Genetic Evaluation and Selection Criteria of Hybrid Rice in Irrigated Ecosystem of Bangladesh

Bangladesh Rice Research Institute, Regional Station, Comilla -3500, Bangladesh
1Genetic Resources and Seed Division, Bangladesh Rice Research Institute, Gezipur 1701, Bangladesh

Abstract: Nineteen hybrid rice were evaluated in order to determine variability and genetic association for grain yield and its component characters. It was observed that all the tested characters had significant variation. The highest genotypic coefficient of variation was found in panicles per m² followed by spikelets per panicles, grain yield, 1000-grain weight and flag leaf area. High heritability was observed for all the tested characters except grains per panicle and harvest index. High heritability and genetic advance was found in panicles per m², spikelets per panicle and 1000-grain weight. Genotypic correlations were higher than the phenotypic correlations in most of the cases. Flag leaf area, days to maturity, grains per panicle, panicles per m², 1000-grain weight and harvest index showed highly significant positive correlation with grain yield both at genotypic and phenotypic levels. Path coefficient analysis of the study revealed that higher harvest index, adequate spikelets per panicles, days to maturity, more panicles per m² and heavy grains had direct effect on grain yield. Grains per panicle had a positive but indirect effect on grain yield through spikelets per panicles and harvest index. Similar trends were also observed in panicle length through spikelets per panicle and in flag leaf area through harvest index.

Key words: Genetic evaluation, selection criteria, hybrid rice, path analysis, heritability, genetic advance

Introduction
The yield level of modern rice varieties obtained from green revolution technologies has reached a plateau especially in irrigated ecosystem. Without an immediate shift in the yield frontier for rice and increased rice production, future rice supplies will not keep up with demand. Hybrid rice helped China in increasing rice production from 129 million tons to 200 million tons annually (Yuan, 1996). Generally hybrid rice offers 30% yield advantage over conventional pure line varieties. Recent breakthrough in tropical hybrid rice technology provide some hope and indication for sustaining future rice production in Bangladesh.

Rice yield depends on many yield-contributing parameters as well as on the environmental factors. As the yield is polygonally controlled and also influenced by its component characters, direct selection for yield is often misleading. Genetic variability, character association pattern and the direct and indirect effect of the yield contributing characters on yield are very useful tools for successful selection of desirable entries. The correlation coefficients between yield and yield components usually show a complex chain of interaction. Considering correlated response, Falconer (1989) suggests that this might sometimes be possible to achieve more rapid progress under selection for a correlated response than from selection for the desired character itself. Accordingly, path coefficient analysis partitions the components of correlation coefficient into direct and indirect effects and visualizes the relationship in a more meaningful way.

At present, the hybrid entries imported and developed by different seed agencies and research stations are being tested every year in on-station and on-farm trials, but no specific selection criteria have yet been reported for the recommendation of hybrid varieties in Bangladesh condition. The present investigation was, therefore, undertaken to study the genetic variability for important economic characters and to determine the nature and types of relationship among yield components through correlation and path analysis, so that appropriate strategies for recommending the suitable hybrid varieties in Bangladesh condition could be worked out.

Materials and Methods
The experiment was conducted at Bangladesh Rice Research Institute, Regional Station, Comilla during boro season in 1998-99, with nineteen hybrid varieties. The entries were tested in a randomized complete block design with three replications. Thirty-five days old seedlings grown in wet seedbed were transplanted in 100 m² plots with 20x15 cm spacing using single seeding per hill. Fertilizers were applied @ 12-66-72, 12-6-0 N, P₂O₅, K₂O, S and Zn per hectare. One-fourth nitrogen and all other recommended fertilizers were applied at final land preparation. Remaining nitrogen was applied in three equal splits, at 15 DAT, 35 DAT and a flowering time. Intercultural operations and pest control measures were done as and when necessary. Firefly 40m² area was harvested for grain yield excluding border area and adjusted at 14% moisture level.

Yield along with plant height (PH), days to maturity (DM), panicle length (PL), panicle per m² (PN), spikelets per panicle (SN), grains per panicle (GN), 1000-grain weight (GW), flag leaf area (FLA), harvest index (HI) and grain yield were recorded and used in the analysis. Flag leaf area was calculated according to Gomez (1983). Genetic variance (σ²g), environmental variance (σ²e), phenotypic variance (σ²p), genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability in broad sense (Hb), genetic advance in percentage of mean (GAPM), genotypic correlation coefficients (r) and phenotypic correlation coefficients (r²) and path coefficient analyses were performed following Singh and Choudhury (1985).

