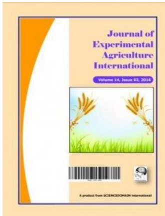

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Correlation and Path Coefficient Analysis of Yield Components in NERICA Mutant Rice Lines under Rainfed Conditions

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Authors' contributions

This work was carried out in collaboration between all authors. Authors MN and LH conceived the idea. Authors MN, LH and SNB participated in designing and executing the experiment. Authors MN and MMH managed the trial and recorded the data. Authors MN and LH analyzed the data. Author MN prepared the manuscript and authors LH and SNB critically assessed and evaluated the results, constructed the manuscript and improved each version as required. All authors read and approved the final manuscript.

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ABSTRACT

Morphological and yield related traits of 31 genotypes were studied to ascertain the genetic and phenotypic correlations among some morphological traits and contribution of these traits to the yield under rainfed conditions directly and indirectly in NERICA mutant rice lines. Field experiment was conducted during the winter season of 2014 at the experimental field of Biotechnology division in Bangladesh Institute of nuclear agriculture (BINA), Mymensingh. The experiment was lay in a randomized complete block design with three replications. The genotypes differed significantly for all the traits *viz.,* days to flowering (1st, 50%, 80%), days to maturity, plant height, total tillers and effective tillers hill^{-1}, filled and unfilled grains panicle^{-1}, 100-seed weight (g) and yield plant^{-1} (g). The results indicate that plant height (0.422*and 0.426*), total tillers hill^{-1} (0.663**and 0.669**), effective

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tillers hill^{-1} (0.734**) and filled grains panicle^{-1} (0.525**and 0.530**) showed positive and significant association with yield per plant under rainfed conditions at both phenotypic and genotypic levels; whereas, days to maturity (-0.554** and 0.574**) had significantly negative correlation with yield. Higher phenotypic correlation values for all traits indicated that the environmental effects on traits are high under rainfed conditions. Plant height, total tillers hill^{-1}, effective tillers hill^{-1}, panicle length, filled grains panicle^{-1} and 100-seed weight showed direct positive effect on yield plant^{-1} at both genotypic and phenotypic levels. Therefore, these characters would be reliable criteria for improving yield. Higher heritability and genetic advance estimates for all the traits under rainfed condition indicates that these characters can be exploited more efficiently through selection in further generations.

Keywords: Yield; morphological trait; correlation; path coefficient; NERICA; mutant lines.

1. INTRODUCTION

The progress in breeding for yield and its contributing characters of any crop is polygenically controlled, environmentally influenced and determined by the magnitude and nature of their genetic variability [1-2]. Genetic variability, character association and path coefficients are pre-requisites for improvement of any crop including rice for selection of superior genotypes and improvement of any trait. Knowledge of correlation between yield and its contributing characters are basic and fore most endeavor to find out guidelines for plant selection. Partitioning of total correlation into direct and indirect effect by path coefficient analysis helps in making the selection more effective.

Rice is the most important and extensively cultivated cereal crop which covers about 77 percent of the total cropped area in Bangladesh. Bangladesh is now world’s sixth largest term rainfed is used to describe farming practises that rely on rainfall for water without any artificial irrigation. NERICA is a new drought tolerant rice variety introduced by the ministry of agriculture for growing in drought prone areas of Bangladesh. The term NERICA stands for New Rice for Africa, an extended family of some 3000 siblings. NERICA is the product of interspecific hybridization between the cultivated rice species of Africa *(O. glaberrima)* and Asia *(Oryza sativa).* NERICA varieties have high yield potential and short growth cycle. Several of them possess early vigor during the vegetative growth phase and this is a potentially useful trait for weed competitiveness. Due to lower productivity in Bangladesh, NERICA genotypes were treated with physical agent to create mutant lines. Drought limits the agricultural production by preventing the crop plants from expressing their full genetic potential. Drought frequently causes loss of yield in rice, one of the staple foods in Asian countries. Grain yield can be drastically reduced if drought stress occurs during flowering. The global reduction in rice production due to drought averages 18 M t annually. This abiotic stress is therefore a major constraint to rice stress. So developing drought resistant cultivars especially under late season drought stress is one of the major objectives in rice breeding programs. Therefore the present study was conducted to screen out the genotypes that perform better in rainfed conditions and estimate the relationship among various morphological traits.

