PERFORMANCE OF PROMISING HYBRID RICE IN TWO DIFFERENT ELEVATIONS OF IRRIGATED LOWLAND IN INDONESIA

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ABSTRACT

The hybrid rice program has been established since early 1990’s at the Indonesia Center for Rice Research (ICRR). Twenty-four experimental hybrid rice varieties which have been developed were tested in lowland rice fields in Sukamandi (West Java) and Batang (Central Java) during the dry season and the rainy season of 2012. Randomized complete block design (RCBD) with three replications was used in each location. The results showed that grains yields were affected by locations, seasons, and genotypes. The genotypes x locations x seasons interaction effect was significant; therefore, the best hybrid was different for each location and season. A7/PK36 hybrid has the best performance in Batang during the dry season, while A7/PK40 and A7/PK32 are the best hybrids in the rainy season. In Sukamandi, nine hybrids were identified as better yielder than that of the check cultivar in the dry season, but not so in the rainy season. Using the correlation and path analysis, we found that the number of panicles per hill and the number of filled grains per panicle could be used as selection criteria for yield in hybrid rice.

Keywords: agronomic performance, correlation, hybrid rice, lowland

INTRODUCTION

Rice is an important crop in Indonesia due to its significance as the country’s first staple food. To increase rice production, there is a slim probability for further expansion in rice area; hence, vertical increase in rice productivity is a vital option to increase yield. To achieve this goal, conventional inbreed varieties need to be supplemented with the hybrid form of variety.

Hybrid rice is expected to gain productivity increase derived from the heterotic effect. This technology has been applied succesfully in China since 1976 (Kueneman, 2006). Indonesia has been active in developing hybrid rice as an alternative strategy to improve rice productivity.

Research on hybrid rice in Indonesia began in 1983 with the aim of exploring prospects and constraints of this technology. Since 1998 the research has been further intensified to breed suitable parental lines and $F_1$ hybrid from the local germplasm. Up to 2011, Indonesian Center for Rice Research has released 17 hybrid rice varieties with some yield advantage over inbreed varieties, Ciherang and IR64 as popular varieties. However, hybrid rice which has been released is susceptible to pests and diseases, and the heterotic effect was not stable. Breeding programs to improve the resistance of parental lines and the $F_1$ hybrid have been intensified (Satoto et al., 2013). Parental lines of the hybrids developed in Indonesia are mostly derived from introduced lines, which are more susceptible to stresses as well as pests and diseases. Therefore, it is imperative to develop a hybrid variety using Indonesian parental line, which is well adapted to the local environment by identifying elit lines as restorer and maintainer (Nugraha et al., 2004). Two new CMS/male sterile lines have been developed, namely GMJ4A dan GMJ5A, which are resistant to BPH (Nugraha et al., 2011). Further research has resulted in GMJ6A and GMJ7A male sterile lines which are identified as having good resistance to BLB.

High grain yield of rice has been the primary objective in the breeding programs. The character is complex and controlled by a number of interactive, duplicative, and/or epistatic genes, and is affected by environment (Reddy et al., 1986). High yielding character of hybrid rice is
also determined by the level of heterosis expressed by the hybrid. Chen et al. (2007) stated that the super hybrid rice should have the following criteria: good rice quality, wide adaptation, lodging resistance, resistant to main insects and diseases, and the yield exceeds 8% over control varieties in the national trials.

Grain yield is a complex polygenic quantitative trait, greatly affected by the environment. Hence, selection of superior genotypes based on yield may not be effective. Information on the correlation between yield and its components is important to make formulation for selection criteria of yield. Board et al. (1997) suggest that the yield components which can be used for the selection criteria are: (i) yield components which have positive correlation and high direct effect on grain yield, (ii) it has large direct effect although less correlated with grain yield, and (iii) characters which have negative indirect effect on grain yield through other characters. The research objectives are to evaluate the grain yield and its components of some promising hybrid rice in lowland rice fields and to analyze the relationship between yield and its components.

