Rice strain selection for Mentik Wangi variety M3 generation resulting from 200 gray gamma irradiation

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Abstract. Mentik Wangi rice is a local variety that is quite popular with the people of Magelang. Mentik Wangi rice has a distinctive aroma and has a fluffier texture. The disadvantage of Mentik Wangi rice is the potential for lower production and the plants are too high. There is an effort done to overcome that problem were planted mutation through the utilization of gamma-ray irradiation. The aim of this research is to select M3 generation mutant rice resulting from 200 gray gamma-ray irradiation which has a short stems and has higher productivity and determine the performance of M3 generation mutant rice resulting from 200 gray gamma-ray irradiation. The observational data were analyzed descriptively and compared the performance of the Mentik Wangi M3 rice plants as a result of 200 gray gamma-ray irradiation with control plants through T-test analysis. The results showed that the performance of the M3 generation of Mentik Wangi rice was better than control plants, there were several strains with potential mutants traits based on the positive character of each individual. There are 24 Mentik Wan gi M3 generation rice plants resulting from 200 gray gamma-ray irradiation plants which are selected based on short stem and have a high productivity.

1. Introduction
Local rice is germplasm which has the potential as the source of genes to control important traits in rice plants [1]. One of the local rice that is quite liked by Magelang society is Mentik Wangi, because it has a fragrant aroma and fluffier rice texture. However, Mentik Wangi rice has a lower production potential, longer harvest life and also high stems [2].

Improving the quality and quantity of Mentik Wangi can be done by plant breeding such as gene mutation. Plant genetic mutations can be inducted by using mutagen such as gamma-ray irradiation. Gamma-ray irradiation in rice can cause phenotypic changes in plants [3]. The determination about appropriate gamma-ray irradiation doses for mutation induction is the most important thing [4]. The radiation doses that are given depends on the type of plants, growth phase, size, hardness and material that will be mutated. The effective doses for rice plants range from 100-500 gray [5]. The objective of this research is to observe and select M3 mutants of Mentik Wangi from gamma ray irradiation and obtain short-stemmed and high productivity mutant plants.
2. Materials
This research was conducted in November 2018 - April 2019 in the Palur Village's experiment area, Mojolaban District, Sukoharjo Regency. The materials used in this research are Mentik Wangi plants without radiation as the control and Mentik Wangi rice seeds M2 generation resulting from 200 gray gamma irradiation. This research was conducted by planting 36 strains code consisting of 35 selected M2 generation lines of 200 gamma ray irradiation and one strain of control plant. The observation data has been selected from 35 strains to 10 best strains. There are 100 plants in one strain and selected to be the best 10 plants. The research's results data were analyzed descriptively and compared the performance of Mentik Wangi M3 rice with the control through t-test analysis.

3. Results and discussion
3.1. Plant height
Plant height is often observed as one of the growth indicators to measure the effect of the environment or treatments given. Mutation through gamma-ray irradiation has given a real contribution to the improvement of the world's plants [6].

| No | M3 Line          | Range (cm) | Average (cm)  |
|----|------------------|------------|---------------|
| 1  | M3-200-G147-10   | 93–99      | 96.00±2.45*   |
| 2  | M3-200-G107-17   | 93–98      | 98.30±2.59*   |
| 3  | M3-200-G147-2    | 92–99      | 96.60±2.79*   |
| 4  | M3-200-G107-15   | 91–104     | 97.80±5.40*   |
| 5  | M3-200-G59-18    | 87–111     | 98.20±8.56*   |
| 6  | M3-200-G29-1     | 97–104     | 98.80±2.95*   |
| 7  | M3-200-G29-11    | 95–103     | 99.00±3.74*   |
| 8  | M3-200-G59-3     | 96–106     | 101.20±4.82*  |
| 9  | M3-200-G147-4    | 96–104     | 101.20±3.37*  |
| 10 | M3-200-G10-3     | 97–105     | 102.60±3.21*  |
| 11 | Control          | 130–144    | 138.00±6.20   |

Mentik Wangi M3 generation variety rice plants resulting from 200 gray gamma irradiation have a lower height compared to the control plants (Table 1). This is in accordance with the statement [7] that the irradiation treatment can cause the change in plants' morphology characters such as plant height that’s shorter than the ones that are not irradiated. The M3-200-G147-10 strain has the lowest plant height with an average of 96.00 cm. Based on [8], the plant height decreases with the increase of the dose of gamma-ray irradiation with a linear pattern.

3.2. Number of productive tillers
Productive tillers are the number of tillers in an individual that produces rice panicles. Based on [9] productive tillers become one of the benchmarks for high production. The number of productive tillers is the main actor with a contribution to a large yield (Table 2.).

