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Agromorphological and Physicochemical Characteristics of F8 Rice Lines Derived from IR64 × Nagdong Cross

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ABSTRACT

The amylose content of rice influences its taste and texture. Large-scale imports suit the community's demand for low-amylose rice. The Faculty of Agriculture at the University of Jember has a Japonica plant breeding line that crosses local rice types, specifically IR64, to generate stable progeny. However, it lacks several agromorphological and physicochemical investigations. Agromorphological characteristics include plant height, number of tillers, number of seeds per panicle, weight of 100 grains, and The Agrotechnology Laboratory at the University of Jember conducted physicochemical tests on amylose concentration, swelling power, gel consistency, and gelatinization temperature. The findings revealed that all observation variables were significantly different, except for plant height and gel consistency. The plant's height was the same as its parent, semi-dwarf; the number of tillers was medium to good; the number of seeds per panicle was 103−108; and the weight of 100 grains was 2.877−3.265 g. Each strain had a low amylose content ranging from 13.87% to 15.85%, a swelling power of 6.61% to 8.93%, a soft gel consistency, and a gelatinization temperature of less than 60°C.

Keywords: agromorphology, amylose, physicochemical, IR64

INTRODUCTION

Current rice production and developments have reached levels adequate to meet Indonesia's food requirements. However, several local rice varieties are losing appeal. The growing public awareness of rice is a considerable barrier to changing demand toward higher-quality rice. Furthermore, the era of globalization, which brings knowledge from all over the world closer together and enables access, has made it unavoidable to compare local rice to other varieties. Japonica rice is a rice cultivar from East Asia. It has a chewy, sticky consistency that does not disintegrate even after being cooked for an extended duration.

Knowing this, Indonesia sees an annual increase in rice imports from East Asian countries. The Central Statistics Agency (BPS) reported that Indonesia imported 90,028 tons of Japonica rice in 2019. According to Setyowati and Kurniawati (2015), most Indonesians prefer softer, slightly sticky rice over dry rice. Breeding was carried out by crossing two rice subspecies, Nagdong and IR64, which produced stable progeny. As a result, this study was expected to provide an overview of the potential for cross-bred rice between the two obtained lines.

Rice's low amylose level gives it a sticky, slightly glossy, and soft texture after cooking. Rice from the Indica variety with a high amylose concentration yields dry and firm grains. Japonica rice is chosen due to its fluffier texture, which results in soft and sticky rice. Rice with an amylose level of 9% to 20% is deemed low (Danbaba *et al*. 2011). Japonica has an amylose content ranging from 10% to 24%, Indica has an amylose content ranging from 23% to 31%, and local rice, or Javanica, has a content that is nearly identical to that of high amylose rice, ranging from 20% to 25% (Sitaresmi *et al*. 2013).

According to Parikh *et al*. (2012), the planting environment had a significant impact on observed agromorphological character variability. One strategy to reduce negative environmental impacts is to put all plant genotypes in the same ecological context. Agromorphological study can provide important insights into genetic variety and the interactions between major agronomic features, hence promoting economic growth. Bisne and Serawgi (2008) stated that the first step in analyzing a plant's genetic diversity is to conduct agromorphological characterisation analysis. Character analysis using agromorphology provides quick and straightforward assessment results, therefore it is frequently employed as the first step in analyzing genetic diversity.

Physicochemical is a property that describes the physical qualities of a chemical compound found in

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plants. The most common physicochemical property of rice is its amylose content. Amylose content can impact rice texture since it absorbs and releases water easily. Febriandi *et al*. (2017) suggested that the rice gelatinization temperature is one of the physicochemical parameters associated with changes in form caused by water heating. Rice with a high gelatinization temperature needs more cooking time and water than rice with a low gelatinization temperature.

The purpose of this study was to establish the agromorphological and physicochemical features of rice resulting from a cross between IR64 and Nagdong that produced stable progeny (F8). The outcomes of this study are likely to help in the creation of rice plant descriptions.

METHODS

Time and Place

The study was carried out from April 2021 to July 2022 in Jubung, Jember Regency. The sample was analyzed at the Agrotechnology Laboratory of the University of Jember.

Agromorphological Characterization

Agromorphological analysis involved estimating plant height, number of tillers, number of seeds per panicle, and weight of 100 grains. The agromorphological analysis used scales and data collection methodologies based on the Standard Evaluation System IRRI (2013), except for the quantity of seeds per panicle

Physicochemical Characterization

The physicochemical examination covered amylose content, swelling power, gel consistency, and gelatinization temperature. Except for swelling power, all analyses used a calculating scale called the Standard Evaluation System, or IRRI (2013).

