Current Botany 2013, 4(1): 01-05
ISSN: 2220-4822
Available Online: http://currentbotany.org/

Efficiency estimation of the agromorphological traits in kernel weight development in landraces of rice

Ashim Chakravorty* and P.D. Ghosh

Cytogenetics and Plant Breeding section, Biotechnology Research Unit
Department of Botany,University of Kalyani, Kalyani-741235, West Bengal, India

Abstract
The objective of this study was to estimate the efficiency of eighteen agromorphological traits, and to determine their interrelationships and their influence on kernel weight development in fifty one traditional rice cultivars. The experiment was conducted at Zonal Adaptive Research Station, Krishnagar, Nadia,West Bengal, following Randomized Complete Block Design with two replications during kharif season of 2008, 2009 and 2010. In maximum cases, the genotypic correlations were higher than the phenotypic correlations. Results of correlation analysis cited that traits, such as, grain weight (0.988), grain length (0.508), grain breadth (0.292) correlated significantly and positively with kernel weight and positively with leaf length (0.258) and flag leaf angle (0.292)   Path coefficient analysis revealed that grain weight having maximum direct effect (0.999) on kernel weight is followed by number of grains panicle-1(0.212), leaf length (0.112) and grain length/breadth ratio (0.108). Hence, the study showed that the direct selection of the above said traits could be relied upon for selection of genotypes for crop improvement as the traits revealed positive relationship with the kernel weight development.

Key Words: Cause effect analysis, correlation coefficients, genetic variability, landraces

INTRODUCTION

Rice (Oryza sativa L., 2n=24) is one of the most important cereal crops in the world and also life blood of southeast Asia where more than 90% of rice is produced and consumed [10].In India, rice contributes around 45% of cereal production and is the main food source for more than 60% of the population in the country [16] covering 44.6 million hectares of total geographic area. Commercialization of agriculture led to the dependence on a relatively few plant varieties throwing of most of the traditional varieties out of cultivation in various states like Andhrapradesh, West Bengal and led to loss of 95% of traditional varieties without their collection and documentation [4]. Landraces offer a valuable gene pool for future breeding programme [15]. Scientists all over the world have tried to transfer the desirable genes from traditional varieties to modern varieties. So, the collection of 51 traditional rice genotypes of three districts of West Bengal viz. Nadia, 24 Parganas (N) and Murshidabad offered a valuable gene pool for the utilization in the breeding programme to improve yield, its components, grain size and shape. The materials under study are maintained in the gene bank of Zonal Adaptive Research Station, Krishnagar, Nadia,West Bengal, India.

For developing high yielding superior germplasms the information on association of characters with kernel weight and among themselves is needed. The knowledge of association, i.e, genotypic and phenotypic correlation between yield and its component characters is essential for yield improvement through selection programmes [2,7, 6]. Partitioning the total correlation into direct and indirect effects by path coefficient analysis helps in making the selection more effective [11]. The major advantage of path analysis is that it permits the partitioning of the correlation coefficients into direct and indirect effects of the component characters on yield on the basis of which crop improvement programmes can be logically devised [5]. 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 [18]. Keeping in view the above facts, the present study was undertaken to find out the genetic variability character association and cause effect analysis of the agromorphological traits under study and selection criteria for kernel development in traditional rice of West Bengal, India.

Received: January, 2013; Revised February, 2013; Accepted. March 2013

*Corresponding Author

Ashim Chakravorty
Department of Botany,University of Kalyani
Kalyani-741235, West Bengal, India
/(M): (+91) 9433814800
Email: ashimbot@gmail.com

MATERIALS AND METHODS

The present investigation was carried out at Zonal Adaptive Research Station, Krishnagar, Nadia, West Bengal, India during kharif season of three consecutive years of 2008, 2009 and 2010 at the Instructional Farm (23˚24´N latitude and 88˚31´E longitude with an altitude of 9.75 meters above mean sea level). The soil reaction gives a slightly acidic pH of 6.0, with low soluble salts (EC of 0.15 dS m-1), medium organic carbon content (0.57%), Total N (0.056%), medium in available P (25.28 kg ha-1) and K (148.77 kg ha-1). The experimental site belongs to tropical humid climate having the average rainfall of 1464 mm, most of the amount falls in between June to September. The minimum temperature reaches 7.6˚C in the month of January and the maximum 41.1˚C in the month of May. It has been observed that 74.7% of the annual rainfall is obtained during June to September and more than 83.6% during June to October.

