Rice grain quality evaluation in some promising lines of swamp and upland rice

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Abstract. The research aimed to determine the rice grain quality of some promising lines from the advanced breeding generation of swamp rice and upland rice. The research material was 43 rice grain samples from the multilocation test sites of swamp rice (16 rice lines, 3 check varieties) and upland rice (20 rice lines, 4 check varieties) harvested in 2018. All rough rice samples were analyzed for the rough rice physical quality, milled rice physical quality, milling quality, physicochemical quality, and organoleptic quality (scoring test and hedonic test). The results showed that in general, the promising lines of swamp rice had higher values of unpolished rice yield, polished rice yield, head rice percentage, and protein content than those of upland rice. In addition, the promising lines of swamp rice had lower empty rough rice and immature+chalky grain than those of upland rice lines. Among the promising lines of swamp rice, B13926E-KA-43, B13931E-KA-33, and BP30400F-KA-5 had the highest head rice percentage, unpolished rice yield, and polished rice yield, whereas, among the promising lines of upland rice, B15392D-KR-12, B15511D-KR-20, and B15514D-KR-5 had the highest head rice percentage, unpolished rice yield, and polished rice yield.

1. Introduction

Improved rice variety is one of the main components of technology that plays a major role in increasing domestic rice productivity and production. Rice is a crop that has a relatively broad ecological spectrum and is cultivated across types of agroecosystems (irrigated land, upland land, and swamp). Each type of agroecosystem has different barriers and constraints, such as water immersion, chemical poisoning, drought, low temperature, particular pests, and diseases [1].

Increasing productivity of rice in sub-optimal lands, such as upland and swamp areas is subject to various biotic and abiotic stresses. Biotic and abiotic stresses in swamp rice cultivation are inundation, salinity, iron (Fe) poisoning, blast disease [2].

The development of new improved rice varieties through a series of processes including crosses/breeding to produce F1, Bastar selection (F2-F6), Pedigree selection (F7-F8), yield observation, preliminary yield test, advanced yield test, multilocation test, and finally the release of rice varieties [3]. Multilocation testing is needed to obtain new improved rice varieties with higher yield potential and more adaptive to environmental changes and fulfills consumer requirements/preferences. One of the consumer preferences is the characteristic or quality of rice. Rice grain quality is a combination of physical (milling), cooking, processing, physicochemical, sensory, and nutritional qualities [4,5]. Rice physical quality includes moisture content, grain dimensions, appearance, head rice yield, grain cracks...
and fissures, and degree of milling [6]. Amylose content, gelatinization temperature, and gel consistency are the main physicochemical tests for measuring rice cooking, eating, and nutritional quality [7].

The factors that influence the quality of rice are genetics (variety), environment, cultivation techniques, harvest, and post-harvest rice [8-12]. The research aimed to determine the rice grain quality of some promising lines from the advanced breeding generation of swamp rice and upland rice.

2. Materials and methods
The research material was 43 dried rough rice samples from the multilocation test of swamp rice (16 rice lines, 3 check varieties) and upland rice (20 rice lines, 4 check varieties) harvested in 2018. Check varieties were popular rice varieties used as a control for swamp rice and upland rice experiments. Check varieties for swamp rice were Inpara 3, Inpara 4, and Inpara 8, while check varieties for upland rice were Situ Bagendit, Inpago 10, Luhur 1, and Luhur 2. All rough rice samples were analyzed for the rough rice physical quality, milled rice physical quality, milling quality, physicochemical quality, and organoleptic quality (scoring test and hedonic test). The study was conducted in the laboratory using the grain samples of these varieties which were produced in the experimental station of the Indonesian Center for Rice Research (ICRR).

The physical quality of rough rice that was observed included moisture content, empty grain, damaged grain + yellow grain, chalky + immature grain, and red grain. The observations follow the Indonesian National Standard for rough rice [13]. In addition, the density and weight of a thousand grains were also observed.

After observing its physical quality, the rough rice was dehulled into unpolished (brown) rice using a rice husker (Satake THU 35A). Before polishing, the rice dimension (shape) and unpolished rice yield were measured. Then the unpolished rice was polished using a rice polisher (SatakeTM-05).

