Evaluation of Some Exotic Rice (Oryza sativa L.) Genotypes for Yield and Yield Component Traits with Reference to Allahabad Agro-climatic Condition

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Abstract A study of genetic variation and interrelationship among grain yield and its component traits in rice (Oryza sativa L.) was carried out using 64 exotic rice genotypes. Maximum genotypic and phenotypic variance was exhibited by number of spikelets per panicle followed by plant height and days to maturity. The maximum GCV and PCV was exhibited by number of spikelets per panicle followed by number of productive tillers per hill, harvest index and flag leaf length whereas rest of the traits showed moderate GCV and PCV. High heritability was recorded for all the traits studied except flag leaf width. High estimates of heritability coupled with high genetic advance as per cent of mean was observed for all the traits studied except flag leaf width whereas flag leaf width exhibited low heritability along with low genetic advance as percent of mean. The component traits viz., plant height, number of productive tillers per hill, biological yield per hill and harvest index showed positive and significant correlation with seed yield per hill at both genotypic level and phenotypic level. The maximum direct effect towards the total correlation with seed yield per hill was observed for harvest index followed by days to maturity and test weight. The direct contribution of days to 50 per cent flowering and flag leaf width was positive but low in magnitude. The strong positive correlation between component traits and seed yield per hill with high direct effect indicating the true relationship between them, therefore direct selection though this trait will be effective for yield improvement.

Keywords Rice; Genetic parameters; Character association; Path analysis; Component traits

Introduction Rice (Oryza sativa L.) is one of the most important food crop of the country. The production and productivity is very low in India due to non availability of high yielding varieties. The productivity will increase by systematic breeding programme. Grain yield is a complex trait and highly influenced by many genetic factors and environmental factors. So any improvement programme which aim at higher yield has to study the traits affecting it and the method used in crop improvement programmes utilize the knowledge of genetic variability, heritability and its related parameters. In plant breeding programme, direct selection for yield as such may be misleading. A successful selection depends upon the information on the genetic variability and association of related traits with grain yield. Correlation coefficient and path analysis provide a better understanding of the association of different characters through other related characters by partitioning the correlation coefficient (Dixet and Dubey, 1984). Keeping the above facts into consideration present study was undertaken to analyze the nature and extent of genetic variability, heritability, genetic advance, character association of grain yield with other related traits and path analysis.

Materials and Methods The field experiment was conducted with 64 exotic rice genotypes during Kharif 2011 at Field Experimentation Center, Department of Genetics and Plant Breeding, Allahabad School of Agriculture, SHIATS, Allahabad, India in Randomized block design (RBD) with three replications. Five plants from each replications were selected at random and observations were recorded on ten yield and its component traits viz., plant height, number of productive tillers per hill, flag leaf length, flag leaf width, panicle length, number of spikelet’s per panicle,
biological yield per hill, harvest index, test weight and seed yield per hill whereas rest two traits viz., days to 50 per cent flowering and days to maturity were computed on plot basis. The mean data after computing for each character was subjected to standard method of analysis of variance following Panse and Sukhatme (1967), phenotypic and genotypic coefficient of variation, heritability (Broad sense) and genetic advance as per cent of mean were estimated by the formula as suggested by Burton (1952) and Johanson et al. (1955). The phenotypic and genotypic correlations were calculated as per the method of Singh and Choudhary (1985) and path coefficient analysis as per method given by Dewey and Lu (1959).

**Results and Discussion**

The analysis of variance is presented in Table 1 which indicates the existence of significant differences among treatments for all the traits studied. The perusal of data revealed that phenotypic variances were higher than the corresponding genotypic variance for all the traits studied, indicated the influences of environmental factor on these traits. Similar finding has earlier been reported by Anandrao et al. (2011). Maximum genotypic and phenotypic variance was exhibited by number of spikelet’s per panicle (2418.73 and 2429.35) followed by plant height (258.23 and 260.27) and days to maturity (217.30 and 222.55). Babu et al. (2006), Pandey et al. (2009) and Prajapati et al. (2011) also observed the similar result for number of spikelet’s per panicle.

