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# CHARACTERISTICS OF EIGHT F7 (7th GENERATION) RICE GENOTYPES FROM PEDIGREE SELECTION

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**Abstracts**
Rice (Oryza sativa L.) is a staple food crop globally, with rising demand. In Indonesia, rice is a crucial commodity, with consumption reaching 30.90 million tons in 2023 and per capita production exceeding 100 kg. Despite this, domestic production falls short of meeting the national carbohydrate needs, highlighting the need for improved productivity to ensure food security. This study evaluated eight F7 rice genotypes, derived from crosses of local and national varieties, to identify new superior genotypes. Conducted at the Teaching Farm Seed Technology from May to November 2023, the experiment used a Randomized Block Design (RBD) with eight F7 genotypes, two comparison varieties, namely Gilirang and Pandan Wangi. Observations included plant height, tiller number, flowering age, panicle length, and grain yield per hill and hectare. Data were analyzed using variance analysis with F and LSD tests at a 0.05 significance level. Results indicated that all eight F7 genotypes outperformed the Pandan Wangi and Gilirang varieties. Genotypes BG2 and GB1 excelled in tiller number and grain yield per hectare, while GB3 had the highest 1000-grain weight. The high heritability of observed traits confirmed the significant role of genetics in rice quality, indicating the potential of new genotypes to boost future productivity.

**Keywords:** Genotypes, rice, characteristics, productivity

## INTRODUCTION

Rice (*Oryza sativa L.*) is a main food crop worldwide with increasing demand (1-3). As an important cereal, rice is a staple food for one-third of the global population, including in Asia. In Indonesia, it is a strategic food commodity and a priority in the development of the agricultural sector (4,5). The cultivation has spread to almost all regions of the country, serving as a main source of carbohydrates with an estimated consumption of approximately 30.90 million tons per year in 2023 and annual domestic production per capita exceeding 100 kg (6). However, domestic production is still unable to meet all carbohydrate needs. This is because the percentage rate of increase in food production, particularly rice, each year should be higher than population growth to achieve food security (7).

The main problem in achieving food security in Indonesia is the demand for food that is growing faster than supply. The shortage of food availability is expected to increase due to changes in consumption patterns, conversion of rice fields to non-rice fields, and stagnation in productivity growth because of limited genetic capacity. However, productivity capacity of existing rice varieties is difficult to increase even when given optimal agricultural inputs. To overcome the limited increase in productivity of existing rice varieties, there is a need to assemble new genotypes that have superior characteristics by using genetic sources as parents from local and national varieties.

Plant breeders at the Polinela Seed Technology Study Program have succeeded in developing several new rice genotypes by combining parents from superior local and national genetic sources. The results of the crosses have reached the F7 generation, with phenotypic appearance in the F6 generation showing very superior characteristics. However, there is concern about whether the superior phenotypic characteristics of the F6 generation will continue to be inherited by the F7 generation. This shows the need for further analysis to ensure that selection in the next generation is more effective in producing new superior genotypes. Therefore, this research aimed to evaluate eight F7 rice genotypes from crosses of superior local and national varieties to produce new superior genotypes.

## MATERIALS AND METHODS

This research was conducted in the paddy fields of the Teaching Farm, Seed Technology Study Program, Department of Food Crop Cultivation, Lampung State Polytechnic, over a period of 7 months, from May to November 2023. The research employed a Randomized Complete Block Design (RCBD), with treatments consisting of eight genotypes, namely GB1, GB2, GB3, GB4, GB5, GB6, BG1, BG2, two comparison varieties, namely Gilirang and Pandan Wangi . The variables observed in this study were: plant height, maximum number of tillers, number of productive tillers, harvest time, flowering time, panicle length, number of grains, number of filled grains, number of empty grains, weight of 1000 grains, grain yield, and productivity. The data were analyzed using analysis of variance (ANOVA) at the 5% level to determine the significant effects of the treatments. Significant results were further tested using the Least Significant Difference (LSD) test at the 5% level.