A collection of fifty one landraces of rice cultivars of three districts of West Bengal viz. Nadia, 24 Parganas, and Murshidabad were evaluated for eighteen agromorphological traits using RCBD technique with two replications. Twenty one days old seedlings of each entry were transplanted in 3.0×2.85m2 plot with plant to plant spacing 15 cm within a row and row to row spacing of 20 cm. Plot to plot distance was 60 cm. A random sample of five competitive plants was used for observations on different traits under study. Crop was raised following recommended package of practices. Fertilizers (N:P2O5:K2O) @ 50:25:25 kg ha-1 were applied. Data was recorded on eighteen quantitative traits and statistical analysis was done using SPAR and MSTATC computer software.

For calculating the genotypic and phenotypic correlation co-efficient for all possible combination, the formula suggested by Singh and Chaudhury (1985) [17] was adopted. Genotypic correlation co-efficient is estimated according to the following formula. The calculation of phenotypic correlation (rp) and genotypic correlation (rg) have been calculated from the corresponding variance and covariance.

Genotypic correlation co-efficient is estimated according to the following formula.

$$r_g = \frac{GC_{ov}(x.y)}{\sqrt{GV(x) \times GV(y)}}$$

r_g = genotypic correlation coefficient

$GC_{ov}(x.y)$ = genotypic covariance between variables X & Y

$GV(x)$ = genotypic variance for the variable X

$GV(y)$ = genotypic variance for the variable Y.

Phenotypic correlation co-efficient is estimated as

$$r_p = \frac{PC_{ov}(x.y)}{\sqrt{PV(x) \times PV(y)}}$$

r_p = phenotypic correlation coefficient

$PC_{ov}(x.y)$ = phenotypic covariance between variables X & Y

$PV(x)$ = phenotypic variance for the variable X

$PV(y)$ = phenotypic variance for the variable Y.

Finally, the path analysis was done to partition the correlation coefficients of independent variables (the 17 characters) with the dependent variable (kernel weight) into direct and indirect effects as proposed by Dewey and Lu (1959)[1].

RESULTS AND DISCUSSION

Analysis of variance indicated that the difference among landraces for all the characters under study were highly significant (α=0.01) except culm diameter, indicating the presence of sufficient genetic variability for effective selection to identify the superior genotypes. The results of simple correlation coefficients analyses (Table 1) indicated that grain weight showed highest correlation (0.988) with kernel weight followed by grain length (0.508) and grain breadth (0.292). Leaf length (0.258), flag leaf angle (0.137) and maturity (0.030) also showed highly positive association with the kernel weight. It has also been found that some traits, like number of grains panicle-1(-0.197), ligule length (-0.169), culm length (-0.122) and culm diameter (-0.017), despite having negative correlation with the kernel weight and in spite of being camouflaged by other characters, have direct positive effect on kernel weight development. So, these traits may be kept in view or in selection programme in case of plant breeding for kernel development in traditional cultivars of rice studied here. The correlation coefficient showed that grains per panicle serve as most important selection indices of grain yield. Emphasis has been laid on the importance of grains per panicle in determining grain yield in rice [8, 9, 3, 13, 14 and12].

Since the simple correlation coefficients did not give clear information about the interrelationship between the causal and resultant variables, the correlation coefficient estimates were partitioned into direct and indirect effects to establish the intensity of effects of independent variables on dependent variable.

The data presented in the table 2 revealed that the direct effect of grain weight on kernel weight was highest and positive (1.001) followed by number of grains panicle-1 (0.212), leaf length (0.112), grain breadth (0.052) and grain length (0.020). The path coefficient analysis further indicated that the positive direct effect of grain weight was masked by the negative indirect effect of number of grains panicle-1 (-0.042), plant height (-0.013), leaf breadth (-0.013) and maturity (-0.001), whereas positive and direct effect of number of grains panicle1 was also masked by some other characteristics like number of primary branches panicle-1 (-0.190), grain weight (-0.197), sterile lemma length (-0.035) and leaf length (-0.024). The data further indicated that the total positive effect of grain weight (0.988) on kernel weight was the result of positive and indirect effect of leaf length (0.029), grain length (0.010), culm number (0.009), flag leaf angle (0.0040 and culm diameter (0.002). however, the total positive effect of grain length (0.508) seemed to be due to positive indirect effect of grain weight (0.490), grain length/breadth ratio (0.057), number of primary branches panicle-1 (0.027), panicle length (0.0130, plant height (0.007) and leaf length (0.001).