Amylose Rate Analysis (Juliano 1972)

In the amylose percentage assay, 100 g of the material was placed in a Valcon tube, added 1 mL of 95% ethanol and 9 mL of 1N NaOH, and heated at 80−100°C for 10 min. The materials were transferred to another Valcon tube and 100 mL of distilled water was added. To 5 mL sample, 2 mL of 2% iodine, 1 mL of 1 N acetic acid, and 100 mL of distilled water were added. A spectrophotometer set at 620 nm was used to take readings. Amylose and amylopectin contents were calculated using the following formula:

$$\%Amylose = \frac{Absorbance\ value\ x\ Dilution\ factor}{Sample\ amount} \times 100\%$$

Swelling Power (Sennayake *et al*. 2013)

Swelling power experiment was accomplished by crushing the rice grains into 50 mg of flour and inserting it into a tube. Next, 2 mL of distilled water was added to the tube. The mixture was then heated to 90°C for 30 min, shaked every 10 min, and centrifuged at 8000 rpm for 30 min. The supernatant was dried at 130°C. The aluminum foil (*w*1) was determined, and the sediment weight (*ws*) was weighed. The score was then computed with the following formula:

$$Swelling\ Power\ (\%) = \frac{ws}{0{,}1\ X\ (100\% - wsi)}$$

$$Wsi = w1/0{,}1\ x\ 100$$

Where:
WS = (Wet Sediment) Weight of the wet sediment after centrifugation
Wsi = (Water Solubility Index) The percentage (%) of solids dissolved in water relative to the total sample
W1 = Weight of soluble solids obtained from the supernatant after drying

Gel Consistency

A 100-g sample of rice flour was sieved through a 100-mesh screen four times, placed into a 13×100 mm culture tube with no lid. The flour was suspended after adding 0.2 mL of 95% ethanol and 0.025% thymol blue and shaking it. Then, 2 mL of 0.2 N KOH was added, vortexed for a few minutes, and heated to 100 °C with marbles on top of the culture tube. Waited for 8 min and looked for bubbles that did not surpass 2/3 of the tube; if they did, withdrew the tube. The tube was placed at room temperature for 5 min, then at 4 °C for 15 min. The tube was placed on millimeter paper. The gel developed and hardened for 35–45 min.

Gelatinization Temperature

This was accomplished by placing six grains of milled rice in a jar with 10 mL of 1.7% KOH and arranging them, so they did not touch each other. Allowed them to sit for 23 h at 30°C, then recorded the results based on the rice's efflorescence score.

Data Analysis

The data was analyzed using Analysis of Variance (ANOVA) and then assessed using the Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Agromorphological Characteristics

All the identified candidate plant features had a lower plant height than the control plant, IR64. The ideal rice plant height was 90−100 cm (Phenget *et al*. 2008). All plants were shorter than the ideal height.

Suprihatno *et al*. (2009) reported that IR64 plants grew to a height of 115 to 126 cm. This means that the plant height represents the best plant height attributes. The International Rice Research Institute's Standard Evaluation System (IRRI 2013) classified all strains and IR64 plants as semi-dwarf. According to Cepy and Wangiyana (2011), environmental circumstances had a significant impact on plant growth, influencing a variety of plant growth features.

The plant lines had seed counts ranging from 103.8 to 108.3 grains per panicle (Table 1). Suprihatno *et al*. (2009) reported that IR64 has 35 to 105 grains per panicle. All lines exhibited seed count in that range or higher, indicating a larger possibility for planting. According to Jumin (2002), a high seed count per panicle could contribute to higher yields computed from the possible number of seeds generated in a panicle, even on a smaller scale. According to Sitinjak and Idwar (2015), the number of seeds per panicle was determined only by genetic variables, panicle length, panicle branches, and the high photosynthetic process, which results in many seeds per panicle.

