Yield quality and performance of line 13, 46 and 52 black rice from gamma ray irradiation

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Abstract. Black rice is a functional food plant with high fiber and anthocyanin content. It has a weakness that is a high content of amylose which causes rice texture to harden. The study used a different treatment of the plant line, namely three promising lines of irradiated black rice M7 (lines 13, 46, and 52) and lines without irradiation (control). The data were analyzed descriptively and qualitatively. The results showed that the three promising lines had better yield quality and performance than the control plants. The highest anthocyanin content and the best fat content were found in line 52, which were 75.04 ppm and 1.35%. Line 46 had the best protein content, vigor, and viability of 7.88%, 88%, and 67%, respectively. Line 13 had the highest amylose content of 14.92%. Line 52 was the best performing line (organoleptic staining and seed pericarp) compared to the other lines, namely 3.25 and 3.

1. Introduction

Rice (Oryza sativa) is an important food crop and a staple food source in Indonesia. Black rice is rice that produces high-intensity anthocyanins and is popularly consumed as a functional food [1]. Currently, black rice in Indonesia becomes difficult to obtain and almost extinct because farmers rarely grow black rice. This is because black rice generally has a long plant life (± 150 days), and low productivity [2]. Black rice has a protein of 7.9173%, lower than white rice which contains up to 8.1669% protein [3]. Black rice also has a relatively high amylose content of 25.49% compared to other rice which causes rice to become dry.

Based on those problems, several ways can be done. One of the ways to increase crop yields and eliminate the weakness of black rice is by mutating plants using gamma-ray irradiation. Mutation breeding is one of the effective ways to improve plant genetic traits and new mutant plants formed from local varieties are used to obtain the desired traits and allow the formation of characteristics that do not exist in nature [4]. The study of the yield and appearance of the 13, 46, and 52 black rice lines produced by gamma irradiation was expected to obtain superior M7 mutant plants.
2. Materials and method

This research was carried out from December 2019 to August 2020. Black rice cultivation was carried out in the rice fields of Ngijo Village, Tasikmadu District, Karanganyar Regency, Central Java Province with an altitude of 105 meters above sea level. The quality test was carried out at the Chem-Mix Pratama Laboratory, Jambidan Village, Banguntapan, Bantul, Yogyakarta, and the Plant Pests and Diseases Laboratory, Sebelas Maret University. This research used different plant lines, namely three irradiated M7 lines of black rice (lines 13, 46, and 52) and lines without irradiation (control), each line was in a plot using the jajar legowo 8:1 system. Every 8 rows of plants were interspersed with 1 empty row with a width of twice the row with a spacing of 24 cm x 24 cm with 30 sample plants per line. The sample used a random sampling determination technique. The quality test of the results included anthocyanin content, amylose content, protein content, fat content, vigor, and seed viability, while performance testing included organoleptic and seed pericarp color. The data were analyzed descriptively and qualitatively to compare the three promising lines of black rice produced by gamma irradiation with the lines without gamma irradiation (control).

3. Result and discussion

3.1. Anthocyanin content

Anthocyanins are polyphenol-derived compounds that are abundant in nature with diversity in various plant species and have many important physiological functions in every living organism. As quoted by Abdullah [5], anthocyanins are pigments that give red, blue, or purplish colors to flowers, fruits, and vegetables. Brown rice and black rice also contain anthocyanins.

Table 1. The anthocyanins content of black rice (Oryza sativa L.) in the gamma ray irradiation and without irradiation lines

| Line   | Anthocyanin Content | Average ppm |
|--------|---------------------|-------------|
|        | Deuteronomy 1 | Deuteronomy 2 |         |
| GH 13  | 61.66              | 60.82       | 61.24   |
| GH 46  | 59.08              | 58.67       | 58.88   |
| GH 52  | 74.83              | 75.23       | 75.04   |
| Control| 45.21              | 44.39       | 44.8    |

Based on table 1, it can be seen that the dose of gamma ray irradiation increased the anthocyanin content in black rice. This is evidenced by the mean value of anthocyanins in the expected lines which was higher than the control lines. The value of the largest anthocyanin content was found in the promising line 52 at 75.04 ppm, while the lowest anthocyanin content was found in the promising line 46 at 58.88 ppm. According to Masruroh et al [6], radiation therapy can affect the decrease or increase in anthocyanin levels, depending on the radiation dose given. The existence of differences in anthocyanin levels between groups of black rice radiation treatment can be caused by the influence of radiation administration which can lead to different genetic traits between generations.