Negative direct effects on kernel weight were exhibited by number of primary branches panicle-1 (-0.225), which is followed by plant height (-0.2250, plant height (-0.123), sterile lemma length (-0.094), maturity (-0.008), panicle length (-0.072) and leaf breadth (-0.070). The residual effect of 0.0273 indicated that the contribution of component characters on kernel weight was 97.27% by the seventeen characters studied in path analysis; the rest 2.73% was the contribution of other factors, like, the characters which were not studied, and sampling error.

By comparing the correlation coefficient values of seventeen independent variables against the dependent variable (kernel weight) per plant, significant differences became evident. Grain weight, number of grains panicle-1, grain length and grain breadth had highly significant association with kernel weight. By partitioning the mutual relationship among the independent variables into direct and indirect effects on kernel weight development, it came into account that grain weight, number of branches panicle-1 and leaf length were the only characteristics that exhibited the highest direct effect on kernel weight per plant. Therefore, these traits seem to be a good selection criterion to improve kernel weight development of landraces of rice.

Table 1 Genotypic and Phenotypic correlation coefficients among eighteen quantitative traits of fifty one traditional rice cultivars

C1:leaf length C2 :leaf breadth C3 :plant height C4:flag leaf angle C5:ligule length C6:culm length

Traits	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18
C1		0.760**	0.309*	0.208	0.136	0.352**	0.269	0.325	0.348	0.008	0.221	-0.229	0.253	0.252	0.016	-0.162	-0.038	-0.183
C2	0.784*		0.089	0.237	0.010	0.351**	0.096	0.182	0.066	0.030	0.070	-0.165	0.179	0.189	0.132	-0.085	-0.154	-0.185
C3	0.335*	0.093		0.337*	0.072	0.127	0.688**	0.706**	0.654**	-0.053	-0.034	-0.029	0.099	0.058	-0.045	-0.160	0.100	0.003
C4	0.211	0.243	0.363**		-0.150	0.032	0.211	0.175	0.161	-0.058	0.062	-0.177	0.149	0.136	0.328*	-0.023	-0.017	0.024
C5	0.184	0.000	0.084	-0.157		0.140	0.337*	0.139	0.081	-0.210	0.389**	-0.316	-0.115	-0.160	-0.249	-0.232	0.253	-0.050
C6	0.439**	0.460**	0.168	0.040	0.190		0.287*	0.136	0.160	-0.231	0.001	-0.198	-0.074	-0.100	0.003	-0.094	0.020	-0.118
C7	0.273	0.099	0.740**	0.211	0.353**	0.362**		0.680**	0.532**	-0.106	-0.009	-0.089	0.028	-0.017	-0.161	-0.136	0.325*	0.048
C8	0.339**	0.200	0.784**	0.181	0.168	0.320*	0.704**		0.611	-0.161	0.025	-0.079	0.116	0.089	-0.132	-0.233	0.217	0.033
C9	0.431**	0.077	0.783**	0.182	0.113	0.363**	0.600**	0.712**		-0.143	-0.075	-0.014	0.109	0.065	-0.059	-0.214	-0.032	-0.165
C10	0.013	0.002	-0.061	-0.065	-0.268	-0.332	-0.119	-0.172	-0.180		0.061	0.357**	0.437**	0.449**	0.029	0.424**	-0.127	-0.132
C11	0.224	0.071	-0.038	0.062	0.408**	0.004	-0.009	0.024	-0.081	0.068		-0.621	0.327*	0.289*	-0.041	-0.020	0.204	0.033
C12	-0.317*	-0.247	-0.034	-0.234	-0.513	-0.348	-0.117	-0.123	-0.003	0.531**	-0.820		0.003	0.042	-0.016	0.204	-0.083	-0.056
C13	0.256	0.184	0.106	0.149	-0.120	-0.092	0.028	0.120	0.122	0.490**	0.328*	0.008		0.982**	0.141	0.020	0.010	-0.167
C14	0.258	0.196	0.067	0.137	-0.169	-0.122	-0.017	0.093	0.078	0.508**	0.292*	0.043	0.988**		0.133	0.018	**-0.015**	**-0.164**
C15	0.008	0.126	-0.059	0.337*	-0.290	0.008	-0.165	-0.137	-0.093	0.024	-0.040	-0.028	0.145	0.133		0.218	-0.188	-0.049
C16	-0.259	-0.175	-0.258	-0.034	-0.339	-0.171	-0.200	-0.345	-0.425	0.694*	-0.027	0.324	0.030	0.033	0.286*		0.082	0.214
C17	-0.043	-0.152	0.079	-0.017	0.273	0.025	0.330*	0.229	-0.032	-0.118	0.207	-0111	0.010	-0.015	-0.194	0.148		0.761**
C18	-0.213	-0.213	-0.027	0.027	-0.060	-0.096	0.055	0.020	-0.262	-0.105	0.042	0.014	-0.197	0.190	0.052	0.372**	0.846**	