Results and Discussions
Genetic Parameters: The analysis of variance revealed highly significant variations among the varieties for all the characters evaluated (Table 1). The phenotypic variance has been partitioned into genotypic and environmental variances for a clear understanding of the pattern of variations. The highest genotypic and phenotypic variance was found in panicles per m² while spikelets per panicle exhibited the highest environmental variance. The lowest magnitude of genotypic, environmental and phenotypic variance was recorded in harvest index. Range and genotypic coefficient of variation measured the variability of the characters. Phenotypic coefficients of variation were slightly higher than genotypic ones for all evaluated characters indicating the presence of environmental influence to some degree in the phenotypic expression of the characters. Similar results were also
Table 1: Estimate of genetic parameters for ten characters in 19 hybrid rice

<table>
<thead>
<tr>
<th>Characters</th>
<th>Range</th>
<th>MS</th>
<th>Sig</th>
<th>Sde</th>
<th>Stp</th>
<th>GCV</th>
<th>PCV</th>
<th>H</th>
<th>GAPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>PH (cm)</td>
<td>33.0-125.0</td>
<td>435.24**</td>
<td>105.70</td>
<td>8.23</td>
<td>113.83</td>
<td>8.48</td>
<td>34.64</td>
<td>98.88</td>
<td>10.83</td>
</tr>
<tr>
<td>DW (g)</td>
<td>171.60</td>
<td>127.00**</td>
<td>42.33</td>
<td>7.78</td>
<td>43.11</td>
<td>5.69</td>
<td>5.69</td>
<td>98.18</td>
<td>10.21</td>
</tr>
<tr>
<td>PL (cm)</td>
<td>22.60-27.19</td>
<td>6.03**</td>
<td>1.70</td>
<td>0.94</td>
<td>2.03</td>
<td>2.63</td>
<td>26.51</td>
<td>94.44</td>
<td>8.64</td>
</tr>
<tr>
<td>PN</td>
<td>236.374</td>
<td>423.47**</td>
<td>1360.66</td>
<td>96.99</td>
<td>1477.65</td>
<td>13.34</td>
<td>13.31</td>
<td>93.44</td>
<td>26.57</td>
</tr>
<tr>
<td>SN</td>
<td>115-181</td>
<td>295.67</td>
<td>37.73</td>
<td>393.70</td>
<td>12.35</td>
<td>14.24</td>
<td>75.18</td>
<td>22.85</td>
<td></td>
</tr>
<tr>
<td>FG</td>
<td>92-135</td>
<td>372.19**</td>
<td>86.28</td>
<td>58.37</td>
<td>154.64</td>
<td>8.51</td>
<td>11.39</td>
<td>56.79</td>
<td>13.09</td>
</tr>
<tr>
<td>G(Wg)</td>
<td>22.30-30.76</td>
<td>23.58**</td>
<td>7.69</td>
<td>0.50</td>
<td>8.20</td>
<td>10.85</td>
<td>11.20</td>
<td>58.66</td>
<td>21.65</td>
</tr>
<tr>
<td>FLA (cm)</td>
<td>23.55-36.42</td>
<td>28.52**</td>
<td>9.67</td>
<td>2.52</td>
<td>11.19</td>
<td>10.01</td>
<td>11.28</td>
<td>77.45</td>
<td>18.16</td>
</tr>
<tr>
<td>H</td>
<td>0.460-0.580</td>
<td>0.004**</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>6.18</td>
<td>8.28</td>
<td>66.66</td>
</tr>
<tr>
<td>Grain Yield (t/ha)</td>
<td>0.33-3.275</td>
<td>2.173**</td>
<td>0.70</td>
<td>0.09</td>
<td>0.78</td>
<td>12.34</td>
<td>13.09</td>
<td>88.97</td>
<td>22.95</td>
</tr>
</tbody>
</table>

** Significant at 1% level of significance

Table 2: Genotypic (G) and phenotypic (P) correlations among ten characters in 19 hybrid rice

<table>
<thead>
<tr>
<th>Characters</th>
<th>DM</th>
<th>PL</th>
<th>PN</th>
<th>SN</th>
<th>GN</th>
<th>GW</th>
<th>FLA</th>
<th>H</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>PH</td>
<td>0.001</td>
<td>-0.183</td>
<td>0.374</td>
<td>0.323</td>
<td>-0.434</td>
<td>-0.359</td>
<td>0.439</td>
<td>0.406</td>
<td>0.004</td>
</tr>
<tr>
<td>G</td>
<td>0.345</td>
<td>0.439</td>
<td>0.389</td>
<td>0.498</td>
<td>0.268</td>
<td>0.135</td>
<td>0.370</td>
<td>0.038</td>
<td>0.077</td>
</tr>
<tr>
<td>P</td>
<td>0.003</td>
<td>0.002</td>
<td>0.001</td>
<td>0.006</td>
<td>0.006</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
</tr>
</tbody>
</table>