The physical quality of milled rice observation included the degree of polishing (milling), moisture content, head rice yield, broken grains, groats, red grains, damaged+ yellow grains, and chalky + immature grains follow the Indonesian National Standard for rice quality [14].

The milling qualities observation included rice size (length (l), width (w), the ratio of l/w), Milling Meter properties (whiteness, and transparency; Satake MMID), and yield of polished rice. Observation of the physicochemical qualities included the amylose content (spectrophotometry method), gel consistency, and protein content (micro Kjeldahl method).

Organoleptic test rice samples were prepared using an electric rice cooker. Rice samples were weighed (150g), then washed until the washing water appears clear (1-2 times). The washed rice was drained, put in a rice cooker pan, added water with a rice-water ratio of 1:1.5 for milled rice or 1:2 for unpolished rice. The pot was inserted into the rice cooker and positioned so that it is just right. The rice cooker was closed. The socket was inserted, and the button was pressed so that the 'cooking' lamp lights up. After the cooking mode was on about 35-40 minutes, the rice cooker automatically switched to warming mode, then it was left for 15 minutes. The rice was rice ready to be served. A scoring test (weighting) rice was carried out to weigh certain characters of rice samples. The attributes tested were color, glossy, texture, and aroma. A hedonic test was conducted to determine the level of acceptance (liking) for rice using about 30 panelists. The parameters tested were taste, texture, and overall. Panelists assessed the cooked rice samples subjectively and spontaneously without comparing samples with one another.

3. Results and discussion
The physical properties of both promising rice lines are presented in table 1. The average moisture content, empty grain, damaged + yellow grain, red grain, grain density, and weight of 1000 grains of swamp rice lines were 12.41%, 0.53%, 1.56%, 3.65%, 0.28%, 538.55 g l⁻¹, and 24.38g, respectively. The average moisture content, empty grain, damaged + yellow grain, red grain, grain density, and weight of 1000 grains of upland rice lines were 11.85%, 1.41%, 1.85%, 3.15%, 0.18%, 542.65 g l⁻¹, and 24.14g, respectively. Compared to the swamp rice lines, the upland rice lines contained higher empty grain and damaged + yellow grain but contained lower chalky+ immature grain and red grain. B15175C-TGB-20
is the only red rice from upland rice lines. Based on the rough rice standard [10], only BP30159E-SKI-2-2 rice fulfilled the first grade of rough rice quality.