C7:culm diameter C8:culm no. C9:panicle length C10:grain length C11:grainbreadth C12:grainL/B ratio
C13:Lgrain weight C14:kernel weight C15:maturity C16:sterile lemma length C 17: primary branches/panicle
C18:number of grains/panicle

*and**indicate significance at 5% and 1% levels, respectively. Upper diagonal correlations are genotypic correlations and lower diagonal correlations are phenotypic correlation. Correlation coefficient r>0.276 and r>0.351 are significant at at 5% and 1% level

Table 2: Path analysis (genotypic) of eighteen quantitative traits of fifty one traditional rice cultivars

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C15	C16	C17	C18	C14
C1	0.112	-0.055	-0.041	0.005	0.000	0.002	0.017	0.026	-0.031	0.000	0.012	-0.034	0.256	0.000	0.024	0.010	-0.045	0.252
C2	0.088	-0.070	-0.011	0.006	0.000	0.002	0.006	0.015	-0.006	0.000	0.004	-0.027	0.184	-0.001	0.016	0.034	-0.045	0.189
C3	0.038	-0.006	-0.123	0.009	0.000	0.001	0.047	0.060	-0.057	-0.001	-0.002	-0.004	0.106	0.000	0.024	-0.018	-0.006	0.058
C4	0.024	-0.017	-0.045	0.026	0.000	0.000	0.013	0.014	-0.013	-0.001	-0.003	-0.025	0.149	-0.003	0.003	0.004	0.006	0.136
C5	0.017	0.000	-0.010	-0.004	0.001	0.001	0.022	0.013	-0.008	-0.005	0.021	-0.055	-0.120	0.002	0.032	-0.061	-0.013	-0.160
C6	0.049	-0.032	-0.021	0.001	0.000	0.005	0.023	0.024	-0.026	-0.007	0.000	-0.037	-0.092	0.000	0.016	-0.006	-0.020	-0.100
C7	0.031	-0.007	-0.091	0.005	0.000	0.002	0.063	0.053	-0.044	-0.002	0.000	-0.013	0.028	0.001	0.019	-0.074	0.012	-0.017
C8	0.038	-0.014	-0.097	0.005	0.000	0.002	0.044	0.076	-0.052	-0.003	0.001	-0.013	0.120	0.001	0.032	-0.052	0.004	0.089
C9	0.048	-0.005	-0.097	0.005	0.000	0.002	0.038	0.054	-0.072	-0.004	-0.004	0.000	0.122	0.001	0.040	0.007	-0.056	0.065
C10	0.001	0.000	0.007	-0.002	0.000	-0.002	-0.007	-0.013	0.013	0.020	0.003	0.057	0.490	0.000	-0.065	0.027	-0.022	0.449**
C11	0.025	-0.005	0.005	0.002	0.000	0.000	-0.001	0.002	0.006	0.001	0.052	-0.088	0.328	0.000	0.003	-0.047	0.009	0.289*
C12	-0.036	0.017	0.004	-0.006	0.000	-0.002	-0.007	-0.009	0.000	0.011	-0.042	0.108	0.008	0.000	-0.030	0.025	0.003	0.042
C13	0.029	-0.013	-0.013	0.004	0.000	0.000	0.002	0.009	-0.009	0.010	0.017	0.001	1.001	-0.001	-0.003	-0.002	-0.042	0.982**
C15	0.001	-0.009	0.007	0.009	0.000	0.000	-0.010	-0.010	0.007	0.000	-0.002	-0.003	0.145	-0.008	-0.027	0.044	-0.011	0.133
C16	-0.029	0.012	0.032	-0.001	0.000	-0.001	-0.013	-0.026	0.031	0.014	-0.001	0.035	0.030	-0.002	-0.094	-0.033	0.079	0.018
C17	-0.005	0.011	-0.010	0.000	0.000	0.000	0.021	0.017	0.002	-0.002	0.011	-0.012	0.010	0.001	-0.014	-0.225	0.180	-0.015
C18	-0.024	0.015	0.003	0.001	0.000	-0.001	0.003	0.002	0.019	-0.002	0.002	0.001	-0.197	0.000	-0.035	-0.190	0.212	-0.164