All the chosen potential plant features produced fewer tillers than the control plant, IR64 (Figure 1). According to the Standard Evaluation System (IRRI 2013), lines 15036-7-12-1 and 15139-2-3-2 had a scale of 5 (Figure 2 and Figure 3), indicating medium, because they have several tillers ranging from 10 to 20, and lines 15139-2-5-2 and 15139-2-7-1 had a scale of 3, indicating good, because they have several tillers ranging from 20 to 25, and 15139-2-7-1 has the same number of tillers as its parent plant (Figure 4 and Figure 5). The "Description of Rice Plant Varieties" lists IR64 as having 20−35 tillers. Although lower than the control plants, the selected contenders nevertheless meet the good and medium standards. The tillers will also be related to the quantity of panicles that sprout on each productive tiller (Prakash & Kumari 2021).

Suprihatno (2009) reported that 100 grains of IR64 rice weigh 2.1 g. Grain weight also effect the grain's shape, making it denser, longer, and fuller. Suryanugraha *et al*. (2017) found that genetic differences between rice plants influence the weight of 100 grains. The physical shape of the rice will also be noticeable, as it differs from the IR64 plant used as control. These variances cause plants to respond differently to their surroundings, influencing the weight of emerging grains (Senewe & Alfons 2011).

Physicochemical Characteristics

All selected candidates reported that the amylose content in all lines was low (Table 2). Danbaba *et al*. (2011) defined low amylose level in rice as a range of 9% to 20%. Suprihatno *et al*. (2009) reported that IR64 contains 23% amylose. This shows that IR64 rice contains a high amylose concentration, which ranges between 20 and 25%, making the rice feel firm and chewy when eaten (Sitaresmi *et al*. 2013).

Strains 15036-7-12-1, 15139-2-3-2, 15139-2-5-2, and 15139-2-7-1 showed swelling power ranging from 6.61 to 8.93% (Table 2). Swelling power is the ability of starch to expand in response to water absorption. An increase in swelling power is due to the increased hydrophilicity of starch, which interacts directly with water (Retnowati *et al*. 2010). The higher the amylose content, the poorer the starch's ability to absorb water when cooked. Li and Yeh (2001) reported that swelling power was negatively correlated with amylose content. The swelling power value decreases as the amylose content increases.

The gel lengths for strains 15036-7-12-1, 15139-2-3-2, 15139-2-5-2, and 15139-2-7-1 ranged from 60.38 to 76.89 mm. According to the IRRI (2013) Standard Evaluation System, IR64 has a gel length of approximately 64.55 mm, indicating a distinctive soft gel consistency. Strains 15036-7-12-1, 15139-2-3-2, 15139-2-5-2, and 15139-2-7-1 had a similar gel consistency type. According to Chemutai *et al*. (2016), soft gel consistency is a common predictor of rice quality and is one of the most often observed values. Wanchana *et al*. (2003) explained that, in addition to environmental influences, gel consistency can be obtained from rice seeds, which have a soft gel consistency due to genetic inheritance from their parents.

Rice gelatinization temperature, according to Firdaus *et al*. (2022), is a criterion that defines how long rice should be cooked. The parent strain, IR64, has a medium-to-high gelatinization temperature. Meanwhile, strains 15036-7-12-1, 15139-2-3-2, 15139-

Table 1 Agromorphological characteristics

Plant	Plant height (cm)	Number of seeds per cluster (grain)	Number of offshoot (stem)	Weight of 100 grains (g)
IR64	89.2 a	84.8 c	23.4 a	2.146 d
15036-7-12-1	79.3 b	108.2 a	19.9 b	3.265 a
15139-2-3-2	81.6 ab	103.8 b	19.7 b	3.055 b
15139-2-5-2	76 b	105.2 a	21.1 b	3.097 b
15139-2-7-1	81.5 ab	108.3 a	20.8 b	2.877 c

Description: Numbers followed by the same letter in the same column are not significantly different based on Duncan Multiple Range Test (DMRT) at the level 5%.

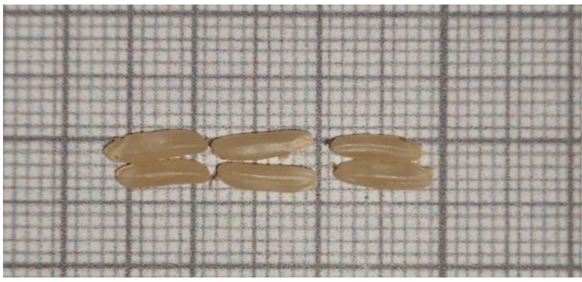

Figure 1 IR64 lines.