### Table 1. Physical properties of rough rice lines of swamp rice and upland rice

| No | Promising rice lines       | Moisture (%) | Empty grain (%) | Damaged+ yellow grain (%) | Chalky + immature grain (%) | Red grain (%) | Grain density (g l⁻¹) | Weight of 1000 grain (g) |
|----|----------------------------|--------------|-----------------|---------------------------|----------------------------|--------------|-----------------------|--------------------------|
|    | Swamp rice lines           |              |                 |                           |                            |              |                       |                          |
| 1  | B13925E-KA-1               | 12.9         | 0.7             | 2.7                       | 1.7                        | 0.0          | 552.0                 | 27.6                     |
| 2  | B13531E-KA-1-B             | 12.5         | 0.7             | 5.1                       | 0.7                        | 0.0          | 518.0                 | 23.9                     |
| 3  | B13926E-KA-43              | 11.6         | 0.7             | 5.2                       | 4.5                        | 0.0          | 554.0                 | 22.0                     |
| 4  | B13931E-KA-33              | 11.4         | 0.6             | 4.1                       | 3.2                        | 0.0          | 547.5                 | 24.5                     |
| 5  | B13100-1-MR-2-KY-2         | 11.5         | 0.7             | 3.4                       | 1.9                        | 2.9          | 533.0                 | 22.8                     |
| 6  | B13983E-KA-12-2            | 12.4         | 0.7             | 3.8                       | 5.1                        | 0.0          | 511.0                 | 23.4                     |
| 7  | BP14352E-2-3-OP-JK-0       | 11.4         | 0.4             | 5.8                       | 0.7                        | 0.0          | 529.0                 | 22.4                     |
| 8  | BP30400F-KA-5              | 13.4         | 0.7             | 4.4                       | 0.6                        | 0.0          | 545.0                 | 24.7                     |
| 9  | BP30159E-SKI-2-2           | 12.7         | 0.4             | 1.9                       | 0.9                        | 0.0          | 522.5                 | 26.8                     |
| 10 | B14333E-KA-48              | 12.9         | 0.6             | 2.4                       | 2.1                        | 0.0          | 530.5                 | 24.2                     |
| 11 | B14308E-KA-35              | 12.2         | 0.5             | 5.0                       | 0.3                        | 0.5          | 551.0                 | 27.3                     |
| 12 | B13134-4-MR-1-KA-3-4       | 12.4         | 0.5             | 1.7                       | 4.4                        | 0.1          | 520.5                 | 24.7                     |
| 13 | B13520E-KA-13-B            | 12.0         | 0.5             | 3.7                       | 0.3                        | 1.0          | 528.5                 | 24.1                     |
| 14 | IR101465-5:25             | 12.7         | 0.4             | 2.3                       | 1.2                        | 0.0          | 557.0                 | 27.0                     |
| 15 | BP14234E-1-5 (US)          | 11.2         | 0.4             | 2.3                       | 0.1                        | 0.0          | 547.5                 | 23.1                     |
|    | IR83832-26-2-1-2-SKI-4 (US)| 13.1         | 0.4             | 4.2                       | 0.5                        | 0.0          | 533.5                 | 25.3                     |
| 16 | Inpara 3                   | 12.9         | 0.4             | 2.7                       | 0.5                        | 0.8          | 526.0                 | 24.4                     |
| 17 | Inpara 4                   | 13.7         | 0.4             | 2.8                       | 1.1                        | 0.0          | 586.5                 | 20.6                     |
| 18 | Inpara 8                   | 12.9         | 0.5             | 6.1                       | 0.2                        | 0.0          | 539.5                 | 24.5                     |
|    | Mean                       | 12.41        | 0.53            | 1.56                      | 3.65                       | 0.28         | 538.55                | 24.38                    |
|    | Upland rice lines          |              |                 |                           |                            |              |                       |                          |
| 20 | B12160D-MR-11-3-4          | 12.3         | 0.7             | 3.2                       | 3.0                        | 2.6          | 534.5                 | 26.6                     |
| 21 | B15119C-TB-5               | 11.4         | 1.2             | 4.4                       | 1.7                        | 0.7          | 554.0                 | 23.3                     |
| 22 | B15119C-TB-13              | 10.8         | 1.7             | 7.0                       | 0.5                        | 0.0          | 538.5                 | 24.4                     |
| 23 | B15119C-TB-42              | 11.2         | 1.1             | 5.6                       | 1.9                        | 0.5          | 552.5                 | 23.9                     |
| 24 | B15340-3B-TB-6             | 12.4         | 2.6             | 6.9                       | 2.8                        | 0.0          | 542.5                 | 22.8                     |
| 25 | B15340-1B-TB-45            | 10.2         | 1.3             | 5.6                       | 1.0                        | 0.0          | 511.5                 | 25.3                     |
| 26 | B15175C-TGB-20             | 11.3         | 1.9             | 1.4                       | 0.5                        | 100.0        | 509.0                 | 27.1                     |
| 27 | B15114C-TB-22              | 10.2         | 1.9             | 7.7                       | 1.1                        | 0.0          | 529.0                 | 25.3                     |
| 28 | B14166E-MR-19              | 12.1         | 1.3             | 1.9                       | 2.3                        | 0.0          | 562.0                 | 25.0                     |
| 29 | B15507D-KR-19              | 12.0         | 0.9             | 1.9                       | 1.1                        | 0.1          | 563.5                 | 25.4                     |
| 30 | B15391D-KR-18              | 11.9         | 1.0             | 2.2                       | 0.4                        | 0.0          | 556.0                 | 26.4                     |
| 31 | B15392D-KR-12              | 12.4         | 1.4             | 2.1                       | 1.9                        | 0.0          | 576.5                 | 24.1                     |
| 32 | B15397D-KR-14              | 12.3         | 1.0             | 1.2                       | 2.0                        | 0.0          | 537.0                 | 32.0                     |
| 33 | B15401D-KR-20              | 12.2         | 1.3             | 1.9                       | 1.9                        | 0.2          | 560.0                 | 20.0                     |
| 34 | B15401D-KR-40              | 12.6         | 0.8             | 0.7                       | 1.1                        | 0.0          | 543.0                 | 22.1                     |
| 35 | B15401D-KR-45              | 12.4         | 1.2             | 2.8                       | 1.5                        | 0.0          | 550.0                 | 20.5                     |
| 36 | B15494D-KR-28              | 11.6         | 1.7             | 1.3                       | 2.0                        | 0.0          | 536.5                 | 21.8                     |
| 37 | B15511D-KR-20              | 11.9         | 1.9             | 1.3                       | 3.2                        | 0.0          | 526.0                 | 22.0                     |
The physical properties of milled rice of swamp rice and upland rice lines are presented in table 2. The average degree of polishing, moisture, head rice yield, broken rice, groats, red rice, yellow/damaged grains dan chalky grains of swamp rice lines was 91.32%, 11.27%, 88.12%, 10.77%, 1.10%, 0.28%, 1.71%, and 0.78%, respectively. The average degree of polishing, moisture, head rice yield, broken rice, groats, red rice, yellow/damaged grains dan chalky grains of upland rice lines was 94.58%, 11.84%, 68.49%, 29.18%, 2.33%, 0.18%, 1.25%, and 1.39%, respectively. Compared to the swamp rice lines, the upland rice line contained lower head rice but higher broken rice and groats which indicated that the swamp rice lines had higher quality in milled rice properties than those of the upland rice line.