Based on Table 2, the number of productive tillers of Mentik Wangi M3 generation resulting from 200 gray gamma irradiation is 14–26. The highest number of productive tillers was in the M3-200-G29-11 strain with the average of 22.80 tillers. Based on the result of t-test, the number of productive tillers of Mentik Wangi M3 generation resulting from 200 gray gamma-ray irradiation was significantly different from the control. This is in accordance with the statement of [10] that the mutation induction in the plant breeding is proven to be able to produce new high yielding varieties.
Table 2. Number of productive tillers of Mentik Wangi rice varieties from gamma-ray irradiation of various doses

| No | M3 Line          | Range (cm) | Average (cm) |
|----|------------------|------------|--------------|
| 1  | M3-200-G147-10   | 16–22      | 18.60±2.70* |
| 2  | M3-200-G107-17   | 17–20      | 18.60±1.52* |
| 3  | M3-200-G147-2    | 18–24      | 21.00±2.45* |
| 4  | M3-200-G107-15   | 18–25      | 19.80±2.95* |
| 5  | M3-200-G59-18    | 19–25      | 21.40±2.51* |
| 6  | M3-200-G29-1     | 15–25      | 21.20±4.15* |
| 7  | M3-200-G29-11    | 17–26      | 22.80±4.09* |
| 8  | M3-200-G59-3     | 15–22      | 19.40±3.58* |
| 9  | M3-200-G147-4    | 14–21      | 17.20±3.11* |
| 10 | M3-200-G10-3     | 17–25      | 20.60±3.36* |
| 11 | Control          | 6–17       | 9.40±4.39   |

3.3. Panicle thickness index

The Panicle Thickness Index shows how many of seeds or grains growing in one panicle. The panicle thickness index is determined by the number of seeds or grains and also the panicle length (Table 3).

Table 3. Panicle thickness index of Mentik Wangi rice varieties from gamma-ray irradiation of various doses

| No | M3 Line          | Average number of grains (g) | Average length of panicle (cm) | Panicle thickness index |
|----|------------------|-----------------------------|-------------------------------|------------------------|
| 1  | M3-200-G147-10   | 161.80                      | 26.11                         | 6.20 ± 0.23            |
| 2  | M3-200-G107-17   | 158.08                      | 25.98                         | 6.09 ± 0.22            |
| 3  | M3-200-G147-2    | 179.64                      | 27.09                         | 6.63 ± 0.41*           |
| 4  | M3-200-G107-15   | 157.08                      | 24.70                         | 6.35 ± 0.23            |
| 5  | M3-200-G59-18    | 169.52                      | 26.90                         | 6.34 ± 0.41            |
| 6  | M3-200-G29-1     | 164.48                      | 26.02                         | 6.32 ± 0.37            |
| 7  | M3-200-G29-11    | 170.96                      | 26.26                         | 6.49 ± 0.47            |
| 8  | M3-200-G59-3     | 161.40                      | 26.40                         | 6.12 ± 0.84            |
| 9  | M3-200-G147-4    | 179.96                      | 27.01                         | 6.65± 0.55             |
| 10 | M3-200-G10-3     | 161.56                      | 26.38                         | 6.13 ± 0.53            |
| 11 | Control          | 136.56                      | 23.97                         | 5.70 ± 0.55            |

Based on Table 3, the control plants have lower panicle thickness index compared to irradiation plants. Mentik Wangi rice plant M3 radiation resulting from 200 gray gamma-ray irradiation that has the highest panicle thickness index is in the M3-200-G147-4 strain with the value of panicle thickness index of 6.65 and has the number of seeds per panicle of 179.96 g and the panicle length 27.01 cm. This shows that the panicle thickness index is determined by the number of total grains and panicle length. Based on [11] the higher the total amount of grains per panicle, then the higher the panicle thickness index. Based on the result of t-test, the number of panicle thickness index of Mentik Wangi M3 generation resulting from 200 gray gamma-ray irradiation was different from the control. According to [12] gamma ray irradiation causes random mutations result in physiological damage in cell development.
3.4. Seed yield per clump
Seed yield per clump is affected by the panicle length, the number of tillers, and also the percentage of rice grains. According to [13], the panicle length significantly has a positive correlation with the grain weight per clump that will affect the yield per ha. [14] stated that the flavour and shape of grains are one of the factors that influence the farmers in choosing high yielding varieties (Table 4).

Table 4. Seed yield per clump of Mentik Wangi rice varieties from gamma-ray irradiation of various doses

| No. | M3 Line          | Range (g) | Average (g) |
|-----|------------------|-----------|-------------|
| 1   | M3-200-G147-10   | 36.60–43.90 | 41.79 ± 2.97* |
| 2   | M3-200-G107-17   | 37.07–49.91 | 43.42 ± 5.25* |
| 3   | M3-200-G147-2    | 47.44–56.78 | 50.52 ± 3.47* |
| 4   | M3-200-G107-15   | 34.88–51.81 | 43.51 ± 7.38* |
| 5   | M3-200-G59-18    | 35.60–57.33 | 47.03 ± 8.42* |
| 6   | M3-200-G29-1     | 26.35–63.25 | 40.98 ± 14.11 |
| 7   | M3-200-G29-11    | 34.08–78.19 | 47.43 ± 18.10 |
| 8   | M3-200-G59-3     | 33.16–65.10 | 46.74 ± 12.27*|
| 9   | M3-200-G147-4    | 36.25–49.69 | 43.94 ± 5.25* |
| 10  | M3-200-G10-3     | 39.67–56.80 | 47.01 ± 6.41* |
| 11  | Control          | 22.32–41.08 | 27.54 ± 7.80 |