2. MATERIALS AND METHODS

2.1 Plant Materials and Experimental Design

The experiment was conducted in the experimental field of Biotechnology division in Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh during winter season 2014. Thirty one NERICA mutant rice lines including three parental lines were used as plant material. The experiment was carried out in a randomized complete block design (RCBD) with three replicates. Recommended dose of fertilizer was applied and weeding was done whenever necessary.

2.2 Data Collection on Different Growth Parameters and Yield Attributes

Data on days to flowering (1st, 50%, 80%), days to maturity, plant height, total tillers and effective tillers hill^{-1}, filled and unfilled grains panicle^{-1}, 100-seed weight (g) and yield plant^{-1}(g) were recorded. Five plants from each replication were picked for collecting data.

2.3 Statistical Analysis and Estimation of Correlation Coefficient and Path Coefficient

The recorded data for different parameters were assembled and organized properly for statistical analysis using SAS software version 9.3 [3] following RCBD design in three replications. The phenotypic correlations were estimated by the formula suggested by [4]. Correlation coefficients were further partitioned into components of direct and indirect effects by path coefficient analysis, as developed by [5] and late described by [6].

3. RESULTS AND DISCUSSION

3.1 Estimation of the Correlation Coefficients

Relationships among yield and yield contributing traits were studied through analysis of correlation among them. Phenotypic and genotypic correlation co-efficient among different traits of 31 rice genotypes are presented in Table 1. In the present study out of 66 associations, 16 associations were significant both at genotypic and phenotypic levels. Among the 16 associations, 13 associations were positively significant and the rest 3 were negatively significant. Besides, 20 associations were positive and non-significant both at genotypic and phenotypic levels. On the other hand, 27 relationships were found negative and non-significant both at genotypic and phenotypic levels. Again one association was negatively significant at genotypic level only. The results of correlation co-efficients implied that significant positive correlations at both the levels were recorded for yield plant^{-1} with plant height, total tillers hill^{-1}, effective tillers hill^{-1}, and filled grains panicle^{-1}. The results of correlation co-efficients implied that significant negative correlations at both the levels were recorded for yield plant^{-1} with days to maturity only.

The significant and positive association between the traits suggested additive genetic model thereby less affected by the environmental fluctuation. The positive and non-significant association referred information of inherent relation among the pairs of combination. The negative and non-significant association referred a complex linked of relation among the pair of combinations. Genotypic correlation coefficients were of higher magnitude than the corresponding phenotypic correlation co-efficients which might be due to masking or modifying effect of environment [7]. These findings are corroborating the observations of [8] and [9]. Very close values of genotypic and phenotypic correlations were also observed between some character combinations which might be due to reduction in error (environmental) variance to minor proportions as reported by [6]. Thus selection for higher yield on the basis of above traits would be reliable. Similar findings were also reported by [10-11]. When traits having direct bearing on yield are selected, their associations with other traits are to be considered simultaneously as this will indirectly affect yield. Any of these morphological traits can be discarded to reduce the number of traits to characterize. This correlation can be used as basis for character discard if similar research is conducted in the future using additional morphological traits. Elimination of redundant traits will reduce the workload of researcher and will render characterization less cumbersome and more efficient. This outcome was supported by the findings of [12].

3.2 Estimation of Path Co-efficient

Path analysis technique furnishes a method portioning the correlation coefficients into direct and indirect effects to provide the information on actual contribution of the independent variables on the dependent variable. The path coefficient analysis was performed using correlation coefficients to determine the direct and indirect effects of 11 yield contributing characters. The values shown in Table 2 and the analysis performed as correlation coefficient estimates were not adequate to measure the cause and effect of dependent and independent variables.