Table 2. Milled rice physical properties of rice lines for swamp rice and upland rice.

| No. | Promising rice lines | Degree of polishing (%) | Moisture (%) | Head rice (%) | Broken rice (%) | Groats (%) | Red rice (%) | Yellow/damaged grain (%) | Chalky grain (%) |
|-----|----------------------|-------------------------|--------------|---------------|----------------|------------|--------------|-------------------------|-----------------|
| 38  | B15514D-KR-5         | 12.1                    | 2.3          | 1.8           | 3.5            | 0.0        | 529.5        | 21.5                    |                 |
| 39  | BA5514D-KR-47        | 12.5                    | 1.9          | 1.8           | 2.5            | 0.0        | 540.0        | 22.3                    |                 |
| 40  | Siti Bagendit        | 11.3                    | 1.6          | 4.0           | 4.7            | 0.0        | 521.0        | 24.3                    |                 |
| 41  | Inpago 10            | 12.8                    | 1.4          | 4.1           | 1.1            | 0.2        | 532.0        | 21.4                    |                 |
| 42  | Luhur 1              | 12.5                    | 0.6          | 3.2           | 1.4            | 0.0        | 571.5        | 28.2                    |                 |
| 43  | Luhur 2              | 12.1                    | 1.4          | 1.6           | 1.4            | 0.0        | 547.5        | 23.4                    |                 |
|     | Mean                 | 11.85                   | 1.41         | 1.85          | 3.15           | 0.18       | 542.65       | 24.14                   |                 |

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The rice grain size, milling meter, and milling yield of swamp rice and upland rice lines are presented in table 3. The average length, width, ratio length-width, whiteness, transparency, yield of unpolished and polished rice of swamp rice lines were 6.91mm, 2.31mm, 3.00, 45.19, 1.89, 78.80%, and 69.89%, respectively. The average length, width, ratio length-width, whiteness, transparency, yield of unpolished and polished rice of upland rice lines were 6.26mm, 2.48mm, 2.55, 50.84, 1.51, 78.53%, and 63.85%, respectively. Compare to the upland rice lines, the swamp rice lines had a higher yield of polished rice which indicated that the swamp rice lines had a higher milling quality.

Head rice yield, milling yield, and milling quality are key factors in rice grain quality [6]. Moisture content, drying, the process of husking, and milling (polishing) are factors that affect the head rice yield during milling. The optimum moisture content for rice milling is 12-14%, above or below will result in lower head rice and greater groats [15,16].