### Table 1 Analysis of variance for twelve quantitative traits in exotic rice genotypes

| SN | Traits                                      | Mean sum of square | Replication (d.f.=2) | Treatment (d.f.=63) | Error (d.f.=126) |
|----|---------------------------------------------|--------------------|----------------------|---------------------|------------------|
| 1  | Days to 50 percent flowering                | 19.47              | 528.33**             | 6.27                |
| 2  | Plant height                                | 0.51               | 776.74**             | 2.04                |
| 3  | Number of productive tillers per hill       | 0.96               | 41.81**              | 1.93                |
| 4  | Flag leaf length                            | 5.00               | 154.01**             | 3.28                |
| 5  | Flag leaf width                             | 0.08               | 0.09**               | 0.03                |
| 6  | Panicle length                              | 0.73               | 49.82**              | 0.60                |
| 7  | Number of spikelets per panicle             | 10.62              | 7266.80**            | 10.62               |
| 8  | Days to maturity                            | 0.19               | 657.15**             | 5.25                |
| 9  | Test weight                                 | 0.02               | 37.18**              | 2.55                |
| 10 | Biological yield per hill                   | 0.50               | 107.40**             | 3.08                |
| 11 | Harvest index                               | 7.23               | 204.96**             | 4.00                |
| 12 | Seed yield per hill                         | 5.66               | 34.79**              | 2.19                |

Note: * and **significant at 0.05 and 0.01 level of significance, respectively

### Table 2 Component of variance for twelve quantitative traits in exotic rice genotypes

| SN | Traits                                      | Variance | \(\sigma^2g\) | \(\sigma^2p\) | \(\sigma^2e\) |
|----|---------------------------------------------|----------|---------------|---------------|---------------|
| 1  | Days to 50 percent flowering                | 174.02   | 180.29        | 6.27          |
| 2  | Plant height                                | 258.23   | 260.27        | 2.04          |
| 3  | Number of productive tillers per hill       | 13.29    | 15.23         | 1.93          |
| 4  | Flag leaf length                            | 50.24    | 53.53         | 3.28          |
| 5  | Flag leaf width                             | 0.02     | 0.05          | 0.03          |
| 6  | Panicle length                              | 0.73     | 49.82         | 0.60          |
| 7  | Number of spikelets per panicle             | 10.62    | 7266.80       | 10.62         |
| 8  | Days to maturity                            | 0.19     | 657.15        | 5.25          |
| 9  | Test weight                                 | 0.02     | 37.18         | 2.55          |
| 10 | Biological yield per hill                   | 0.50     | 107.40        | 3.08          |
| 11 | Harvest index                               | 7.23     | 204.96        | 4.00          |
| 12 | Seed yield per hill                         | 5.66     | 34.79         | 2.19          |
The coefficient of variation studies indicated that the magnitude of phenotypic coefficient of variation (PCV) were slightly higher than the corresponding genotypic coefficient of variation (GCV) for all the characters studied, indicated that these characters were less influenced by environment the following comparison is drawn in Table 3. Similar finding has also been reported by Padmaja et al. (2008). The maximum genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) was exhibited by number of spikelet’s per panicle (32.35% and 32.43%) followed by number of productive tillers per hill (26.78% and 28.66%), harvest index (21.81 and 22.46) and flag leaf length (21.16% and 21.84%) whereas rest characters showed moderate genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV). Similar result for number of spikelets per panicle has earlier been observed by Singh et al. (2011). The high magnitude of GCV and PCV for these traits viz., number of spikelets per panicle, number of productive tillers per hill, harvest index and flag leaf length indicating the possibility of yield improvement through selection for these traits.

Table 3 Genetic parameters for twelve quantitative characters in exotic rice genotypes