* Significant at 5% level of significance, ** Significant at 1% level of significance

Table 3: Path coefficient analysis showing direct (bold) and indirect effects of nine characters on grain yield in 19 hybrid rice

<table>
<thead>
<tr>
<th>Characters</th>
<th>Effect through</th>
<th>Genotypic correlation with yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>PH</td>
<td>DM, PL, PN, SN, GN, GW</td>
<td>0.040</td>
</tr>
<tr>
<td>DM</td>
<td>-0.005</td>
<td>-0.056</td>
</tr>
<tr>
<td>SN</td>
<td>-0.019</td>
<td>0.018</td>
</tr>
<tr>
<td>GN</td>
<td>-0.013</td>
<td>-0.005</td>
</tr>
<tr>
<td>GW</td>
<td>-0.014</td>
<td>-0.017</td>
</tr>
<tr>
<td>FLA</td>
<td>0.050</td>
<td>-0.045</td>
</tr>
<tr>
<td>H</td>
<td>0.372</td>
<td>0.281</td>
</tr>
</tbody>
</table>

* Significant at 5% level of significance, ** Significant at 1% level of significance

Reported by Akanda et al. (1997). Moderate genotypic and phenotypic coefficient of variation was recorded for panicles per m², spikelets per panicle, 1000-grain weight, flag leaf area and grain yield. The findings were almost supported by Saravanam and Senthil (1997), who obtained moderate genotypic and phenotypic coefficient of variation in plant height, spikelets per panicle and 1000-grain weight in rice. On the other hand, plant height, days to maturity, panicle length and harvest index exhibited low genotypic and phenotypic coefficient of variation in hybrid rice which may be due to presence of both positive and negative alleles in the population.

High heritability was observed in days to maturity, 1000-grain weight, panicles per m², plant height, grain yield, flag leaf area, spikelets per panicle and panicle length while moderate in grains per panicle and harvest index. However, Bhatti et al. (1998) reported high heritability for spikelets per panicle, 1000-grain weight and panicles per plant in rice. Although high heritability estimates have been found to be effective in performing selection of superior genotypes on the basis of phenotypic performance, heritability estimates along with genetic advance will be more useful in predicting the effect for selecting the best individual. High heritability associated with high genetic advance were obtained in panicles per m², spikelets per panicle, 1000-grain weight and grain yield which indicated that the characters were simply inherited in nature controlled by a few major genes or possessed additive gene effects. Similar results were also reported by Lal et al. (1960) for panicles per plant, days to 50% flowering and grain yield in rice. The high heritability estimates with low genetic advance indicates that non additive type of gene action and genotypic x environmental interaction plays a significant role in the expression of the traits as observed in panicle length. Panicles per m², spikelets per panicle and 1000-grain weight had moderate genotypic and phenotypic coefficient of variation, high heritability and high genetic advance which made these three characters most effective in the selection of hybrid rice.

Correlations: Correlation study was made to establish the extent of association between yield and yield attributes in hybrid rice under irrigated ecosystem. Phenotypic and genotypic correlation coefficients between yield and its component traits besides the inter-correlation coefficients among the component traits are presented in Table 2. It was revealed that, in most of the cases, the genotypic correlations were higher than the corresponding phenotypic correlations suggesting that the character association had not been largely

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influenced by environment which are also agreed with Das et al. (1992).

Plant height showed highly significant positive correlation with
percentages. Data in Table 2 show that both at genotypic and
phenotypic level and significant negative correlation with percentages per m², 1000-
grain weight, harvest index and grain yield. However, Mirza et al. (1992) reported positive correlation of plant height with
length. Days to maturity showed highly significant
positive correlation for percentages per m² and grain yield. Percent
length exhibited positive correlation with spikelets per panicle
and negative correlation with 1000-grain weight, harvest
index and yield. Percentages per m² had highly significant
negative correlation with 1000-grain weight and
harvest index but significantly positive with grains per
panicle. The correlations of grains per panicle with 1000-grain
weight, flag leaf area, harvest index and grain yield were
significantly positive. In this aspect, Mirza et al. (1992) also
obtained significant positive correlation between percentages per
panicle and 1000-grain weight. There were highly significant
positive correlations of 1000-grain weight with flag leaf area,
harvest index and grain yield both at genotypic and phenotypic
levels. Flag leaf area showed highly significant positive
relation for harvest index and grain yield. The correlation
between harvest index and grain yield was significantly
positive in present study.