Residual=0.01
C1:leaf length C2 :leaf breadth C3 :plant height C4:flag leaf angle C5:ligule length C6:culm length C7:culm diameter
C8:culm number C9:panicle length C10:grain length C11:grain breadth C12:grainL/B ratio C13:Lgrain weight C15:maturity
C16:sterile lemma length C 17: primary branches/panicle C18:number of grains/panicle, C14:kernel weight(Dependent)
Diagonal values indicate the direct effects

Table 3: Path analysis (phenotypic) of eighteen quantitative traits of fifty one traditional rice cultivars

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C15	C16	C17	C18	C14
C1	0.058	-0.013	-0.013	0.001	-0.004	-0.008	0.000	0.011	-0.017	0.000	-0.003	-0.007	0.248	0.000	0.003	0.002	-0.006	0.258
C2	0.044	-0.017	-0.004	0.001	0.000	-0.008	0.000	0.006	-0.003	0.000	-0.001	-0.005	0.175	-0.002	0.002	0.007	-0.006	0.196
C3	0.018	-0.001	-0.042	0.002	-0.002	-0.003	-0.001	0.023	-0.032	0.000	0.000	-0.001	0.097	0.001	0.003	-0.004	0.000	0.067
C4	0.012	-0.004	-0.014	0.005	0.004	-0.001	0.000	0.006	-0.008	0.000	-0.001	-0.005	0.146	-0.005	0.000	0.001	0.001	0.137
C5	0.008	0.000	-0.003	-0.001	-0.029	-0.003	-0.001	0.005	-0.004	-0.001	-0.006	-0.009	-0.013	0.004	0.005	-0.011	-0.002	-0.169
C6	0.020	-0.006	-0.005	0.000	-0.004	-0.022	0.000	0.008	-0.008	-0.001	0.000	-0.006	-0.073	0.000	0.002	-0.001	-0.004	-0.122
C7	0.015	-0.002	-0.029	0.001	-0.010	-0.006	-0.002	0.022	-0.026	-0.001	0.000	-0.003	0.027	0.003	0.003	-0.014	0.002	-0.017
C8	0.019	-0.003	-0.030	0.001	-0.004	-0.005	-0.001	0.033	-0.030	-0.001	0.000	-0.002	0.114	0.002	0.005	-0.009	0.001	0.093
C9	0.020	-0.001	-0.028	0.001	-0.002	-0.003	-0.001	0.020	-0.048	-0.001	0.001	0.000	0.107	0.001	0.004	0.001	-0.005	0.078
C10	0.000	-0.001	0.002	0.000	0.006	0.005	0.000	-0.005	0.007	0.005	-0.001	0.010	0.429	0.000	-0.009	0.005	-0.004	0.508**
C11	0.013	-0.001	0.001	0.000	-0.011	0.000	0.000	0.001	0.004	0.000	-0.014	0.018	0.322	0.001	0.000	-0.009	0.001	0.292*
C12	-0.013	0.003	0.001	-0.001	0.009	0.004	0.000	-0.003	0.001	0.002	0.009	0.029	0.003	0.000	-0.004	0.004	-0.002	0.043
C13	0.015	-0.003	-0.004	0.001	0.003	0.002	0.000	0.004	-0.005	0.002	-0.005	0.000	0.982	-0.002	0.000	0.000	-0.005	0.988**
C15	0.001	-0.002	0.002	0.002	0.007	0.000	0.000	-0.004	0.003	0.000	0.001	0.000	0.139	-0.016	-0.005	0.008	-0.002	0.133
C16	-0.009	0.001	0.007	0.000	0.007	0.002	0.000	-0.008	0.010	0.002	0.000	0.006	0.020	-0.003	-0.021	-0.003	0.007	0.033
C17	-0.002	0.003	-0.004	0.000	-0.007	0.000	-0.001	0.007	0.002	-0.001	-0.003	-0.002	0.010	0.003	-0.002	-0.042	0.025	-0.015
C18	-0.011	0.003	0.000	0.000	0.001	0.003	0.000	0.001	0.008	-0.001	0.000	-0.002	-0.164	0.001	-0.004	-0.032	0.033	0.190