The broad-sense heritability ($h^2$) was calculated using the following equation:

The calculation of heritability values is: $$h^2 = \frac{\sigma^2 g}{\sigma^2 p}$$

Explanation:

$h^2$ = Broad-sense heritability value

$\sigma^2 g$ = Genetic variance value

$\sigma^2 p$ = Phenotypic variance value

Heritability ($h^2$) is classified as follows: high if the heritability value ($h^2$) is greater than > 50%, moderate if the heritability value ($h^2$) is between 20% - 50%, and low if the heritability value ($h^2$) is less than <20%.

## RESULT AND DISCUSSIONS

Statistical analysis showed significant differences in the maximum number of panicles, the number of productive tillers, and plant height in eight F7 generation rice genotypes. Based on the results, genotypes BG2 and GB1 were superior with the highest maximum number of tillers, 26.1 and 25.3, respectively. The number of productive tillers was better than other genotypes, including Gilirang and Pandan Wangi. BG2, GB1, GB2, and GB3 showed high potential, with a maximum range of 18.1–26.1 stems and productive tiller of 14.0–20.3 stems. (8) stated that the diversity of genetic composition caused variation in the number of effective tillers per plant. According to the (9), six genotypes were included in the high potential category (20–25 tillers), while GB5 and GB6 were in the medium category (10–19 tillers). This was supported by (10), who reported that productive tiller was among the most important yield components since the final yield was significantly determined by the number of tiller panicles per unit area. Plant height was found to be an essential growth parameter because it affected characteristics contributing to yield, thereby determining grain production (8). The analysis results of new rice genotypes showed a higher plant height of 110.0 - 125.7 cm than the Gilirang and Pandan Wangi, with Pandan Wangi as the lowest.

Table 2. Characteristics analysis on the maximum number of tillers, number of productive tillers, plant height, and flowering age of eight F7 rice genotypes.

| Genotypes | Plant Height | Maximum Number of Tillers | Number of Productive Tillers |
|---|---|---|---|
| | (cm) | (stems) | (cm) |
| BG 2 | 125.7 a | 26.1 a | 20.3 a |
| GB 1 | 123.4 a | 25.3 a | 19.1 a |
| GB 2 | 121.9 ab | 23.1 ab | 16.1 b |
| GB 3 | 119.4 abc | 20.4 bc | 16.0 b |
| GB 3.1 | 116.1 bcd | 19.9 bc | 15.3 bc |
| GB 4 | 113.5 cd | 19.7 bc | 15.1 bc |
| GB 5 | 110.2 de | 18.7 c | 14.9 bcd |
| GB 6 | 110.0 de | 18.1 c | 14.0 bcd |
| Gilirang | 107.2 e | 17.3 c | 13.6 cd |
| Pandan Wangi | 84.3 f | 17.3 c | 12.7 d |
| BNT | 7.0 | 4.0 | 2.3 |

Description: Numbers followed by the same letter in the same column show no significant difference according to the 5% BNT test.

Early maturing plants are preferred by farmers to enable multiple planting and harvesting approximately two or three times to maximize land potential (11). The use of earlier maturing rice varieties is expected to enable farmers to maximize the potential of their land (12) GB6 genotype flowers the fastest, equivalent to Gilirang, while BG2 has the slowest at 83.6 days. Furthermore, GB5 genotype flowers faster than BG2, GB1, and GB2. As shown in Table 3, harvesting age varies significantly across genotypes, with BG2 the slowest (112.7 days) and GB6 the fastest (108.7 days).