MATERIALS AND METHODS

Twenty-four new promising hybrid rice are used as testing materials, compared to Hipa10 as hybrid check variety and Ciherang as popular inbred check variety. These hybrids are derived from one CMS introduction (A7), three CMS improved resistant to pest and disease (GMJ3, GMJ6, and GMJ7), and 13 restorer lines from ICRR. Field experiments were conducted during the 2012 dry season (DS) and rainy season (WS) at two locations i.e. Sukamandi, West Java (Alluvial, 16 m above sea level ) and Batang, Central Java (Latosol, 276 m above sea level), Indonesia. Experiments were laid out in a randomized complete block design (RCBD) involving 26 genotypes with three replications. The plot size was 2 x 5 m².

The land for the experiments was plowed and harrowed. Fertilizer of 300 kilos of urea/ha, 100 kilos of TSP/ha, and 100 kilos of KCl/ha were applied following the recommended time and doses. Twenty-one day old seedlings were planted in each designated plot, using one-two seedling per hill, with planting space of 20 x 20 cm. In the 2 x 5 m plot, there were ten rows with 25 hills per row. Replanting when needed was done a week after transplanting. Hand weeding was done when weeds were observed. Standard cultural practices were followed. The crop was protected from insect pest and diseases using chemical control as needed. Harvesting was done manually when 85% of the grains in the upper portion of the panicle were yellow and those at the base are at hard dough stage. Each plot was harvested after cutting one border of row, off-type and abnormal plants. Grain yield and yield components, (panicle length at harvest, number of filled and unfilled grains per panicle, and weight of 1,000 grains) were recorded. Grain yield data and yield components were analyzed using SAS (version 9.1.3) and the analysis of variance in RCBD was used to determine treatment differences using the procedure described by Gomez (1985). Hybrid yield performance was compared with check varieties based on least significant difference (LSD) value at the 5%. Partitioning the correlation coefficient of characters into direct and indirect effects was carried out using the procedure described by Singh and Chaudary (1979).

RESULTS AND DISCUSSION

The combined analysis of variance revealed that the genotype x locations, and genotype x location x season interaction were significant for yield and 1000-grain weight, implying the differential response of genotypes to locations, and to seasons in each location (Table 1). All characters were affected by seasons, while effect of locations and genotypes were significant for yield, panicle length, number of unfilled grain, and 1000-grain weight. However, number of panicle and number of filled grain per panicle were not affected by locations or genotypes.

Performance of Agronomic Traits

The data on mean values and each location for number of panicle per hill (Table 2) showed that all hybrids except GMJ3/PK35 and A7/PK40 produced the same number of panicle per hill as that of Hipa10 and Ciherang. Both hybrids produced significantly higher (15) panicle per hill as compared to 14 and 13 panicle per hill of Hipa10 and Ciherang. Number of panicles per hill is an important yield
component in rice. The hybrid with low tillering capacity is not required in transplanted rice culture.

Generally, larger panicle is associated with high number of grains/panicle resulting in higher productivity. The five hybrids having panicle significantly longer than Ciherang (24.8 cm) were GMJ6/PK32, A7/PK38, A7/PK36, A7/PK21, and GMJ7/PK40. The number of grains/panicle consists of number of filled and unfilled grains/panicle. There were three hybrids resulted significantly in more number of filled grains/panicle than Hipa10 (135); while hybrid A7/PK21 produced significantly more number of filled grains/panicle than Hipa10 and Ciherang (142). Another hybrid produced equal or less number of filled grains per panicle than both of check varieties (Table 3).