3.2.1 Path coefficient analysis for phenotypic correlation

Partitioning of phenotypic correlation coefficients into direct and indirect effects of 11 important traits of 31 rice genotypes by path analysis is shown in Table 2. Path coefficient analysis for Phenotypic Correlation revealed that plant height (0.034), total tillers hill^{-1} (0.269), effective tillers hill^{-1}(0.328), panicle length (0.093), filled grain panicle^{-1}(0.258) and 100 seed weight (0.275) had direct positive effect on yield plant^{-1}. However days to 1st flowering (-0.712), days to 50% flowering (-0.715), days to 80% flowering (-0.108), days to maturity (-0.256) and unfilled grain panicle^{-1} (-0.019) had direct negative effect on yield plant^{-1}. Effective tillers hill^{-1}(0.328) and days to 50% flowering (-0.715) had highest direct positive and negative effect on yield plant^{-1}, respectively. The residual effect was 0.1882 at phenotypic level.

Table 1. Coefficients of phenotypic and genotypic correlation among different yield components

Characters	correlation	Days to 50% flowering	Days to 80% flowering	Days to maturity	Plant height (cm)	Total tillers hill^{-1}	Effective tillers hill^{-1}	Panicle length (cm)	Filled grain panicle^{-1}	Unfilled grain panicle^{-1}	100 Seed weight (g)	Yield plant^{-1} (g)
Days to 1st	r_p	0.993**	0.986**	0.420*	-0.062	-0.156	-0.063	-0.109	-0.337	0.021	0.327	-0.071
flowering	r_g	0.992**	0.985**	0.413*	-0.060	-0.164	-0.067	-0.124	-0.338	0.017	0.330	-0.072
Days to 50%	r_p		0.991**	0.404*	-0.035	-0.144	-0.046	-0.103	-0.322	0.031	0.352	-0.037
flowering	r_g		0.987**	0.384*	-0.030	-0.148	-0.041	-0.129	-0.317	0.028	0.352	-0.037
Days to 80%	r_p			0.442*	-0.071	-0.119	-0.040	-0.151	-0.308	0.024	0.364*	-0.035
flowering	r_g			0.423*	-0.073	-0.128	-0.038	-0.177	-0.307	0.022	0.368*	-0.035
Days to	r_p				-0.612**	-0.328	-0.368*	-0.268	-0.346	0.034	-0.122	-0.554**
maturity	r_g				-0.625**	-0.372*	-0.387*	-0.327	-0.353	0.032	-0.137	-0.569**
Plant height	r_p					0.159	0.156	0.432*	0.256	-0.161	0.331	0.422*
	r_g					0.166	0.156	0.444*	0.280	-0.169	0.339	0.426*
Total tillers	r_p						0.942**	-0.118	0.242	-0.068	-0.142	0.663**
hill^{-1}	r_g						0.930**	-0.138	0.242	-0.066	-0.147	0.669**
Effective tillers	r_p							-0.077	0.306	0.021	-0.059	0.734**
hill^{-1}	r_g							-0.064	0.314	0.013	-0.063	0.734**
Panicle length	r_p								0.147	0.129	0.163	0.163
	r_g								0.151	0.134	0.195	0.176
Filled Grain	r_p									-0.024	0.117	0.525**
Panicle^{-1}	r_g									-0.003	0.128	0.530**
Unfilled grain	r_p										0.027	-0.028
panicle^{-1}	r_g										0.019	-0.029
100 Seed	r_p											0.341
weight	r_g											0.345

*Notes: * and ** indicate significant at 5% and 1% level of probability, respectability. $r_{p=}$ Phenotypic Correlation and $r_{g=}$ Genotypic Correlation*

Table 2. Partitioning of phenotypic correlation coefficients into direct and indirect effects of 11 important traits of 31 rice genotypes by path analysis