| SN  | Traits                                  | Genetic parameters |          |          | GA @ % of mean |
|-----|-----------------------------------------|--------------------|----------|----------|----------------|
| 1   | Days to 50 percent flowering            | 13.17              | 13.41    | 0.97     | 26.66          |
| 2   | Plant height                            | 14.49              | 14.54    | 0.99     | 29.73          |
| 3   | Number of productive tillers per hill   | 26.78              | 28.66    | 0.87     | 51.54          |
| 4   | Flag leaf length                        | 21.16              | 21.84    | 0.94     | 42.23          |
| 5   | Flag leaf width                         | 10.10              | 15.87    | 0.40     | 13.23          |
| 6   | Panicle length                          | 14.71              | 14.97    | 0.96     | 29.75          |
| 7   | Number of spikelets per panicle         | 32.35              | 32.43    | 1.00     | 66.50          |
| 8   | Days to maturity                        | 11.85              | 12.00    | 0.98     | 24.13          |
| 9   | Test weight                             | 14.60              | 16.14    | 0.82     | 27.21          |
| 10  | Biological yield per hill               | 12.90              | 13.46    | 0.92     | 25.47          |
| 11  | Harvest index                           | 21.81              | 22.46    | 0.94     | 43.65          |
| 12  | Seed yield per hill                     | 15.03              | 16.48    | 0.83     | 28.24          |

Note: GCV= Genetic coefficient of variation, PCV= Phenotypic coefficient of variation, \( h^2 \)bs= Heritability in broad sense, GA=Genetic advance

Heritability and genetic advance are important selection parameters. High heritability was recorded for all the traits studied (Umadevi et al., 2009) except flag leaf width. The high heritability of characters indicates selection for these characters should be fairly easy. This is because; there would be close correspondence between the genotype and phenotype due to a relatively smaller contribution of the environment to the phenotype. Heritability estimates along with genetic gain are normally more helpful in predicting the gain under selection than heritability estimates alone (Johanson et al., 1955). High estimates of heritability coupled with high genetic advance as per cent of mean was observed for the entire yield and yield component traits studied except flag leaf width. High heritability of these characters may be governed by additive gene effects. Hence, these characters are likely to respond to direct selection. Several workers viz., Singh et al. (2007) observed similar results for test weight, Yadav et al. (2008) for plant height, number of spikelet’s per panicle, flag leaf length, biological yield per plant, test weight, harvest index and yield per plant. Flag leaf width (40% and 13.23%) exhibited low heritability along with low genetic advance as percent of mean, indicated the dominance types of gene action involved to govern this trait.

Information regarding the nature and extent of association of component characters would be helpful in developing a suitable plant type. Yield is a complex polygenic trait (Mustafa and Elsheikh, 2007; Atta et al., 2008; Majumder et al., 2008) for which direct selection is not effective. Thus it is important to explore the possibility of increasing grain yield by indirect selection of some component characters. The nature and extent of genetic variation governing the inheritance of characters and association will facilitate effective genetic improvement (Ismile et al., 2001). The results of correlations revealed that genotypic correlation coefficient were higher than
the corresponding phenotypic correlation coefficient, indicating the characters are governed by additive gene action and are useful in yield improvement.