The 1000-grain weight in the hybrids ranged from 22.8-29.5 grams (Table 4). None of the hybrids showed significantly higher or lower than Hipa10 (27.1 g) and Ciherang (26.6 g). Hybrids A7/PK37 and GMJ6/PK38 produced the minimum 1000-grain weight (22.8 g). Hybrid GMJ3/PK42 produced the highest (29.5 g) 1000-grain weight. Eight hybrids look more like Ciherang, the most popular rice inbred in the farmers, namely A7/PK99, A7/PK37, A7/PK38, A7/PK36, A7/PK21, A7/PK40, A7/PK42 and A7/PK32. Similarly, 1000-grain weight is also an important component that contributes towards the increase in yield. In Indonesia, farmers will be more interested in developing hybrid varieties if they have the same shape and size as Ciherang.

### Performance of Grain Yield

In average, the grain yield of the hybrid rice was higher in dry season compared to rainy season, while the grain in Sukamandi was also higher than in Batang. In Sukamandi, there were nine hybrid rice which gave higher yield compared to Ciherang as check cultivar during the dry season 2012, but none of the hybrids were better than Ciherang during the rainy season. In Batang, there was one hybrid (A7/PK36) which is better than Ciherang in dry season, while two hybrids (A7/PK40 and A7/PK32) were better than Ciherang in the rainy season.

The grain yields of the hybrids in the dry season ranged from 4.3 t ha⁻¹ (GMJ3/PK43) to 9.4 t ha⁻¹ (GMJ7/PK40) with an average of 7.1 t ha⁻¹, while in the rainy season ranged from 3.1 t ha⁻¹ (GMJ6/PK38) to 7.9 t ha⁻¹ (A7/PK40) with an average of 5.2 t ha⁻¹. The grain yield in the dry season was found higher than in the rainy season. The hybrids showing better performance in the dry season were GMJ7/PK37, A7/PK35, A7/PK37, A7/PK36, A7/PK21, A7/PK40, A7/PK42 and GMJ7/PK40 (Table 3). Standard heterosis is defined as the amount by which a hybrid exceeds the most popular variety. The hybrids gave standard heterosis from 16.1% (GMJ7/PK37) to 25.4% (GMJ7/PK40). None of the hybrids showed better performance than Ciherang in the rainy season except A7/PK40. This hybrid gave grain yield 7% higher over Ciherang.

### Table 1. Combined analysis of variance of yield and agronomic traits of 26 hybrids of rice grown in two locations and two seasons, 2012

<table>
<thead>
<tr>
<th>Source of variance</th>
<th>Df</th>
<th>Mean square characters of:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Grain yield</td>
</tr>
<tr>
<td>Location (L)</td>
<td>1</td>
<td>121.825**</td>
</tr>
<tr>
<td>Season (S)</td>
<td>1</td>
<td>124.464**</td>
</tr>
<tr>
<td>LxS</td>
<td>1</td>
<td>0.442 ns</td>
</tr>
<tr>
<td>Error a</td>
<td>8</td>
<td>1.182</td>
</tr>
<tr>
<td>Genotype (G)</td>
<td>25</td>
<td>5.355**</td>
</tr>
<tr>
<td>LxG</td>
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<td>2.701</td>
</tr>
<tr>
<td>SxG</td>
<td>25</td>
<td>2.396</td>
</tr>
<tr>
<td>LxSxG</td>
<td>25</td>
<td>5.860**</td>
</tr>
<tr>
<td>Error b</td>
<td>200</td>
<td>0.622</td>
</tr>
</tbody>
</table>

Remarks: ** = Significant at 5% level; * = Significant at 1% level; ns = Non significant at 1% level.
### Table 2. Number of panicle per hill and panicle length of 26 hybrids rice grown in two location and two season, 2012

