY	-0.232**	-0.192*	0.072^{NS}	0.194*	0.080^{NS}	0.287**	0.237**	0.205*	0.112^{NS}	-0.019^{NS}	-0.484**	1	
HI	0.074^{NS}	0.083^{NS}	-0.01^{NS}	0.063^{NS}	0.231**	0.711**	0.214*	0.174*	0.077^{NS}	-0.016^{NS}	0.270**	0.307**	1

NB: *Significant at 0.05 probability level, **Significant at 0.01 level of probability, NS = Non-significant

Phenotypic and genotypic path analysis

The direct and indirect effect of different characters on grain yield per panicle computed by using phenotypic and genotypic correlations are present in (Table 3-4). At phenotypic level a very high direct positive effect was shown by filled grains per panicle (0.6083) and moderate direct positive effect was shown by effective tillers (0.31) and 100 grain weight (0.268). Positive direct effect was also shown by days to maturity (0.146), panicle length (0.079) and biological yield (0.0353) [18-19]. At genotypic level, almost the same trend was noticed with minimum variations in the range. The highest positive direct effect on grain yield was shown by days to maturity (1.347), followed by filled grains per panicle (0.832), effective tillers (0.588) and 100 grain weight (0.4228). In contrast negative direct effect on grain yield at was shown by days to flowering (-0.250) at genotypic level and (-1.515) at phenotypic level respectively, grain weight (-0.485) at genotypic level and (-0.354) at phenotypic level respectively, L:B ratio (-0.4630) at genotypic level and (-0.316) at phenotypic level respectively. Negative direct effect was also shown by plant height (-0.0310) and harvest index (-0.015) at phenotypic level. The high positive indirect effect was shown by days to maturity with grain yield via days to flowering (1.383), grain length (0.328), biological yield (0.417) and filled grains per panicle (0.153). This result was in accordance with Hossain *et al.* [18] which stated 'Negative direct effect of plant height and days to 50% flowering towards yield indicated short plant with short duration rice hybrids could be developed without sacrificing grain yield'. Filled grains per panicle also exhibited high positive indirect effects on grain yield per plant via days to flowering, days to maturity, grain width, biological yield and harvest index at both genotypic and phenotypic level. At phenotypic level, days to maturity had indirect positive effect on days to flowering, filled grains per panicle and harvest index. Effective tillers had moderate positive indirect effect on grain yield per plant via panicle length, grain length and length: breadth ratio. At genotypic level, filled grains per panicle had indirect positive effect on grain yield via days to flowering, days to maturity, grain length, grain width, harvest index, biological yield. Effective tillers had moderate indirect effect on all the traits except plant height, filled grains, grain weight and grain width. 100 grain weight had indirect effect on grain yield via plant height, grain length, grain width and harvest index at both phenotypic and genotypic level.

Table 3 Direct and indirect effects of agronomic characters on grain yield (Phenotypic)

	DF	DM	PH	PL	EF	FG/P	100G Wt	GL	GW	L:B	BY	HI
DF	-0.2495	-0.2431	0.0075	0.011	-0.0061	-0.418	0.0131	0.0506	0.0013	0.0285	-0.077	0.0567
DM	0.1426	0.1463	-0.0076	-0.0047	0.0031	0.0263	-0.0052	-0.024	-0.001	-0.013	0.0447	-0.031
PH	0.009	0.0016	-0.0315	-0.0106	0.0008	0.0009	-0.0025	-0.001	-0.004	0.0041	0.0005	-0.003
PL	-0.0035	-0.006	0.0267	0.0797	0.0034	0.0007	-0.0114	0.0046	-0.003	-0.003	-0.004	0.0126
ET	0.0076	0.0065	-0.0082	0.0134	0.3111	-0.0201	-0.0752	0.0248	0.0222	0.0222	0.0077	0.0137
FG	0.1019	0.1093	-0.0178	-0.0051	0.0393	0.6083	-0.0262	0.0129	-0.124	-0.124	0.1754	0.1711
100 GWt	-0.0109	-0.0074	0.0163	-0.0296	-0.05	-0.0089	0.2068	0.0625	0.0022	0.0022	0.0028	0.0472
GL	-0.0543	-0.0448	0.0011	0.0156	0.1071	0.0057	0.081	0.268	0.0521	0.0804	-0.031	0.0549
GW	0.0025	0.0042	-0.0707	- 0.0383	0.0313	-0.107	-0.0656	-0.094	-0.485	0.4158	-0.013	-0.081
L:B	0.0529	0.0426	0.0599	0.0187	0.0102	0.0948	-0.0049	-0.139	0.3965	-0.463	0.0471	0.0346
BY	0.0109	0.0108	-0.0005	-0.0019	0.0009	0.0102	0.0005	-0.004	0.001	-0.003	0.0353	-0.017
HI	0.0036	0.0034	-0.0016	-0.0025	-0.0007	-0.0045	-0.0036	-0.003	-0.002	0.0012	0.0077	-0.015
GY	0.0047	0.0269	-0.0264	0.0559	0.2428	0.5645	0.1068	0.1579	0.1048	-0.053	0.1947	0.242
Partial R^2	-0.0012	0.0039	0.0008	0.0045	0.0755	0.3434	0.0221	0.0423	-0.050	0.0248	0.0069	-0.003