3.2. Amylose content

Testing the amylose content is the initial selection to estimate the texture of rice. According to Luna et al [7], rice containing high amylose when cooked will produce dry rice and a hard texture after cooling. On the other hand, low amylose content in rice will produce fluffier rice and a soft texture. Therefore, amylose is one of the quality components analyzed in the release of rice varieties. The higher the amylose content, the higher the ratio of adding water to the cooking process.

Table 2 shows the analysis results of amylose content in cempo ireng black rice with a higher dose of gamma irradiation than plants without a dose of gamma irradiation. The highest amylose content was found in the promising line 13 of 14.92%, while the lowest amylose content was in the promising line 46 of 7.22%. Gamma ray irradiation treatment has an effect on the yield of amylose content, this is proven by Suarti et al [8] which states that the variety of amylose content is influenced by genetics.
Table 2. The amylose content of black rice (*Oryza sativa L.*) in the gamma ray irradiation and without irradiation lines

| Line    | Amylose Content    | Average (ppm) |
|---------|--------------------|---------------|
|         | Deuteronomy 1      | Deuteronomy 2 |
| GH 13   | 14.96              | 14.89         | 14.92 |
| GH 46   | 7.25               | 7.19          | 7.22  |
| GH 52   | 9.43               | 9.40          | 9.41  |
| Control | 11.84              | 11.77         | 11.81 |

3.3. Protein content

Rice is a food source of energy that has a high carbohydrate content but low protein. Protein is one of the macronutrients that play a role in the process of forming biomolecules. According to Hernawan and Meylani [2], the nutritional content of rice per 100 grams of material is 360 kcal of energy, 6.6 grams of protein, 0.58 grams of fat, and 79.34 grams of carbohydrates. One of the nutritional content that reflects the yield quality of black rice is protein content.

Table 3. The protein content of black rice (*Oryza sativa L.*) in the gamma ray irradiation and without irradiation lines

| Line    | Protein Content | Average (ppm) |
|---------|-----------------|---------------|
|         | Deuteronomy 1   | Deuteronomy 2 |
| GH 13   | 6.50            | 6.43          | 6.46  |
| GH 46   | 7.92            | 7.85          | 7.88  |
| GH 52   | 7.53            | 7.57          | 7.55  |
| Control | 6.97            | 6.93          | 6.95  |

Based on table 3, it can be seen that the highest protein content is the promising line 46 of 7.88% while the lowest protein content is the promising line 13 of 6.65%. Gamma ray irradiation treatment increases the protein content of black rice, according to Putri [9], giving irradiation treatment to "Cempo Ireng" black rice causes a significant increase in protein content and increases with increasing irradiation dose. From the data obtained, the promising line 13 is lower in the protein content compared to the control plants. This is according to Nisa [10] that stated the decrease in the value of seed protein content due to a certain dose can be caused by an interaction between radiation and seed material that can change the shape (denaturation) of the protein. So that the denatured protein is not dissolved and is detected during protein testing.

3.4. Fat content

The physicochemical properties of rice greatly determine the quality of cooking and the quality of the taste of the rice produced. The effect of fat mainly appears after grain or rice is stored. Fat damage causes a decrease in the quality of rice. According to Astawan and Leomitro [11], the fat contained in the rice husk is generally essential. Fat is very important for brain development. The natural fiber content in the epidermis also provides a satiety effect and cleanses the digestive tract.

Table 4. The fat content of black rice (*Oryza sativa L.*) in the gamma ray irradiation and without irradiation lines

| Line    | Fat Content | Average (ppm) |
|---------|-------------|---------------|
|         | Deuteronomy 1 | Deuteronomy 2 |
| GH 13   | 1.47        | 1.40          | 1.43  |
| GH 46   | 1.47        | 1.48          | 1.48  |
| GH 52   | 1.35        | 1.34          | 1.35  |
| Control | 1.55        | 1.55          | 1.55  |

The highest fat content value in control plants was 1.55%, while the lowest fat content was in line 52 at 1.35%. All of the expected yield lines were lower than the control plants. From the table above, it
shows that there are lower fat content of the rice in the promising lines when compared to the control line. According to Hasanah [12], the decrease in the value of fat content is due to the radiation process using a large amount of energy, so it can damage the composition of the fat until it is broken down into simpler molecules.

3.5. Vigor and seed viability
In improving the quality of seeds and seedlings, gamma ray irradiation has been widely applied to increase seed viability and vigor. Vigor is described by the strength of seed growth, physiologically the seeds can grow normally even though the conditions in the field are not optimal. Meanwhile, seed viability is defined as the ability of seeds to grow into sprouts which can be shown through metabolic symptoms or growth symptoms. This is supported by Mulyana [13] which states that the benchmark for seed viability is germination power, while the benchmark for seed vigor is germination speed.