<table>
<thead>
<tr>
<th>No.</th>
<th>Genotypes</th>
<th>Number of panicles per hill at:</th>
<th>Mean</th>
<th>Panicle length (cm) at:</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>Batang</td>
<td>Sukamandi</td>
<td>Mean</td>
<td>Batang</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DS</td>
<td>WS</td>
<td>DS</td>
<td>WS</td>
</tr>
<tr>
<td>1.</td>
<td>GMJ6/PK32</td>
<td>13.5</td>
<td>12.5</td>
<td>12.3</td>
<td>13.9</td>
</tr>
<tr>
<td>2.</td>
<td>GMJ7/PK99</td>
<td>13.7</td>
<td>13.2</td>
<td>16.3</td>
<td>12.0</td>
</tr>
<tr>
<td>3.</td>
<td>GMJ3/PK39</td>
<td>14.7</td>
<td>14.1</td>
<td>15.3</td>
<td>13.2</td>
</tr>
<tr>
<td>4.</td>
<td>GMJ7/PK39</td>
<td>13.8</td>
<td>13.0</td>
<td>14.9</td>
<td>12.8</td>
</tr>
<tr>
<td>5.</td>
<td>GMJ3/PK35</td>
<td>14.9</td>
<td>14.5</td>
<td>16.7</td>
<td>14.4</td>
</tr>
<tr>
<td>6.</td>
<td>GMJ7/PK37</td>
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<td>13.0</td>
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<td>13.5</td>
</tr>
<tr>
<td>7.</td>
<td>GMJ7/PK33</td>
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<td>14.3</td>
<td>12.5</td>
<td>12.8</td>
</tr>
<tr>
<td>8.</td>
<td>A7/PK99</td>
<td>14.9</td>
<td>14.3</td>
<td>15.5</td>
<td>12.7</td>
</tr>
<tr>
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<td>A7/PK35</td>
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<td>9.4</td>
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<td>9.5</td>
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<td>16.9</td>
<td>14.1</td>
</tr>
<tr>
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<td>15.6</td>
<td>14.9</td>
<td>13.5</td>
</tr>
<tr>
<td>13.</td>
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<td>15.</td>
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<td>13.4</td>
</tr>
<tr>
<td>17.</td>
<td>A7/PK42</td>
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<td>14.8</td>
<td>14.8</td>
<td>13.6</td>
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<tr>
<td>18.</td>
<td>GMJ3/PK43</td>
<td>13.4</td>
<td>13.4</td>
<td>13.1</td>
<td>13.2</td>
</tr>
<tr>
<td>19.</td>
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<td>13.1</td>
<td>14.7</td>
<td>12.4</td>
</tr>
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<td>12.4</td>
<td>14.4</td>
<td>12.8</td>
</tr>
<tr>
<td>21.</td>
<td>A7/PK32</td>
<td>13.3</td>
<td>12.7</td>
<td>16.0</td>
<td>13.9</td>
</tr>
<tr>
<td>22.</td>
<td>GMJ7/PK40</td>
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<td>14.5</td>
<td>14.2</td>
<td>12.9</td>
</tr>
<tr>
<td>23.</td>
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<td>13.7</td>
<td>15.5</td>
<td>12.2</td>
</tr>
<tr>
<td>24.</td>
<td>GMJ6/PK38</td>
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<td>14.1</td>
<td>14.4</td>
<td>12.9</td>
</tr>
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<td>25.</td>
<td>Hipa10 (Check)</td>
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<td>14.0</td>
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<td>12.1</td>
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<tr>
<td>26.</td>
<td>Ciheraang (Check)</td>
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<td>12.1</td>
</tr>
<tr>
<td>Mean</td>
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<td>14.0</td>
<td>13.4</td>
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<td>13.0</td>
</tr>
<tr>
<td>Mean (location)</td>
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<td>13.9</td>
<td>14.7</td>
<td>13.0</td>
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<tr>
<td>Mean (season)</td>
<td>14.3⁵</td>
<td>12.9⁵</td>
<td>14.0</td>
<td>12.9</td>
<td>13.8</td>
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<tr>
<td>LSD 5%</td>
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<td>1.1</td>
<td>1.1</td>
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<td>1.8</td>
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<tr>
<td>Coefficient Variation (%)</td>
<td>4.9</td>
<td>4.9</td>
<td>11.0</td>
<td>8.53</td>
<td>8.5</td>
</tr>
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</table>