In different studies, Tsuzuki and Umeki (1990), Mirza et al.
reported significant positive correlation of grain yield with
1000-grain weight, grains per panicle and percentages per
plant in rice. Marzal and Palanisamy (1989) obtained significantly
positive correlation of grain yield with days to flowering, flag
leaf area, percentages per plant and grains per plant in hybrid
rice. On the other hand, Kennedy and Rengadamy (1980)
reported highly significant positive correlation of grain yield
with percentages number, harvest index and 1000-grain weight in
hybrid rice. This study revealed that the characters flag leaf
area, days to maturity, grains per panicle, percentages per m²,
1000-grain weight and harvest index were important to be
recommended in the selection for yield improvement of hybrid
rice.

**Path coefficient analysis:** Path coefficient analysis (Table 3)
revealed that the highest positive direct effect on grain yield
was obtained by harvest index followed by spikelets per
panicle, days to maturity, percentages per m², plant height and
1000-grain weight. Accordingly, Scores et al. (1990)
reported positive direct effect of percentages per m², spikelets per
panicle and 1000-grain weight on grain yield in rice, while Selvarani
and Rengadamy (1998) obtained positive indirect effect of harvest
index, days to flowering and percentages number on grain yield in
rice. Maximum direct effect of growth duration and plant
height on grain yield has been reported by Comathineygar
et al. (1988). Highest positive indirect effects on grain yield
were obtained by 1000-grain weight, flag leaf area and percentages
per panicle through harvest index followed by grains per
panicle through spikelets per panicle and panicle length
through spikelets per panicle. The correlation coefficient of 1000-grain weight with
grain yield was almost equal to its direct effect, indicating that
this trait had true relationship with grain yield and direct selection
through this trait will be effective for yield improvement of
hybrid rice. Those kinds of true relationships of grains per
panicle and 1000-grain weight with grain yield have been
reported by Sano et al. (1989). High positive indirect effect of
grains per panicle on grain yield through harvest index and
spikelets per panicle might be due to significant positive
correlation of grains per panicle with the corresponding
growth characters (Table 2). The results suggest that while
using grains per panicle as a selection criterion, harvest index
as well as spikelets per panicle should be given due
importance. Despite of significant positive correlation with grain
yield, flag leaf area showed negative direct effect on grain
yield which has been overcome by its positive and remarkable
indirect effect on grain yield through harvest index, spikelets
per panicle and 1000-grain weight.

The residual effect was moderate (0.475) in the present
study, which was also obtained by Selvarani and Rengadamy
(1998) in rice. This gives an impression that few other
characters than those involved in the present study might also
contribute to yield.

The genetic variability, correlation and path coefficient
analysis of the present study revealed that harvest index,
spikelets per panicle, days to maturity, percentages per m² and
1000-grain weight were the most important yield components
in hybrid rice. The characters also showed moderate to high
heritability and genetic advance in percentage of means.
Therefore, the results suggest that higher harvest index,
adequate spikelets per panicle, days to maturity, more percentages
per m² and larger grains are the important yield contributing
traits and selection of high yielding hybrid rice based on these
traits would be most effective.

**References**

variability, correlation and path analysis in rice (Oryza sativa L.)


and N.M. Miah, 1992. Variability and genetic association in

Fellman, D.S., 1983. Introduction to Quantitative Genetics. 3rd Ed.
English language Book Society, London.

Path coefficient analysis in upland varieties of rice. Madras

The International Rice Research Institute, Philippines, P. 48.

studies in rice (Oryza sativa L.). Madras Agricultural Journal,
78: 380 - 383.

hybrids under low temperature conditions. Madras Agricultural

correlation and genetic parameters in semidwarf cultures of rice.
Oryza, 26: 165-162.


Mirza, M.J., F.A. Haff and A. Mokri, 1997. Correlation studies and
path analysis of plant height, yield and yield components in rice
(Oryza sativa L.) Sorkhe J. Agric., 8: 647 - 652.

Correlation and path analysis of some yield contributing characters
in some high yielding and local varieties of irrigated rice. Bangladesh

variability, heritability and genetic advance in some important

among characters of rice cultivated under wet and conditions
under irrigated with continuous flooding. Revista Ceara, 39: 1-16.


Singh, R.K. and R.D. Choudhary, 1985. Biometrical Methods and
 Quantitative Genetic Analysis. Revised Edn, Kalron Publishers,
Luchana, India, pp 93-96.

and increasing yield in early cultivated rice. 4: Correlation between
grain yield and characters related with yield. Bulletin of the
Faculty of Agriculture, Miyazaki University, Japan, 36: 261 -
269.

Rice Technology. International Rice Research Institute, Los
Banos, Philippines, pp 27-34.