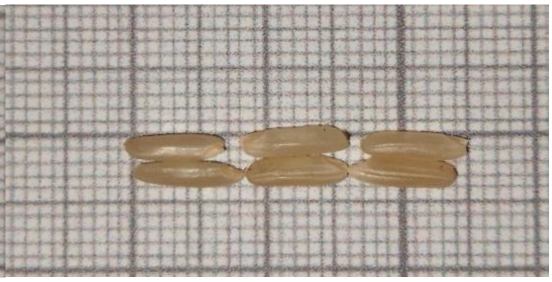

Figure 2 15036-7-12-1 lines.

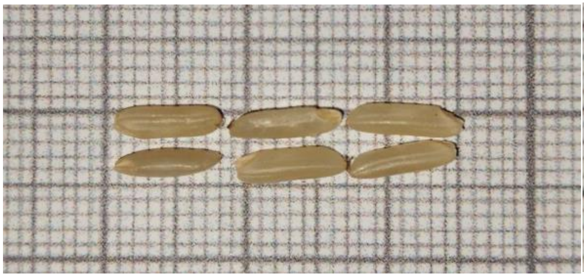

Figure 3 15139-2-3-2 lines.

Figure 4 15139-2-5-2 lines.

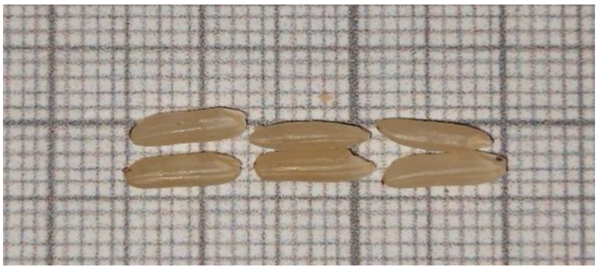

Figure 5 15139-2-7-1 lines.

Table 2 Physicochemical characteristics

Plant	Amylose content (%)	Swelling power (%)	Gel consistency (mm)	Gelatinization temperature
IR64	5.15 c	64.6	5.15 c	3
15036-7-12-1	8.12 ab	69	8.12 ab	7
15139-2-3-2	8.93 a	76.9	8.93 a	7
15139-2-5-2	6.61 bc	60.4	6.61 bc	7
15139-2-7-1	7.85 ab	67.9	7.85 ab	7

Description: Numbers followed by the same letter in the same column are not significantly different based on Duncan Multiple Range Test (DMRT) at the level 5%.

2-5-2, and 15139-2-7-1 all have low gelatinization temperatures (Table 2). Ray *et al.* (2021) defined a low gelatinization temperature as 55−60°C, an average temperature as 60−74°C, and a high temperature as more than 74°C. According to Alfron *et al*. (2011), the gelatinization temperature of rice was closely related to its amylose content, impacting rice's physical qualities in a direct proportionate manner.

Based on a combination of agromorphological and physicochemical character tests, lines 15036-7-12-1 and 15139-2-5-2 outperformed their parents and other lines. This was proved by the 100-grain weight values of 3,625 and 3,097 g, respectively, as well as the high yield value, which was distinguished by swelling power and low amylose content. However, the 15139-2-5-2 strain had a lower amylose content (6.61%) than the 15036-7-12-1 strain (8.12%), which contributed to the *nasi pulan* texture. Kartahadimaja *et al*. (2016) revealed that rice with a low amylose percentage of 12−15% yields a soft, translucent, and sticky texture when compared to rice with a 20% amylose content. This remark is consistent with the tastes of Indonesian rice consumers, who prefer softer rice textures. As a result, the 15139-2-5-2 strain is the leading option with the most potential for future improvement and deserves to be considered a superior rice variety. Meanwhile, the 15036-7-12-1 strain may be considered an alternative for future breeding programs.

CONCLUSION

The lines 15036-7-12-1, 15139-2-3-2, 15139-2-5-2, and 15139-2-7-1 exhibited semi-dwarf plant height, with the number of tillers classified as (5), medium, and (3) good. Each panicle varied from 103 to 108, and 100 grains weigh between 2,877 and 3,265 g. Each line had a low amount of amylose, ranging between 13.87% and 15.85%. The swelling power ranged from 6.61% to 8.93%, with soft gel consistency and a gelatinization temperature below 60 °C. Among the four lines, line 15139-2-5-2 is determined to be superior and hence worthy of commercialization since it produces agromorphological and physicochemical features that correspond to customer desires. Meanwhile, line 15036-7-12-1, which is similar in performance to the superior line, may be a viable candidate for future plant breeding development.

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