Remarks: DS= dry season; WS= wet season; ⁵ and ⁶ are mean of the character for dry and rainy season respectively
Table 3. Number of filled and unfilled grains per panicle of 26 hybrids rice grown in two location and two season, 2012

<table>
<thead>
<tr>
<th>No.</th>
<th>Genotypes</th>
<th>Number of filled grains/panicle at:</th>
<th>Mean</th>
<th>Number of unfilled grains/panicle at:</th>
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<td>Sukamandi</td>
<td>Mean</td>
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<td></td>
<td>DS</td>
<td>WS</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>GMJ6/PK32</td>
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</tr>
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<td>154.2</td>
</tr>
<tr>
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<td>GMJ3/PK32</td>
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<td>162.1</td>
<td>111.9</td>
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<td>Cihernang</td>
<td>127.3</td>
<td>138.7</td>
<td>159.1</td>
</tr>
</tbody>
</table>

| Mean (location) | 150.3 | 126.3 | 53.9 | 61.4 | 120.8 | 179.9 | 135.3 | 117.3 | 138.3 | 60.6 | 47.3 | 42.7 | 80.0 | 57.6 |
| Mean (season)   | 128.1a | 148.6b | 51.7a | 63.6b | 30.3 | 120.9 | 68.7 | 38.0 | 32.9 | 21.8 | 25.6 | 19.9 | 38.5 | 14.1 |

| Coefficient Variation (%) | 15.3 | 41.9 | 27.9 | 19.8 | 30.2 | 21.2 | 34.5 | 29.1 | 29.7 | 31.4 |

Remarks: DS=dry season; WS= wet season; a and b are mean of the character for dry and rainy season respectively
Table 4. One-thousand grain weight and grain yield of 26 hybrids rice grown in two locations and two seasons, 2012

<table>
<thead>
<tr>
<th>No.</th>
<th>Genotypes</th>
<th>1000-grain weight (g) at:</th>
<th>Grains yield (t ha⁻¹) at:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Batang</td>
<td>Sukamandi</td>
<td>Mean</td>
</tr>
<tr>
<td></td>
<td>DS</td>
<td>WS</td>
<td>DS</td>
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<td>1.</td>
<td>GMJ6/PK32</td>
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<td>27.4</td>
</tr>
<tr>
<td>2.</td>
<td>GMJ7/PK99</td>
<td>28.6</td>
<td>26.4</td>
</tr>
<tr>
<td>3.</td>
<td>GMJ3/PK39</td>
<td>29.2</td>
<td>29.6</td>
</tr>
<tr>
<td>4.</td>
<td>GMJ3/PK99</td>
<td>30.6</td>
<td>28.4</td>
</tr>
<tr>
<td>5.</td>
<td>GMJ3/PK35</td>
<td>28.7</td>
<td>30.6</td>
</tr>
<tr>
<td>6.</td>
<td>GMJ7/PK37</td>
<td>26.7</td>
<td>25.2</td>
</tr>
<tr>
<td>7.</td>
<td>GMJ7/PK33</td>
<td>27.9</td>
<td>28.9</td>
</tr>
<tr>
<td>8.</td>
<td>A7/PK99</td>
<td>28.0</td>
<td>25.5</td>
</tr>
<tr>
<td>9.</td>
<td>A7/PK35</td>
<td>27.6</td>
<td>28.5</td>
</tr>
<tr>
<td>10.</td>
<td>A7/PK37</td>
<td>25.6</td>
<td>27.6</td>
</tr>
<tr>
<td>11.</td>
<td>A7/PK38</td>
<td>27.9</td>
<td>26.1</td>
</tr>
<tr>
<td>12.</td>
<td>A7/PK36</td>
<td>25.9</td>
<td>26.0</td>
</tr>
<tr>
<td>14.</td>
<td>GMJ3/PK40</td>
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<td>30.6</td>
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<td>15.</td>
<td>A7/PK40</td>
<td>25.9</td>
<td>27.1</td>
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<tr>
<td>16.</td>
<td>GMJ3/PK42</td>
<td>31.0</td>
<td>30.5</td>
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<td>18.</td>
<td>GMJ3/PK43</td>
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<td>29.1</td>
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<td>19.</td>
<td>GMJ3/PK97</td>
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<td>23.2</td>
</tr>
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<td>20.</td>
<td>GMJ3/PK32</td>
<td>29.0</td>
<td>29.4</td>
</tr>
<tr>
<td>22.</td>
<td>GMJ7/PK40</td>
<td>27.9</td>
<td>27.1</td>
</tr>
<tr>
<td>23.</td>
<td>GMJ6/PK36</td>
<td>27.2</td>
<td>28.6</td>
</tr>
<tr>
<td>25.</td>
<td>Hipa10</td>
<td>27.3</td>
<td>26.8</td>
</tr>
<tr>
<td>26.</td>
<td>Ciherang</td>
<td>26.7</td>
<td>25.5</td>
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</table>