Seed yield per clump is the parameter which affects yield. The result data of seed yield per clump (Table 4) shows different results between control plants and Mentik Wangi rice plants resulting from 200 gray gamma-ray irradiation. Control plants have seed yield per clump of 27.54 g. Mentik Wangi M3 generation rice plant resulting from 200 gray gamma-ray irradiation which has the highest average seed yield per clump is in the M3-200-G147-2 strain with the average of 50.52 in the range of 47.44 – 56.78 g. Seed yield per clump is affected by some factors. [15] stated that the factors that can influence the ups and downs of the average of rice production per hectare are the soil fertility problems, rainfall, humidity, the use of fertilizers, seed selection, farming methods, intruder bodies, and so on. The availability of sunlight is also one of the factors that affect grain filling. [16] stated that one of the conditions that cause rice plants to have low harvest yield is because the plants didn't receive enough sunlight during the reproductive phase. The decrease of yield also happen because of the instability in the mutation induction results. Based on [17] stated that macro mutation using high irradiation would cause genetic instability.

3.5. M3 mutant selection
Mutant selection is done to get individual plants that have superior traits. The selection was carried out by comparing rice plants of Mentik Wangi M3 generation resulting from 200 Gray gamma-ray irradiation with control plants on each observation of the variables. The first selection made was looking for the 10 best strains of 35 strains. After getting the 10 best strains, then selecting the superior plants of the 10 best strains. The criteria used to look for superior plant individuals are short-stemmed and have a high clump weight. Selection of individual plants produced 24 selected plants from 50 existing plants (Table 5).

Table 5 shows selected individual Mentik Wangi M3 generation rice plants resulting from 200 gray gamma-ray irradiation. Selected plants are plants that are better compared to control plants according to the observing variables. The selection result of Mentik Wangi M3 generation mutant rice resulting from 200 gray gamma-ray irradiation has a range of height 87-100. Individual plant with the lowest height is in M3-200-G59-18 strain with the plant number 1, which is 87 cm. Individual plant with the highest weight per clump is in the M3-200-G29-11 strain with plant number 105, which is 78.19 g.
Table 5. M3 mutant selection Mentik Wangi rice varieties from gamma-ray irradiation of various doses

| No | M3 Line         | Selected plant number | Plant height (cm) | Seed yield per clump (g) |
|----|-----------------|-----------------------|-------------------|--------------------------|
| 1  | M3-200-G147-109 | 76                    | 93                | 43.90                    |
|    |                 | 24                    | 98                | 42.15                    |
|    |                 | 45                    | 95                | 43.21                    |
|    |                 | 69                    | 95                | 43.11                    |
| 2  | M3-200-G107-17  | 60                    | 93                | 40.68                    |
|    |                 | 51                    | 97                | 47.38                    |
|    |                 | 17                    | 98                | 42.04                    |
|    |                 | 70                    | 93                | 49.91                    |
| 3  | M3-200-G147-2   | 48                    | 92                | 56.78                    |
|    |                 | 66                    | 98                | 47.87                    |
|    |                 | 55                    | 99                | 50.26                    |
|    |                 | 15                    | 96                | 47.44                    |
|    |                 | 27                    | 98                | 50.27                    |
| 4  | M3-200-G107-15  | 105                   | 98                | 51.81                    |
| 5  | M3-200-G59-18   | 1                     | 87                | 51.67                    |
|    |                 | 43                    | 99                | 4838                     |
|    |                 | 20                    | 97                | 42.35                    |
| 6  | M3-200-G29-1    | 1                     | 97                | 63.25                    |
|    |                 | 54                    | 98                | 42.35                    |
| 7  | M3-200-G29-11   | 105                   | 97                | 78.19                    |
|    |                 | 98                    | 97                | 47.33                    |
| 8  | M3-200-G59-3    | 30                    | 96                | 51.05                    |
| 9  | M3-200-G147-4   | 85                    | 100               | 41.26                    |
| 10 | M3-200-G10-3    | 19                    | 100               | 44.90                    |
| 11 | Control         | -                     | 144               | 27.31                    |

4. Conclusion
The conclusions of this study are as follows: There are differences in the performance of agronomic traits of Mentik Wangi M3 generation rice resulting from gamma-ray irradiation such as plant height, number productive of tillers, panicle thickness index and weight of seeds per clump that are better compared to control plants. Mentik Wangi M3 generation rice plants resulting from 200 gray gamma-ray irradiation have lower plant height compared to control plants. There are 24 Mentik Wangi M3 generation rice plants resulting from 200 gray gamma-ray irradiation plants which are selected based on short stems and have a high yield.

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