Characters	Days to 1st flowering	Days to 50% flowering	Days to 80% flowering	Days to maturity	Plant height (cm)	Total tillers hill^{-1}	Effective tillers hill^{-1}	Panicle length (cm)	Filled grain panicle^{-1}	Unfilled grain panicle^{-1}	100 Seed weight (g)	Correlation with Yield plant^{-1} (g)
Days to 1st flowering	**-0.712**	0.710	0.107	-0.108	0.002	-0.042	-0.021	-0.010	-0.087	0.0004	0.090	-0.071
Days to 50% flowering	-0.707	**-0.715**	0.107	-0.104	0.001	-0.039	-0.015	-0.010	-0.083	0.0006	0.097	-0.037
Days to 80% flowering	-0.702	0.708	**-0.108**	-0.113	0.002	-0.032	-0.013	-0.014	-0.079	0.0005	0.100	-0.035
Days to maturity	-0.299	0.289	0.048	**-0.256**	0.021	-0.088	-0.121	-0.025	-0.089	0.0007	-0.034	-0.554**
Plant height	0.044	-0.025	-0.008	0.157	**0.034**	0.043	0.051	0.040	0.066	-0.003	0.091	0.422*
Total tillers	0.111	-0.103	-0.013	0.084	-0.005	**0.269**	0.309	-0.011	0.062	-0.001	-0.039	0.663**
Effective tillers hill^{-1}	0.045	-0.033	-0.004	0.094	-0.005	0.253	**0.328**	-0.007	0.079	0.0004	-0.016	0.734**
Panicle length	0.078	-0.074	-0.016	0.069	-0.015	-0.032	-0.025	**0.093**	0.038	0.003	0.045	0.163
Filled grain panicle^{-1}	0.240	-0.230	-0.033	0.089	-0.009	0.065	0.101	0.014	**0.258**	-0.0005	0.032	0.525**
Unfilled grain Panicle^{-1}	-0.015	0.022	0.003	-0.009	0.006	-0.018	0.007	0.012	-0.006	**-0.019**	0.007	-0.028
100 Seed weight	-0.233	0.252	0.039	0.031	-0.011	-0.038	-0.019	0.015	0.030	0.005	**0.275**	0.341

Table 3. Partitioning of genotypic correlation coefficients into direct and indirect effects of 11 important traits of 31 rice genotypes by path analysis

Characters	Days to 1st flowering	Days to 50% flowering	Days to 80% flowering	Days to maturity	Plant height (cm)	Total tillers hill^{-1}	Effective tillers hill^{-1}	Panicle length (cm)	Filled grain panicle^{-1}	Unfilled grain panicle^{-1}	100 Seed weight (g)	Correlation with yield plant^{-1} (g)
Days to 1st flowering	**-0.294**	0.284	0.103	-0.091	0.001	-0.054	-0.019	-0.012	-0.088	0.0005	0.097	-0.072
Days to 50% flowering	-0.292	**-0.287**	0.104	-0.085	0.0007	-0.048	-0.012	-0.012	-0.083	0.0008	0.103	-0.037
Days to 80% flowering	-0.290	0.283	**-0.105**	-0.094	0.002	-0.042	-0.011	-0.017	-0.080	0.0006	0.108	-0.035
Days to maturity	-0.121	0.110	0.044	**-0.221**	0.015	-0.122	-0.111	-0.031	-0.092	0.0009	-0.040	-0.569**
Plant height	0.018	-0.009	-0.008	0.138	**0.023**	0.054	0.045	0.043	0.073	-0.005	0.100	0.426*
Total tillers	0.048	-0.042	-0.013	0.082	-0.004	**0.327**	0.266	-0.013	0.063	-0.002	-0.043	0.669**
Effective tillers hill^{-1}	0.020	-0.012	-0.004	0.086	-0.004	0.304	**0.286**	-0.006	0.082	0.0004	-0.018	0.734**
Panicle length	0.036	-0.037	-0.019	0.072	-0.010	-0.045	-0.018	**0.096**	0.039	0.004	0.057	0.176
Filled grain panicle^{-1}	0.099	-0.091	-0.032	0.078	-0.007	0.079	0.090	0.015	**0.261**	-0.00008	0.038	0.530**
Unfilled grain panicle^{-1}	-0.005	0.008	0.002	-0.007	0.004	-0.022	0.004	0.013	-0.0008	**-0.027**	0.006	-0.029
100 Seed weight	-0.097	0.1001	0.039	0.030	-0.008	-0.048	-0.018	0.019	0.033	0.0005	**0.294**	0.345