Mean

<table>
<thead>
<tr>
<th>Mean (location)</th>
<th>DS</th>
<th>WS</th>
<th>DS</th>
<th>WS</th>
<th>Mean</th>
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<tbody>
<tr>
<td>26.7</td>
<td>28.2</td>
<td>6.7</td>
<td>5.3</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mean (season)</th>
<th>DS</th>
<th>WS</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>27.7</td>
<td>27.3</td>
<td>5.3</td>
<td>6.7</td>
</tr>
</tbody>
</table>

LSD 5%

| Coefficient Variation (%) | 2.2 | 4.7 | 2.2 | 5.2 | 14.4 | 8.3 | 19.8 | 12.7 | 12.7 | 16.4 |

Remarks: DS=dry season; WS= wet season; a and b are mean of the character for dry and rainy season respectively.
Table 5. Correlation coefficients among characters in Batang (under the diagonal) and Sukamandi (above the diagonal)

<table>
<thead>
<tr>
<th>Characters</th>
<th>Grain yield</th>
<th>No. of prod. tillers/pan</th>
<th>Panicle length</th>
<th>No. of filled grains/pan.</th>
<th>No. of unfilled grains/pan.</th>
<th>1000-grain weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain yield</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of prod. tillers/pan</td>
<td>0.21**</td>
<td>-0.17* ns</td>
<td>-0.25**</td>
<td>-0.36**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panicle length</td>
<td>0.05 ns</td>
<td>-0.01 ns</td>
<td>-0.18 ns</td>
<td>0.27**</td>
<td>0.26**</td>
<td></td>
</tr>
<tr>
<td>No. of filled grains/pan.</td>
<td>0.12 ns</td>
<td>-0.06 ns</td>
<td>-0.43**</td>
<td>-0.29**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of unfilled grains/pan</td>
<td>0.07 ns</td>
<td>0.04 ns</td>
<td>0.02 ns</td>
<td>-0.40**</td>
<td>0.41**</td>
<td></td>
</tr>
<tr>
<td>1000-grain weight</td>
<td>-0.32**</td>
<td>-0.07 ns</td>
<td>0.01 ns</td>
<td>-0.24**</td>
<td>0.17**</td>
<td></td>
</tr>
</tbody>
</table>

Remarks: ** = Significant at 1% probability level; ns = Non significant

The data on average yield revealed that only one hybrid produced significantly higher paddy yield than Ciherang (inbreed check and popular variety) and Hipa10 (hybrid check variety), namely A7/PK40 (Table 4). The average yield of hybrids at ranged from 4.5 t ha\(^{-1}\) (GMJ3/PK99) to 7.7 t ha\(^{-1}\) (A7/PK40). On the average, A7/PK40 produced the highest yield (7.7 t ha\(^{-1}\)) compared to all check varieties and the other hybrid rice, followed by A7/PK37 (7.3 t ha\(^{-1}\)). The yield advantage of hybrid rice over inbreed or local varieties has already been reported by several researchers (Akram et al., 2007; Satoto et al., 2007; Akhter et al., 2007; Widyastuti and Satoto, 2012).