The association between yield and yield component traits was presented in Table 4. The component traits viz., biological yield per hill (rp= 0.672** and rg= 0.731**), number of panicles per hill (rp= 0.479** and rg= 0.557**), harvest index (rp= 0.418** and rg= 0.439**) and plant height (rp= 0.184* and rg= 0.205**) showed positive and significant correlation with seed yield per hill at both genotypic level and phenotypic level whereas in addition to these traits flag leaf length (rp= 0.130 and rg= 0.160*) and flag leaf width (rp= 0.119 and rg= 0.172*) showed positive and significant correlation with seed yield per hill at genotypic level only. These component traits showed higher degree of association with grain yield per hill and can be well utilized as an indicator trait of grain yield in designing selection strategies to improve the grain yield. Nath et al. (2008) also observed the significant and positive correlation of panicle bearing tillers per plant, number of grains per panicle, harvest index and 1000 seed weight with grain yield. Sabesan et al. (2009) found the positive and significant correlation of grain yield per plant with plant height and productive tillers per plant. Test weight is a most important trait to enhance the seed yield while it exhibited positive but non significant correlation with seed yield per hill (rp= 0.111 and rg= 0.128). Similar result for 100 seed weight has earlier been reported by Umadevi et al. (2011). Test weight showed significant and positive correlation with plant height (rp= 0.156* and rg= 0.186**) and number of spikelets per panicle (rp= 0.237** and rg= 0.265**) at both phenotypic level and genotypic level. Days to 50% flowering showed positive and significant correlation with flag leaf length (rp= 0.345** and rg= 0.357**), panicle length (rp= 0.354** and rg= 0.358**), number of spikelets per panicle (rp= 0.374** and rg= 0.381**) and days to maturity (rp= 0.210** and rg= 0.203**) at both phenotypic and genotypic level. The positive significant association between days to 50 per cent flowering and days to maturity indicated the selection of early flowering genotypes may be beneficial for evolvement of early maturing promising variety. Plant height showed positive and significant correlation with flag leaf length (rp= 0.304** and rg= 0.314**), flag leaf width (rp= 0.196** and rg= 0.307**), days to maturity (rp= 0.282** and rg= 0.288**), test weight (rp= 0.156* and rg= 0.186**), biological yield per hill (rp= 0.203** and rg= 0.214**) and seed yield per hill (rp= 0.184* and rg= 0.205**) at both phenotypic and genotypic level. Number of productive tillers showed negative and significant correlation with number of spikelets per panicle (rp= 0.237** and rg= -0.254**) and test weight (rp= -0.180* and rg= -0.172**) whereas positive and significant correlation with flag leaf length (rp= 0.246** and rg= 0.279**), flag leaf width (rp= 0.168* and rg= 0.249**), biological yield per hill (rp= 0.646** and rg= 0.726***) and harvest index (rp= 0.406* and rg= 0.458**) and seed yield per hill (rp= 0.479** and rg= 0.557**) at both phenotypic and genotypic level. Flag leaf length showed positive significant correlation with flag leaf width (rp= 0.146* and rg= 0.202**), panicle length (rp= 0.192** and rg= 0.202**), number of spikelets per panicle (rp= 0.150* and rg= 0.155*), days to maturity (rp= 0.197** and rg= 0.205**), biological yield per hill (rp= 0.166* and 0.190**) at both levels. Larger flag leaf increases the photosynthetic rate and provides the food material in good amount resulting enhancement of other component traits finally seed yield. Number of spikelets per panicle showed negative significant correlation with biological yield per hill (rp= -0.160* and rg= -0.167*) and harvest index (rp= 0.377** and rg= -0.388**) at both levels. Days to maturity was negatively associated with biological yield per hill (rp= -0.058 and -0.057) and harvest index (rp= -0.755** and rg= -0.782**) whereas harvest index showed positive and significant association with seed yield per hill (rp= 0.418* and rg= 0.439**).

The correlation coefficient alone is inadequate to interpatate the cause and effect relationships among the traits and ultimately with yield. Path analysis technique furnishes a method portioning the correlation coefficients into direct and an indirect effect provides the information on actual contribution of a trait on the yield. Path coefficient analysis provides an effective way of finding out direct and indirect sources of correlations. The direct and indirect contribution of the morphological traits towards seed yield per hill estimated through path–coefficient analysis is shown in Table 5. The component traits viz., biological yield per hill, number of panicles per hill, harvest index and plant height showed positive and significant correlation with seed yield per hill. The direct effect of biological yield per hill towards total correlation with seed yield was high at phenotypic level whereas it had negative direct
Table 4 Phenotypic (Lower diagonal) and genotypic correlation (Upper diagonal) between seed yield and its component traits in exotic rice genotypes