Table 3. Rice grain size, milling meter, and milling yield of rice lines for swamp and upland rice.

| No. | Promising rice lines | Length (l, mm) | Grain size Width (w, mm) | Ratio of l/w | Milling Meter* Whiteness | Transparency | YIELD (%) Unpolished rice | Polished rice |
|-----|----------------------|----------------|--------------------------|--------------|--------------------------|-------------|--------------------------|-------------|
| **Swamp rice lines** | | | | | | | | |
| 1   | B13925E-KA-1         | 6.4            | 2.5                      | 2.5          | 45.1                     | 2.4         | 78.7                     | 69.7        |
| 2   | B13531E-KA-1-B       | 6.9            | 2.4                      | 2.9          | 43.0                     | 1.2         | 78.3                     | 70.0        |
| 3   | B13926E-KA-43        | 6.5            | 2.3                      | 2.9          | 45.1                     | 1.4         | 79.9                     | 70.8        |
| 4   | B13931E-KA-33        | 6.9            | 2.3                      | 3.0          | 41.7                     | 1.9         | 79.1                     | 71.4        |
| 5   | B13100-1-MR-2-KY-2   | 6.7            | 2.4                      | 2.8          | 43.4                     | 1.3         | 78.1                     | 69.8        |
| 6   | B13983E-KA-12-2      | 7.0            | 2.2                      | 3.2          | 46.3                     | 1.9         | 78.8                     | 67.0        |
| 7   | BP14352E-2-3-OP-JK-  | 6.6            | 2.1                      | 3.1          | 34.6                     | 1.7         | 78.0                     | 70.8        |
| 8   | BP30400F-KA-5        | 7.1            | 2.3                      | 3.2          | 44.2                     | 1.9         | 79.6                     | 71.0        |
| 9   | BP30159E-SKI-2-2     | 7.6            | 2.2                      | 3.4          | 53.0                     | 2.1         | 79.1                     | 69.4        |
Based on the gel consistency, rice can be categorized into: soft (61-100mm), intermediate (41-60mm), and hard (25-40mm) [17].
### Table 4. Physicochemical properties of rice lines for swamp rice and upland rice.