**Correlation and Path Analysis**

Grain yield is a complex trait and highly dependent on the other agronomic characters (Hairmansis et al., 2010). All possible correlations among the different characters for each location were measured (Table 5). In Batang, grain yield exhibited significantly positive correlation with number of panicles per hill (r=0.21) and also exhibited significantly negative correlation with 1000-grain weight (r=-0.32). Panicle length showed positive correlation with the number of filled grain per panicle (r=0.19). While the number of unfilled grains per panicle had a positive correlation with 1000-grain weight (r=0.17).

In Sukamandi, grain yield also showed significantly positive correlation with the number of panicles per hill (r=0.21) and the number of filled grains per panicle (r=0.20). Panicle length revealed positive correlation with the number of unfilled grains per panicle (r=0.27) and 1000-grain weight (r=0.26). Meanwhile, the number of unfilled grains per panicle had positive correlation with 1000-grain weight (r=0.41). Similarly the result of the study conducted by Akinwale et al., (2011) revealed that the number of panicles per plant, panicle weight and the number of grains per panicle were the most important yield components.

Generally, the study conducted at two locations revealed the same pattern of correlation among different characters. Hence, intensive selection on the positive side number of tillers per plant and number of filled grains per panicle since these characters showed positive correlation with grain yield (Table 5).

Table 6 explains the details of agromonic character effects on grain yield and its relationship with each other in the determination of rice yield. The two locations showed different direct effects of agronomic traits on yield. Batang has Latosol soil type and altitude 16 m above sea level; the path analysis showed that the number of panicles per hill, panicle length, and the number of unfilled grains per panicle had significant positive direct effect on grain yield. Meanwhile, Sukamandi which has Alluvial soil type and altitude 276 meters above sea level; the path analysis result indicated that the number of panicles per hill and the number of filled grains per panicle had significant positive direct effect on grain yield, with correlation value of 0.099 and 0.139 respectively.
Table 6. Direct and indirect of yield-related traits

<table>
<thead>
<tr>
<th>Characters</th>
<th>Direct and indirect effect</th>
<th>Location: Sukamandi</th>
<th>Location: Batang</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of panicles/hill</td>
<td>0.099</td>
<td>0.007</td>
<td>-0.003</td>
</tr>
<tr>
<td>Panicle length</td>
<td>-0.010</td>
<td>-0.071</td>
<td>-0.025</td>
</tr>
<tr>
<td>No. of filled grains/panicle</td>
<td>-0.002</td>
<td>0.013</td>
<td><strong>0.139</strong></td>
</tr>
<tr>
<td>No. of unfilled grains/panicle</td>
<td>-0.011</td>
<td>-0.019</td>
<td>-0.059</td>
</tr>
<tr>
<td>1000-grain weight</td>
<td>-0.037</td>
<td>-0.019</td>
<td>-0.040</td>
</tr>
</tbody>
</table>

Information on the contribution of each agronomic character to grain yield is very useful for breeders as the indirect selection of grain yield during the early generation before conducting replicated yield trials (Samonte et al., 1998). However, this study also showed high residual effect coefficient, namely 0.908 and 0.927, which indicated there were other variables which determined rice grain yield and had not been explained in this experiment. Further studies are required to elucidate the relationship between the grain yield and the other morpho-physiological traits.

CONCLUSION AND SUGGESTIONS

From the research, it is concluded that among F₁ hybrids rice, the identified superior performing hybrids A7/PK37 and A7/PK40 which have good performance for mean yield and its component are also resistant to BLB strain III. Based on correlation and path analysis, the number of panicles per hill and the number of filled grains per panicle could be used as selection criteria for yield in hybrid rice.

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REFERENCES