| SN | Character | DFF   | PH   | NPH  | FLL  | FLW  | PL   | NSP  | DM   | TW   | BYH  | HI   | SYP  |
|----|-----------|-------|------|------|------|------|------|------|------|------|------|------|------|
| 1  | DFF       | **1.000** | -0.076 | 0.118 | 0.357** | 0.034 | 0.358** | 0.381** | 0.203** | 0.177* | 0.123 | -0.063 | 0.090 |
| 2  | PH        | -0.071 | **1.000** | 0.146* | 0.314** | 0.307** | 0.062 | -0.056 | 0.288** | 0.186** | 0.214** | -0.124 | 0.205** |
| 3  | NPH       | 0.119  | 0.141* | **1.000** | 0.279** | 0.249** | 0.070 | -0.254** | 0.014  | -0.172* | 0.726** | 0.458** | 0.557** |
| 4  | FLL       | 0.345** | 0.304** | 0.246** | **1.000** | 0.201** | 0.202** | 0.155*  | 0.205** | 0.061  | 0.190** | -0.037 | 0.160* |
| 5  | FLW       | 0.026  | 0.196** | 0.168*  | 0.146*  | **1.000** | 0.196** | 0.169*  | -0.001 | 0.050  | 0.199** | 0.117  | 0.172* |
| 6  | PL        | 0.354** | 0.063  | 0.066  | 0.192** | 0.136  | **1.000** | 0.047  | -0.089 | -0.017 | 0.115  | 0.139  | -0.133 |
| 7  | NSP       | 0.374** | -0.055 | -0.237** | 0.150*  | 0.107  | 0.046  | **1.000** | 0.408** | 0.265** | -0.167* | -0.388** | -0.090 |
| 8  | DM        | 0.210** | 0.282** | 0.005  | 0.197** | -0.001 | -0.092 | 0.402** | **1.000** | 0.170*  | -0.057 | -0.782** | 0.024 |
| 9  | TW        | 0.114  | 0.156*  | -0.180* | 0.042  | 0.020  | -0.033 | 0.237** | 0.129  | **1.000** | -0.061 | -0.189** | 0.128 |
| 10 | BYH       | 0.104  | 0.203** | 0.646** | 0.166*  | 0.134  | 0.105  | -0.160* | -0.058 | -0.014  | **1.000** | 0.661** | 0.731** |
| 11 | HI        | -0.073 | -0.122 | 0.406** | -0.036 | 0.080  | 0.127  | -0.377** | -0.755** | -0.124 | 0.676** | **1.000** | 0.439** |
| 12 | SYP       | 0.075  | 0.184*  | 0.479** | 0.130  | 0.119  | -0.133 | -0.084 | 0.018  | 0.111  | 0.672** | 0.418** | **1.000** |

Note: *and ** Significant at 5% and 1% levels of significance, respectively. DFF= Days to 50 per cent flowering, PH= Plant height, NPH= Number of productive tillers per hill, FLL= Flag leaf length, FLW= Flag leaf width, PL= Panicle length, NSP= Number of spikelets per panicle, DM= Days to maturity, TW= Test weight, BYH= Biological yield per hill, HI= Harvest index, SYP= Seed yield per hill.
| SN | Characters | DFF | PH | NPH | FLL | FLW | PL | NSP | DM | TW | BYH | HI | r  |
|----|------------|-----|----|-----|-----|-----|----|-----|----|----|-----|----|----|
| 1  | DFF        | G   | 0.057 | -0.004 | 0.007 | 0.020 | 0.002 | 0.020 | 0.022 | 0.012 | 0.010 | 0.007 | -0.004 | 0.090  |
|    |            | P   | 0.071 | -0.005 | 0.009 | 0.025 | 0.002 | 0.025 | 0.027 | 0.015 | 0.008 | 0.007 | -0.005 | 0.075  |
| 2  | PH         | G   | 0.084 | 0.008 | 0.012 | 0.026 | 0.026 | 0.005 | -0.005 | 0.024 | 0.016 | 0.018 | -0.010 | 0.205** |
|    |            | P   | 0.055 | 0.001 | 0.017 | 0.011 | 0.004 | -0.003 | 0.015 | 0.009 | 0.011 | -0.007 | 0.184*  |
| 3  | NPH        | G   | 0.039 | -0.048 | -0.091 | -0.081 | -0.023 | 0.083 | -0.005 | 0.056 | -0.237 | -0.150 | 0.557** |
|    |            | P   | 0.004 | 0.035 | 0.009 | 0.060 | 0.002 | -0.008 | 0.001 | -0.005 | 0.023 | 0.014 | 0.479** |
| 4  | FLL        | G   | -0.001 | -0.001 | 0.000 | -0.001 | -0.001 | -0.001 | -0.001 | -0.001 | -0.001 | 0.001 | 0.160*  |
|    |            | P   | -0.002 | 0.000 | -0.007 | 2  |
| 5  | FLW        | G   | 0.002 | 0.018 | 0.015 | 0.012 | 0.059 | 0.012 | 0.010 | -0.001 | 0.003 | 0.012 | 0.005 | 0.172*  |
|    |            | P   | 0.001 | 0.007 | 0.006 | 0.005 | 0.036 | 0.005 | 0.004 | 0.001 | 0.001 | 0.003 | 0.119  |
| 6  | PL         | G   | -0.082 | -0.014 | -0.046 | -0.045 | -0.228 | -0.011 | 0.020 | 0.004 | -0.026 | -0.032 | -0.133 |
|    |            | P   | -0.080 | -0.014 | -0.043 | -0.031 | -0.225 | -0.011 | 0.020 | 0.007 | -0.024 | -0.029 | -0.133 |
| 7  | NSP        | G   | -0.017 | 0.011 | 0.007 | -0.007 | -0.002 | -0.043 | -0.018 | -0.012 | 0.007 | 0.017 | -0.090 |
|    |            | P   | -0.000 | 0.001 | 0.001 | 1  |
| 8  | DM         | G   | 0.314 | 0.445 | 0.022 | 0.317 | -0.002 | -0.138 | 0.630 | 1.546 | 0.262 | -0.088 | -1.209 |
|    |            | P   | 0.045 | 0.060 | 0.001 | 0.042 | -0.001 | -0.019 | 0.086 | 0.213 | 0.028 | 0.012 | 0.018  |
| 9  | TW         | G   | 0.040 | 0.042 | 0.014 | 0.011 | -0.004 | 0.059 | 0.038 | 0.224 | -0.014 | -0.042 | 0.111  |
|    |            | P   | 0.017 | 0.023 | 0.006 | 0.003 | -0.005 | 0.036 | 0.019 | 0.150 | -0.002 | -0.016 | 0.128  |
| 10 | BYH        | G   | -0.073 | -0.128 | -0.108 | -0.119 | -0.066 | 0.099 | 0.034 | 0.036 | -0.596 | -0.3937 | 0.731** |
|    |            | P   | 0.040 | 0.077 | 0.063 | 0.051 | 0.040 | -0.061 | -0.022 | -0.005 | 0.380 | 0.2567 | 0.672** |
| 11 | HI         | G   | -0.128 | -0.252 | 0.929 | -0.075 | 0.237 | 0.281 | -0.787 | -1.587 | -0.383 | 1.341 | 2.029 | 0.439** |
|    |            | P   | -0.022 | -0.037 | 0.124 | -0.011 | 0.025 | 0.039 | -0.116 | -0.231 | -0.038 | 0.207 | 0.306 | 0.418** |