Residual=0.0273
C1:leaf length C2 :leaf breadth C3 :plant height C4:flag leaf angle C5:ligule length C6:culm length C7:culm diameter
C8:culm number C9:panicle length C10:grain length C11:grain breadth C12:grainL/B ratio C13:Lgrain weight C15:maturity
C16:sterile lemma length C 17: primary branches/panicle C18:number of grains/panicle C14: kernel weight(Dependent)
Diagonal values indicate the direct effects

CONCLUSION

The study revealed that the direct selection for the above traits might be rewarding for kernel weight development in crop improvement program since they revealed a true relationship with the kernel weight. So, the positively associated characters appeared to be most reliable and may be selected for future breeding program. Further study can reconfirm this information and may be exploited in rice breeding system.

ACKNOWLEDGEMENT

The authors acknowledge the Head of the Department of Botany, K.U. for providing facilities in the department and Dr. A. Ghosh (Z.A.R.S) for necessary help and assistance.

REFERENCES

[1] Dewey D. R. and. Lu K. H. 1959. Correlation and path coefficient analysis of components on crested wheat grass and seed production. Agron. J., 51:515-18.

[2] Ismail A. A., Khalifa M. A. & Hamam K. A. 2001. Genetic studies on some yield traits of durum wheat. Asian J. Agric. Sci., 32:103-120.

[3] Janardhanam V., Nadarajan N. & Jebaraj S. 2001. Correlation and Path analysis in rice (Oryza sativa L.). Madras Agric. J., 88: 719-720.

[4] Kothari A. (1999). Intellectual Property Rights And Biodiversity: Are India's Proposed Biodiversity Act And Plant Varieties Act Compatible? Paper presented at Workshop on Biodiversity Conservation and Intellectual Property Rights, 29-31 January, 1999, Research and Information System, Kalpavriksh, and IUCN-TheWorldConservationUnion, New Delhi.

[5] Kozak M., Singh K. P., Verma M. R. & Hore D. K. 2007. Causal mechanism for determination of grain yield and milling quality of lowland rice. Field Crops Res., 102:178-184.

[6] Kumar G. S., Mahadevappa R. S., & Rudradhya M. 1998. Studies on genetic variability, correlation and path analysis in rice during winter across the locations. Karnataka J. Agric. Sci., 11:73-77.

[7] Kumar P. & Shukla R. S. 2002. Genetic analysis for yield and its attributed traits in bread wheat under various situations. JNKVV Res. J., 36: 95-97.

[8] Meenakshi T., Ratinam A. A. D. & Backiyarani S. 1999. Correlation and path analysis of yield and some physiological characters in rain fed rice. Oryza, 6: 154-156.

[9] Mustafa M. A. & Elsheikh M. A. Y. 2007. Variability, correlation and path co-efficient analysis for yield and its components in rice. Afr. Crop Sci. J., 15: 183-189.

[10] Nanda J. S. 2002. Rice Breeding and Genetics: Research Priorities and Challenges. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, pp: 1-15.

[11] Priya, A.A. & Joel A.J. 2009. Grain yield response of rice cultivars under upland condition. Elect. J. Plant breed., 1:6-11.

[12] Pushpa K., Singh D. N., Singh M. P, Haque M.F. & Kumari P. 1999. Genetic variability in gora rice (Oryza sativa L.). J. Res., 11: 23-26.

[13] Rao, S.S. & Saxena R.R. 1999. Correlation and regression analysis in upland rice. Oryza, 36: 82-84.

[14] Ray P. K. S. & Debi B.P. 1999. Correlation response and path analysis in irrigated rice and their implication in selection. J. Bio-Sci., 7: 99-101.

[15] Richharia R.H. 1979. An Aspect of Genetic Diversity in rice, Oryza 16:1-31.

[16] Siddiq E.A. 2002. Exploring means to adopt GM rice. In :The Hindu survey of Indian Agriculture,Chennai,India.,pp:47-5.

[17] Singh R.K. & Chaudhury B.D.1985. Biometrical methods in Quantitative Genetic Analysis. Kalyani Publishers, New Delhi.

[18] Surek H. & Baser N. 2003. Correlation and path coefficient analysis of some yield-related traits in rice (Oryza sativa L.) under terrace conditions. Turk. J. Agric., 27:77-83.