**Table 5.** The average value of germination power and germination speed of black rice (*Oryza sativa L.*) in gamma ray irradiation and without irradiation lines

| Line     | Germination power (%) | Germination speed (%) |
|----------|-----------------------|-----------------------|
| GH 13    | 46                    | 22                    |
| GH 46    | 88                    | 67                    |
| GH 52    | 40                    | 27                    |
| Kontrol  | 29                    | 25                    |

Based on Table 5, the highest germination yield was in the promising line 46 at 88%. The lowest yield was in the control line, which was 29%. According to Zanzibar et al [14], biochemical changes affect the process of cell metabolism which at a certain level can decompose chemicals that inhibit germination and increase cell division so that not only effect on germination but also on seedling growth. The speed of germination from the data in Table 5, for the highest results in the promising line 46, which is 67% and the lowest is in the promising line 13, which is 22%. According to Prabhandaru and Saputro [15], the decrease in seed germination speed can be affected by the administration of high doses of gamma ray irradiation because electromagnetic irradiation has the ability to affect electrons in the nucleus, so metabolism decreases and decreases germination speed.

3.6. Organoleptic test
Sensory assessment is also called organoleptic assessment or sensory assessment. In general, organoleptic tests are subjective. According to Sari et al [16], in terms of the application of rice quality standards, the quality character that is most favored by consumers can be interpreted as identification of the status of understanding and acceptance of existing rice quality standards or classes.

**Table 6.** The average value of an organoleptic test of black rice (*Oryza sativa L.*) in the gamma ray irradiation and without irradiation lines

| Line  | Color | Scent | Flavor | Texture | Average |
|-------|-------|-------|--------|---------|---------|
| GH 13 | 3.2   | 2.9   | 3      | 1.9     | 2.75    |
| GH 46 | 2.3   | 2.6   | 3.2    | 3.0     | 2.78    |
| GH 52 | 3.8   | 2.5   | 4.1    | 2.6     | 3.25    |
| Kontrol | 2.2 | 2.8   | 2.9    | 2.1     | 2.50    |

According to Ayustaningwarno [17] Organoleptic testing is an assessment method by utilizing the five human senses to observe the color, scene, flavor, texture of a food product, drink or drug. After assessing the texture, the panelists will rate the taste of the rice. In determining the taste of a food can be done by using sensors. The sense of taste is used to assess the taste of a food. Based on Table 6, it can be seen that the highest average color, aroma, taste, and texture assessment results were found in the promising line 52 which was 3.25 and the lowest was found in the control plant which was 2.5.


### 3.7. Seed pericarp color

Based on the pigment, rice has white, red, purple to black colors. According to Kristamtini et al [18], there are various colors of rice and the color depends on the color pigments, especially anthocyanins in the pericarp layer, seed coat (seed coat) or aleurone. Black rice (*Oryza sativa L.indica*) has a deep red-blue-purple pericarp, aleurone and endosperm, this color indicates the presence of anthocyanins.

**Table 7.** The fat content of black rice (*Oryza sativa L.*) in the gamma ray irradiation and without irradiation lines

| Line   | Seed Pericarp Color |
|--------|---------------------|
| GH 13  | 2.0                 |
| GH 46  | 2.0                 |
| GH 52  | 3.0                 |
| Control| 2.0                 |

Based on table 7, the highest yield of black rice pericarp color was in the promising line 52. The lowest result was in the control line black rice, the promising line 13 and the promising line 46. Pericarp color itself was strongly influenced by the anthocyanin content in black rice, so the higher anthocyanin content the rice is getting dark purple to black the color of the rice. In relation to agronomy, according to Widyayanti [19], it is stated that pericarp color can be used to support the effectiveness of selection because color has wide genetic diversity, with high heritability and genetic progress to produce superior cultivars of black rice.

There were differences in pericarp color in the promising and control lines. According to Kaplan [20], the difference in the pericarp color of black rice in the promising and control lines was thought to be caused by the color variation of the rice, from bright black to dark black. Differences in rice color occur as a result of differences in anthocyanin content.

![Pericarp color of black rice (*Oryza sativa L.*).](image)

### 4. Conclusion

Based on the results, it can be concluded that the quality and performance of line 13, 46, and 52 black rice from Gamma ray irradiation, results showed better compared to another line without gamma ray irradiation (control). Promising line 46 has good yield quality and promising line 52 has good performance.

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