| No. | Promising rice lines | Gel Consistency | Protein Content (%) | Amylose Content (%) |
|-----|----------------------|-----------------|---------------------|---------------------|
|     |                      | mm Information |                     |                     |
| **Swamp rice lines** |                      |                 |                     |                     |
| 1   | B13925E-KA-1         | 56.0            | Medium              | 7.5                 | 19.1                |
| 2   | B13531E-KA-1-B       | 55.0            | Medium              | 8.8                 | 23.1                |
| 3   | B13926E-KA-43        | 37.0            | Hard                | 8.3                 | 28.1                |
| 4   | B13931E-KA-33        | 38.0            | Hard                | 8.2                 | 27.7                |
| 5   | B13100-1-MR-2-KY-2   | 58.0            | Medium              | 9.0                 | 22.2                |
| 6   | B13983E-KA-12-2      | 59.0            | Medium              | 9.7                 | 21.5                |
| 7   | BP14352E-2-3-3OP-JK-0| 78.5            | Soft                | 9.0                 | 16.4                |
| 8   | BP30400F-KA-5        | 56.0            | Medium              | 9.3                 | 20.2                |
| 9   | BP30159E-SKI-2-2     | 46.0            | Medium              | 8.7                 | 20.9                |
| 10  | B14333E-KA-48        | 55.5            | Medium              | 9.2                 | 24.6                |
| 11  | B14308E-KA-35        | 53.0            | Medium              | 8.4                 | 24.8                |
| 12  | B13134-4-MR-1-KA-3-4 | 43.5            | Medium              | 7.9                 | 21.1                |
| 13  | B13520E-KA-13-B      | 44.0            | Medium              | 8.6                 | 22.9                |
| 14  | IR101465-5:25        | 35.0            | Hard                | 8.4                 | 27.9                |
| 15  | BP14234E-1-5(US)     | 43.0            | Medium              | 9.7                 | 22.1                |
| 16  | IR83832-26-2-1-2-SKI-4(US) | 52.5 | Medium | 8.4                   | 22.5                |
| 17  | Inpara 3             | 35.0            | Hard                | 9.0                 | 25.0                |
| 18  | Inpara 4             | 36.0            | Hard                | 7.8                 | 27.6                |
| 19  | Inpara 8             | 57.0            | Medium              | 7.9                 | 23.6                |
|     | Mean                 | 49.4            |                     | 8.6                 | 23.2                |
| **Upland rice lines** |                      |                 |                     |                     |
| 20  | B12160D-MR-11-3-4    | 38.0            | Hard                | 7.3                 | 27.8                |
| 21  | B15119C-TB-5         | 55.0            | Medium              | 7.5                 | 22.1                |
| 22  | B15119C-TB-13        | 58.0            | Medium              | 6.7                 | 24.8                |
| 23  | B15119C-TB-42        | 59.0            | Medium              | 7.3                 | 24.4                |
| 24  | B15340-3B-TB-6       | 45.0            | Medium              | 9.3                 | 22.5                |
| 25  | B15340-1B-TB-45      | 44.0            | Medium              | 8.0                 | 21.1                |
| 26  | B15175C-TGB-20       | 42.0            | Medium              | 9.9                 | 20.0                |
| 27  | B15114C-TB-22        | 57.0            | Medium              | 7.9                 | 23.1                |
| 28  | B14168E-MR-19        | 58.0            | Medium              | 6.9                 | 23.8                |
| 29  | B15507D-KR-19        | 59.0            | Medium              | 8.4                 | 23.3                |
| 30  | B15391D-KR-18        | 58.0            | Medium              | 9.2                 | 24.0                |
| 31  | B15392D-KR-12        | 53.5            | Medium              | 7.1                 | 24.1                |
| 32  | B15397D-KR-14        | 72.5            | Soft                | 7.5                 | 17.5                |
| 33  | B15401D-KR-20        | 39.0            | Hard                | 7.2                 | 25.4                |
| 34  | B15401D-KR-40        | 53.5            | Medium              | 6.2                 | 22.6                |
| 35  | B15401D-KR-45        | 38.0            | Hard                | 6.4                 | 29.7                |
| 36  | B15494D-KR-28        | 54.5            | Medium              | 6.9                 | 22.9                |
| 37  | B15511D-KR-20        | 43.5            | Medium              | 7.8                 | 23.3                |
| 38  | B15514D-KR-5         | 42.5            | Medium              | 8.5                 | 20.9                |
| 39  | BA5514D-KR-47        | 51.5            | Medium              | 8.3                 | 23.4                |
| 40  | Situ Bagendit        | 58.0            | Medium              | 7.3                 | 23.2                |
| 41  | Inpago 10            | 58.5            | Medium              | 11.0                | 21.7                |
| 42  | Luhur 1              | 50.5            | Medium              | 7.5                 | 24.3                |
The organoleptic evaluation included the Scoring test and Hedonic test (Table 5). In the Scoring test, most of the cooked rice samples were assessed as white (2), but BP30159E-SKI-2-2, B13134-4-MR-1-KA-3-4, and B14168E-MR-19 were assessed as very white (1). Some of the swamp rice lines, namely B13926E-KA-43, B13931E-KA-33, and IR101465-5:25 had hard cooked rice texture (4), similar to the corresponding check varieties (Inpara 3, Inpara 4, and Inpara 8). IR83832-26-2-1-2-SKI-4 (US) and B15507D-KR-19 had a “pandan” or popcorn-like (fragrant) odor. In the hedonic test, most of the cooked rice received a general assessment of liking (2), some received slightly like (3), but B13931E-KA-33 received dislike (4). Most likely the cooked rice was judged to be somewhat like (3) or not (4) due to its unwelcome or hard texture.