**Table 3.** Characteristics analysis of harvest age, flowering age, panicle length, number of grains, and number of filled grains of eight F7 rice genotypes.

| Genotypes | Harvest Age | Flowering Age | Panicle Length | Amount of Rice | Total Filled Rice Grain |
|---|---|---|---|---|---|
| | (DAP) | (Day) | (cm) | (Grain) | (Grain) |
| BG 2 | 112.7 a | 83.6 a | 26.6 a | 228.7 a | 170.2 a |
| GB 1 | 111.8 ab | 82.1 b | 26.3 ab | 195.0 b | 153.7 ab |
| GB 2 | 110.9 bc | 81.6 bc | 26.,0 ab | 188.1 bc | 151.9 ab |
| GB 3 | 110.6 bcd | 80.8 bcd | 25.9 ab | 186.5 bcd | 150.1 abc |
| GB 3.1 | 110.3 cd | 80.5 cd | 25.7 b | 174.8 cde | 140.6 bcd |
| GB 4 | 109.7 cde | 80.4 cd | 24.5 c | 169.3 cdef | 130.5 cde |

| | | | | | |
|---|---|---|---|---|---|
| GB 5 | 109.5 de | 80.1 d | 24.3 c | 167.7 def | 129.8 de |
| GB 6 | 108.7 ef | 78.5 e | 23.2 d | 158.9 ef | 124.7 de |
| Gilirang | 107.8 f | 78.1 e | 23.1 de | 150.9 f | 118.0 ef |
| Pandan Wangi | 107.6 f | 75.2 f | 22.2 e | 124.3 g | 103.1 f |
| BNT | 1.4 | 1.4 | 0.94 | 19.7 | 20.2 |

Description: Numbers followed by the same letter in the same column show no significant difference according to the 5% BNT test.

Panicle length is one of the key traits evaluated by rice farmers in yield analysis, as longer panicles with more grains provide greater benefits (13). In this research, genotypes BG2, GB1, BG2, GB3, and GB3.1 had longer panicles compared to GB4, GB5, GB6, as well as Gilirang and Pandan Wangi. Specifically, BG2 recorded the highest number of grains per panicle with an average of 228.7 grains. BG2, GB1, BG2, and GB3 also had more filled grains per panicle compared to GB5, GB6, Gilirang, and Pandan Wangi. Meanwhile, Gilirang and Pandan Wangi produced fewer filled grains per panicle. GB6 genotype had the lowest number of empty grains per panicle, while BG2 and GB1 showed the highest, affecting grains productivity per hectare, as presented in Table 3. According (14) and (15), rice yield is the product of the number of panicles per unit area, the percentage of grains per panicle, and the weight of 1000 grains.

Table 4. Characteristics analysis of total empty grains, weight of 1000 grains, grain yield per m$^2$, and grain yield/hectare of eight rice genotypes.

| Genotypes | Number of Empty Rice Grain | Weight of 1000 Rice Grains | Rice Yield/m² | Productivity/Ha-$^1$ |
|---|---|---|---|---|
| | (Grain) | (g) | (kg) | (ton) |
| BG 2 | 58.5 a | 26.6 e | 0.5 e | 4.9 e |
| GB 1 | 57.7 a | 27.7 c | 0.6 bc | 6.5 bc |
| GB 2 | 43,1 b | 25.5 f | 0.6 de | 5.6 d |
| GB 3 | 37.9 bc | 25.2 f | 0.7 a | 7.5 a |
| GB 3.1 | 36.3 bc | 30.3 a | 0.7 ab | 6.8 ab |
| GB 4 | 34.2 cd | 29.8 b | 0.7 ab | 6.8 ab |
| GB 5 | 31.9 cd | 27.0 d | 0.6 cd | 5.9 cd |
| GB 6 | 28.7 d | 27.0 de | 0.6 bc | 6.4 bc |
| Gilirang | 21.3 e | 24.5 g | 0.6 bcd | 6.1 bcd |
| Pandan Wangi | 21.1 e | 26.8 e | 0.6 bc | 6.5 bc |
| BNT | 7.02 | 0.44 | 0.07 | 0.7 |

Description: Numbers followed by the same letter in the same column show no significant difference according to the 5% BNT test.