Note: *and ** Significant at 5% and 1% levels of significance, respectively. DFF= Days to 50% per cent flowering, PH= Plant height, NPH= Number of productive tillers per hill, FLL= Flag leaf length, FLW= Flag leaf width, PL= Panicle length, NSP= Number of spikelets per panicle, DM= Days to maturity, TW= Test weight, BYH= Biological yield per hill, HI= Harvest index, SYP= Seed yield per hill.
effect at genotypic level but it showed major contribution towards the total correlation. The direct effect of harvest index towards total correlation with seed yield was high due to its high direct effect as well as high indirect effects of flag leaf width, panicle length and biological yield per hill. Plant height also exhibited positive significant correlation with seed yield per hill but direct effect of this trait on seed yield was negligible but its effect was contributed indirectly by number of productive tillers per hill, flag leaf length, flag leaf width, panicle length, days to maturity, test weight and biological yield per hill in very small proportion. The maximum direct effect towards the total correlation with seed yield per hill was observed for harvest index followed by days to maturity and test weight. High direct effect for harvest index towards total correlation with grain yield have earlier been reported by Yadav et al. (2010), Yadav et al. (2011). The direct contribution of days to 50 per cent flowering and flag leaf width was positive but low in magnitude. Several workers observed the similar results for days to 50 per cent flowering (Paul et al., 2011). The strong positive correlation between component traits and seed yield per hill with high direct effect indicating the true relationship between them, therefore direct selection though this trait will be effective for yield improvement.

Results of the present study indicated significant variation among the genotypes for all the characters studied and selection would be effective for the characters viz., plant height, number of productive tillers per hill, number of spikelets per panicle, flag leaf length, panicle length, biological yield per hill and harvest index to increase the seed yield per hill as reflected by strong and positive correlation along with high heritability coupled with high genetic advance.

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