Table 5. Organoleptic properties of cooked rice of rice lines for swampy rice and upland rice.

| No | Promising rice lines | Scoring* | | Hedonic** |
|---|---|---|---|---|
| | | Color*** | Glossiness | Texture | Odor | Taste | Texture | Overall |
| **Swampy rice lines** | | | | | | | | |
| 1 | B13925E-KA-1 | 2 | 2 | 2 | 3 | 2 | 2 | 2 |
| 2 | B13531E-KA-1-B | 2 | 2 | 3 | 4 | 2 | 3 | 3 |
| 3 | B13926E-KA-43 | 2 | 3 | 4 | 4 | 3 | 3 | 3 |
| 4 | B13931E-KA-33 | 2 | 3 | 4 | 4 | 3 | 4 | 4 |
| 5 | B13100-1-MR-2-KY-2 | 2 | 3 | 3 | 4 | 2 | 2 | 2 |
| 6 | B13983E-KA-12-2 | 2 | 3 | 2 | 4 | 2 | 2 | 2 |
| 7 | BP14352E-2-3-30P-JK-0 | 2 | 2 | 2 | 4 | 2 | 2 | 2 |
| 8 | BP30400F-KA-5 | 2 | 2 | 2 | 4 | 2 | 2 | 2 |
| 9 | BP30159E-SKI-2-2 | 1 | 2 | 2 | 4 | 2 | 2 | 2 |
| 10 | B14333E-KA-48 | 2 | 3 | 3 | 4 | 3 | 3 | 3 |
| 11 | B14308E-KA-35 | 2 | 2 | 3 | 4 | 2 | 3 | 3 |
| 12 | B13134-4-MR-1-KA-3-4 | 1 | 2 | 2 | 4 | 2 | 2 | 2 |
| 13 | B13520E-KA-13-B | 2 | 2 | 3 | 4 | 3 | 3 | 3 |
| 14 | IR101465-5:25 | 2 | 3 | 4 | 4 | 3 | 4 | 3 |
| 15 | BP14234E-1-5(US) IR83832-26-2-1-2-SKI-4 (US) | 2 | 2 | 2 | 4 | 2 | 2 | 2 |
| 16 | | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 17 | Inpara 3 | 2 | 3 | 4 | 4 | 3 | 3 | 3 |
| 18 | Inpara 4 | 2 | 3 | 4 | 4 | 3 | 4 | 3 |
| 19 | Inpara 8 | 2 | 3 | 4 | 4 | 3 | 3 | 3 |
| **Upland rice lines** | | | | | | | | |
| 20 | B12160D-MR-11-3-4 | 2 | 3 | 3 | 4 | 3 | 3 | 3 |
| 21 | B15119C-TB-5 | 2 | 2 | 2 | 4 | 2 | 2 | 2 |
| 22 | B15119C-TB-13 | 2 | 2 | 3 | 4 | 3 | 3 | 3 |
| 23 | B15119C-TB-42 | 2 | 2 | 2 | 4 | 2 | 2 | 2 |
| 24 | B15340-3B-TB-6 | 3 | 3 | 3 | 4 | 3 | 3 | 3 |
| 25 | B15340-1B-TB-45 | 3 | 4 | 3 | 4 | 3 | 3 | 3 |
| 26 | B15175C-TGB-20 ** | 2 | 3 | 3 | 4 | 3 | 3 | 3 |
| 27 | B15114C-TB-22 | 2 | 2 | 2 | 3 | 2 | 2 | 2 |
| 28 | B14168E-MR-19 | 1 | 2 | 2 | 4 | 2 | 2 | 2 |
| 29 | B15507D-KR-19 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
Among the promising lines of swampy rice had lower empty rough rice and immature+ chalky grain than those of upland rice. In addition, the promising lines of swampy rice had lower empty rough rice and immature+ chalky grain than those of upland rice lines. Among the promising lines of swampy rice, B13926E-KA-43, B13931E-KA-33, and BP30400F-KA-5 had the highest head rice yield, unpolished rice yield, and polished rice yield, whereas, Sensory properties that important for cooked rice are color and appearance, flavor and aroma, stickiness, and hardness [18]. In general, consumers prefer white cooked rice. Some rice consumers prefer fragrant rice while others prefer plain rice. Similar to the odor, some consumers prefer soft-cooked rice while others prefer hard-cooked rice.