Based on the results, GB 3.1 had the highest 1000 grain weight of 30.3 g, while the BG2 and GB3 genotypes weighed 25.5 g and 25.2 g, respectively. Gilirang showed a lighter weight compared to these new genotypes, while Pandan Wangi was also used for comparison (Table 4). Higher 1000-grain weight tended to be positively correlated with grain yield per hectare, particularly at an elevated number of grains per panicle, which contributed to increased productivity. Eight F7 rice genotypes showed differences in grain yield productivity per hectare. GB3 had significantly higher productivity than BG2, GB1, GB2, GB5, GB6, Gilirang, and Pandan Wangi varieties, but was equivalent to GB3.1 and GB4. According to (8), rice grain yield could be influenced by tillering ability. Although few tillers had the potential to reduce the number of panicles produced, several tillers could cause high mortality, small panicle size, poor grain filling, and decreased grain yield.

Table 5. Analysis of Heritability Estimate Values of Eight F7 Rice Genotypes

| No | Observed Characters | $\sigma_e^2$ | $\sigma_p^2$ | $\sigma_g^2$ | $h^2$ |
|---|---|---|---|---|---|
| 1 | Maximum Number of Tillers | 5.33 | 10.20 | 8.42 | 0.83 |
| 2 | Number of Productive Tillers | 1.77 | 5.66 | 5.07 | 0.90 |
| 3 | Max Plant Height at Leaf Tip | 8.22 | 86.71 | 83.97 | 0.97 |
| 4 | Max Plant Height at Panicle Tip | 16.79 | 141.37 | 135.78 | 0.96 |
| 5 | Flowering Age | 0.67 | 5.54 | 5.32 | 0.96 |
| 6 | Harvest Age | 0.69 | 2.73 | 2.50 | 0.92 |
| 7 | Panicle Length | 0.30 | 2.41 | 2.31 | 0.96 |
| 8 | Number of Grains/Panicle | 132.25 | 785.92 | 741.83 | 0.94 |
| 9 | Number of Filled Rice Grains/Panicle | 138.10 | 394.23 | 348.19 | 0.88 |
| 10 | Number of Empty Rice Grains/Panicle | 16.75 | 169.79 | 164.20 | 0.97 |
| 11 | Weight of 1000 Grains (g) | 0,07 | 3,49 | 3,47 | 0,99 |
| 12 | Rice Grain Yield/m² (kg) | 0,00 | 0,01 | 0,00 | 0,88 |
| 13 | Rice Grain Yield/Ha (ton) | 0,18 | 0,52 | 0,46 | 0,88 |

Heritability estimation is the proportion of variation that can be transmitted to tillers in the next generation, where genetic progress measures gain during selection (13). In this research, heritability for 12 characteristics from eight F7 rice genotypes showed values above 0.8. This showed that the phenotypic characteristics of the F7 rice and two comparison varieties were influenced by genetic factors, as shown in Table 5. (16-18) stated that characteristics with high heritability values were more controlled by genetic factors. According to (19, 20), high heritability values showed that the influence of genetic factors was greater than environmental. This was because wide genetic diversity could increase the effectiveness of selection programs on characteristics (21).

The appearance of diverse phenotypic characteristics from eight new rice genotypes in F7 facilitated the selection process. The value of genetic variation ($\sigma g^2$) which was higher than environmental (σe²) showed that genetic factors had a greater influence on rice characteristics. Productivity of new rice genotypes was more influenced by genetic factors. According to (22-24), the real genetic variability among individuals in breeding materials assisted in determining the most efficient selection procedure. Characteristics with high heritability and genetic progress were mostly governed by additive gene effects, making direct selection based on phenotypic expression effective (25, 26).

## CONCLUSION

Based on the results of the research conducted, the following conclusions can be drawn:

1. The analysis revealed significant differences in the maximum number of panicles, productive tillers, and plant height among eight F7 rice genotypes.
2. BG2 and GB1 excelled with the highest maximum number of tillers, 26.1 and 25.3 respectively, and also had better productive tillers compared to other genotypes such as Gilirang and Pandan Wangi.
3. GB3.1 recorded the highest 1000-grain weight at 30.3 g, followed by BG2 with 25.85 g and GB3 with 25.2 g, in comparison, Gilirang had a lower weight.
4. The heritability values for 10 characteristics exceeded 0.8, indicating a strong genetic influence.

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