3.2.2 Path coefficient analysis for genotypic correlation

Partitioning of genotypic correlation coefficients into direct and indirect effects of 11 important traits of 31 rice genotypes by path analysis is shown in Table 2. Path coefficient at genotypic level revealed that plant height (0.023), total tillers hill^{-1} (0.327), effective tillers hill^{-1} (0.286), panicle length (0.096), filled grain panicle^{-1} (0.261), and 100 seed weight (0.294) had direct positive effect on yield plant^{-1}. However days to 1st flowering (-0.294), days to 50% flowering (-0.287), days to 80% flowering (-0.105), days to maturity (-0.221) and unfilled grain panicle^{-1} (-0.027) had direct negative effect on yield plant^{-1}. Total tillers hill^{-1} (0.327) and days to 1st flowering (-0.294) had highest direct positive and negative effect on yield plant^{-1} respectively. The residual effect was 0.1909 at genotypic level.

Plant height, total tillers hill^{-1}, effective tillers hill^{-1}, panicle length, filled grain panicle^{-1} and 100 seed weight showed direct positive effect on yield plant^{-1} at both levels. Therefore, these characters would be reliable criteria for improving yield. Similar results had also been reported by [13-14]. [15-16] reported that number of filled grains panicle^{-1} has highest positive direct effect on yield. The above information revealed that highly significant positive correlation with highest positive direct effect was observed in number of effective tillers hill^{-1}. So the number of effective tillers hill^{-1} could be considered as critical criteria for yield improvement in these genotypes of rice. Similar results had also been reported by [17-18]. The residual effect determines how best the causal factors account for the variability of the dependent factor, the yield plant^{-1} in this case. In case of the present study the residual effect was 0.1882 and 0.1909 at phenotypic and genotypic levels respectively.The residual effect 0.1882 at phenotypic level indicates that the eleven traits explain 82% of variability in yield plant^{-1}. The reason seems to be very low and non-significant correlation of some traits with yield. Besides, some other factors which have not been considered here need to be included in this analysis to account fully for the variation in yield.

4. CONCLUSION

Relationship among yield and yield contributing traits was studied through analysis of correlation among them. Yield was significantly positively correlated with total tillers hill^{-1} , effective tillers hill^{-1}, plant height and significantly negatively correlated with days to maturity, suggesting that the selection of genotypes having higher number of filled grains panicle^{-1} with a reasonable balance for moderate days to maturity, higher number of effective tillers hill^{-1}, moderate panicle length, less number of unfilled grains panicle^{-1} and moderate plant height would particularly encourage the breeders to achieve higher yield. Again the traits such as days to 1st flowering, days to 50% flowering, days to 80% flowering, days to maturity and plant height were significantly and positively correlated with each other, suggesting that any of these morphological traits can be discarded if similar research is conducted in the future using these genotypes.

The path coefficient analysis was performed using phenotypic and genotypic correlation to determine direct and indirect influence considering different traits. Effective tillers hill^{-1} and days to 50% flowering had highest direct positive and negative effect on yield plant^{-1}, respectively at phenotypic level. The residual effect was 0.1882 at phenotypic level. Total tillers hill^{-1} and days to 1st flowering had highest direct positive and negative effect on yield plant^{-1}, respectively at genotypic level. The residual effect was 0.1909 at genotypic level. Plant height, total tillers hill^{-1}, effective tillers hill^{-1}, panicle length, filled grains panicle^{-1} and 100 seed weight showed direct positive effect on yield plant^{-1} at both levels. Therefore, these characters would be reliable criteria for improving yield.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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