Cooked rice is preferred if the soft texture lasts a long time or does not harden quickly. This easily hardened cooked rice texture is caused by amylopectin staling, which tends to occur in rice with medium and high gelatinization temperatures compared to rice with low gelatinization temperatures [19]. The texture of cooked rice is more correlated with chemical properties than the physical properties of rice [20]. Furthermore, rice texture is strongly influenced by variety, post-harvest handling (degree of milling, drying conditions, moisture content), and cooking methods [21]. Cooked rice with pera texture (hard texture and separated) is preferred by rice consumers in West Sumatra and partly in South Kalimantan [22].

The preference for rice characteristics may differ among regions and countries. Rice producing and consuming countries are generally divided into three zones, namely South Asia, Southeast Asia, and East Asia - Northeast Asia. The types of rice in these three zones differ in grain size and shape, amylose content, and physicochemical properties. Rice consumers in South Asia (such as India, Bangladesh, and Pakistan) have the same preferences, namely rice with small, long, and slender grains, high amylose (≥ 26%). This type of rice produces rice grains with a dry texture (hard, dry, and not sticky), like rice that has been stored for a long time. East and Northeast Asian rice consumers (such as Japan and Korea) prefer short-grain rice, round, glossy, low amylose (≤ 20%), soft and sticky rice texture when cooked like rice fresh rice harvest (without storage). Rice consumers in Southeast Asia (such as Indonesia, Malaysia, and Thailand) prefer rice with characteristics between these two extremes such as medium-lean rice grains, fluffier rice texture, and moderate amylose content (20-26%) [23]. Furthermore, the preference for rice quality may differ among cities, and levels of urbanization [24].

| **Scoring** : | **Hedonic** : |
|---------------|---------------|
| 30 B15391D-KR-18 | 2 2 2 4 2 2 2 |
| 31 B15392D-KR-12 | 2 2 2 4 2 2 2 |
| 32 B15397D-KR-14 | 2 2 2 4 2 2 2 |
| 33 B15401D-KR-20 | 2 3 3 4 3 3 2 |
| 34 B15401D-KR-40 | 2 3 2 4 2 2 2 |
| 35 B15401D-KR-45 | 2 2 2 3 4 3 2 |
| 36 B15494D-KR-28 | 2 2 2 4 3 2 2 |
| 37 B15511D-KR-20 | 2 2 2 4 2 2 2 |
| 38 B15514D-KR-5 | 2 2 2 4 2 2 2 |
| 39 BA5514D-KR-47 | 2 2 2 4 2 2 2 |
| 40 Situ Bagendit | 2 2 2 4 2 2 2 |
| 41 Inpago 10 | 2 2 3 3 4 2 3 |
| 42 Luhur 1 | 2 2 2 4 2 2 2 |
| 43 Luhur 2 | 2 2 2 4 2 2 2 |

*Color (white rice): 1. very white; 2. white; 3. slightly white; 4. dull; 5. very dull
*Color (**red rice): 1. Very red; 2. red; 3. Slightly red; 4. dull; 5. Very dull
Glossiness: 1. Very glossy; 2. glossy; 3. Slightly glossy; 4. dull; 5. Very dull
Texture: 1. Very soft; 2. soft; 3. Slightly soft; 4. hard; 5. Very hard
Odor: 1. Very fragrant; 2. fragrant; 3. Slightly fragrant; 4. Plain odor; 5. Unpleasant odor

1. Very like; 2. Like; 3. Slightly like; 4. Dislike; 5. Very dislike

4. Conclusion
The results showed that in general, the promising lines of swampy rice had higher values of unpolished rice yield, polished rice yield, head rice yield, and protein content than those of upland rice. In addition, the promising lines of swampy rice had lower empty rough rice and immature+ chalky grain than those of upland rice lines. Among the promising lines of swampy rice, B13926E-KA-43, B13931E-KA-33, and BP30400F-KA-5 had the highest head rice yield, unpolished rice yield, and polished rice yield, whereas,
among the promising lines of upland rice, B15392D-KR-12, B15511D-KR-20, and B15514D-KR-5 had the highest head rice yield, unpolished rice yield, and polished rice yield.

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