R^2 = 0.4683; Residual effect = 0.7292

Table 4 Direct and indirect effects of agronomic characters on grain yield (genotypic)

	DF	DM	PH	PL	EF	FG/P	100G Wt	GL	GW	L:B	BY	HI
DF	**-1.515**	-1.504	0.0487	0.0787	-0.0613	-0.2626	0.0812	0.328	0.012	0.187	-0.477	0.3518
DM	1.3378	**1.347**	-0.748	-0.048	0.0534	0.2486	-0.058	-0.244	-0.005	-0.134	0.417	-0.297
PH	-0.003	-0.006	**0.1037**	0.0421	-0.005	-0.004	0.0113	-0.004	0.0158	-0.015	-0.003	0.0109
PL	-0.003	-0.002	0.0261	**0.0644**	0.0043	0.0005	-0.034	0.0038	0.0065	-0.004	-0.004	0.0107
ET	0.0238	0.0233	-0.026	0.0394	**0.5885**	-0.038	-0.189	0.0644	-0.052	0.0504	0.0116	0.0199
FG	0.1443	0.1573	-0.03	0.0067	-0.054	**0.832**	-0.03	0.0233	0.2053	-0.019	0.24	0.2387
100 GWt	-0.022	-0.018	0.0461	-0.082	-0.136	-0.016	**0.4228**	0.1338	0.068	-0.003	0.0066	0.1016
GL	-0.015	-0.013	-0.003	0.0043	0.007	0.002	0.0229	**0.0724**	0.0156	0.021	-0.008	0.0154
GW	0.0028	0.0038	-0.054	-0.036	0.0313	-0.087	-0.057	-0.076	**-0.355**	0.3034	-0.013	-0.061
L:B	0.0391	0.0317	0.0443	0.0198	-0.027	0.0729	0.0019	-0.092	0.2709	**-0.317**	0.035	0.0244
BY	-0.010	-0.01	0.008	0.002	-0.001	-0.009	-0.005	0.0039	-0.001	0.0036	**-0.033**	0.0161
HI	0.0315	0.0299	-0.014	-0.023	-0.0046	-0.038	-0.033	-0.029	-0.023	0.0105	0.0673	**-0.135**
GY	0.0085	0.0353	0.0703	0.068	0.3972	0.7011	0.1591	0.1883	0.1487	-0.088	0.2413	0.2957
Partial R^2	-0.013	0.047	0.007	0.004	0.2338	0.5839	0.0673	0.0136	-0.0527	0.0279	-0.008	-0.04

R^2 = 0.8721; Residual effect = 0.357

Abbreviations for (Table 1-4): DF-days to 50% flowering, DM-days to maturity, PH-plant height, PL-panicle length, EF-effective tillers, FG-filled grains, GW-grain weight, GY-grain yield, GL-grain length, GB-grain breadth, BY-biological yield, HI-harvest index. GCV- genetic coefficient of variation, PCV- Phenotypic coefficient of variation. CV-coefficient of variation

CONCLUSION

Correlation coefficient and path analysis study of 12 yield associated traits at genotypic and phenotypic level for 64 cultivars of Assam revealed that direct selection of effective tillers per plant, 100 grain weight, and biological yield had both positive correlation as well as positive direct effect on grain yield. Hence direct selection and improvement of these traits will prove fruitful in further plant breeding programs and an improvement in yield. Along with, recombination breeding may be suggested to break undesirable negative association or to induce positive association of important yield components with grain yield.

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Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: This article does not contain any studies with human participants or animals performed by any of the authors.

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