Performance selection of Mentik Wangi M5 generation rice resulting from 100 gray gamma-ray irradiation

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Abstract. Mentik Wangi rice is local rice originating from Yogyakarta Indonesia, which has distinctive fragrant and fluffier texture. The problems that occur in Mentik Wangi rice cultivation are that the harvest time is longer, and the plants are too high so that it gives a potential lower production impact because it is easy to collapse. One way to overcome this problem is through plant breeding with gamma-ray irradiation. The aim of this research is to select Mentik Wangi M5 irradiated by 100 Gy gamma-ray, which has a short stem and has high productivity. Observation data were analyzed descriptively, followed by a T-test to compare the performance of Mentik Wangi M5 rice plants from 100 gray gamma irradiation with control plants (without irradiation). The shortest plant height is in the M-MW1-G12-01-18-05 of 96cm with a height range of 96–110 cm. The highest number of productive tillers was found in the M-MW1-G80-11-08-15 with a range of 15–25 tillers. The highest panicle density index range was found in the M-MW1-G35-02-06-19 of 4.6–6.77. The highest level of plant productivity was found in the M-MW1-G12-01-18-01 which was 5.95 tons/ha. The results of the selection there are 21 individual plant mutans.

1. Introduction
The local rice Mentik Wangi varieties are originated from the Special Region of Yogyakarta and are aromatic rice. Characteristics of morphology or performance of Mentik Wangi rice plant are plant height between 100–130 cm, panicle length of about 20–40 cm with the number of grains per panicle of 70–180 grains [1]. Mentik Wangi has a fluffier rice texture, which makes this rice very popular with consumers [2]. However, Mentik Wangi Rice has several disadvantages compared to new superior rice varieties, namely a longer harvest age, and relatively high plant height so that it can easily collapse.

One way to overcome weaknesses is through plant breeding using gamma-ray radiation mutations. Gamma-ray irradiation can improve the quality of the genetic diversity of superior new varieties of assembly plants [3]. Gamma-ray radiation of rice seeds has an effective dosage range in the range of 100–500 grays, which can produce mutants that have agronomic characteristics such as low height, early maturity and have high production [4].
2. Materials and methods
This research was conducted in November 2018-April 2019 in the Experimental Rice Fields of Palur Village, Mojolaban District, Sukoharjo Regency. The research was conducted by planting 35 M5 strain codes of 100 gray Mentik Wangi rice and control plants parallel without doing randomization. The observation data has been selected from 35 strains to 10 best strains. In one strain, there are 150 plants selected to be the best 10 plants, which are presented in the data table per line, which was the average yield of all selected plants. The observational data were analyzed descriptively and compared between control plants and Mentik Wangi 100 gray plants using a T-test analysis.

3. Results and discussion
3.1. Plant height
Height is a parameter in the plant growth process. Plant height is influenced by inherited (genetic) and environmental traits. The mutation-induced short plants can be caused by the abnormal function of gibberellins [5].

| Table 1. The plant height of Mentik Wangi M5 rice from 100 gray gamma irradiation. |
|---------------------------------------------------------------|
| **M5 line** | **Range (cm)** | **Average (cm)** |
| M-MW1-G35-02-06-19 | 103–126 | 114.40±11.81 |
| M-MW1-G35-02-06-20 | 105–124 | 114.50±9.95 |
| M-MW1-G35-02-06-13 | 105–125 | 115.10±10.09 |
| M-MW1-G35-02-06-01 | 109–122 | 115.50±6.77 |
| M-MW1-G12-01-18-01 | 102–126 | 114.10±11.66 |
| M-MW1-G12-01-18-19 | 99–118 | 108.50±9.41 |
| M-MW1-G12-01-18-05 | 96–110 | 103.20±7.07 |
| M-MW1-G80-11-08-15 | 97–106 | 101.30±4.52 |
| M-MW1-G89-20-03-01 | 97–108 | 102.30±5.44 |
| M-MW1-G89-20-12-17 | 103–121 | 112.30±8.86 |
| Control | 136–146 | 141.00±4.69 |

The Mentik Wangi M5 generation rice plant produced by 100 gray gamma-ray irradiation has a lower plant height compared to control plants (Table 1). This is consistent with the statement [6] that the decrease in plant height is due to gamma-ray radiation, which inhibits auxin synthesis and cell division. The shortest plant height was found in the M-MW1-G12-01-18-05 strain of 96 cm with a plant height range of 96–110 cm. Rice plants that have short stems will reduce the level of agitation due to environmental factors such as rain and wind [7].

3.2. Number of productive tiller
Productive tillers are tillers that have developed further and produce panicles on rice plants. Increased productivity of rice plants is influenced by the number of productive tillers that produce grains [8].

The results of data analysis (Table 2) explain that Mentik Wangi M5 generation resulting from 100 gray gamma-ray irradiation has a higher average number of productive tillers compared to control plants (without irradiation). The calculation of the number of productive tillers is one of the components that can affect the yield components of rice productivity [9]. The highest number of productive tillers was found in the M-MW1-G80-11-08-15 strain with a range of 15–25 tillers. The formation of productive rice tillers has a positive correlation with an increase in grain production. If the formation of productive tillers is a lot, then it will increase the results of their productivity [10].
Table 2. Number of productive tillers of Mentik Wangi M5 rice from 100 gray gamma irradiation.

| M5 line              | Range (cm) | Average (cm) |
|----------------------|------------|--------------|
| M-MW1-G35-02-06-19   | 8–14       | 10.80±2.74   |
| M-MW1-G35-02-06-20   | 9–18       | 13.20±4.42   |
| M-MW1-G35-02-06-13   | 9–14       | 11.10±2.56   |
| M-MW1-G35-02-06-01   | 8–13       | 10.20±2.39   |
| M-MW1-G12-01-18-01   | 14–20      | 17.10±3.35   |
| M-MW1-G12-01-18-19   | 11–17      | 13.90±3.14   |
| M-MW1-G12-01-18-05   | 12–22      | 17.30±5.08   |
| M-MW1-G80-11-08-15   | 15–25      | 20.10±5.34   |
| M-MW1-G89-20-03-01   | 14–22      | 18.10±6.60   |
| M-MW1-G89-20-12-17   | 13–18      | 15.40±2.76   |
| Control              | 8–13       | 10.60±2.17   |

3.3. Panicle density index

The panicle density index is an indicator to see how much yield a rice plant can produce. A high panicle density index is obtained if the value of the total grain value is high [11]. The panicle density index can also be used to determine the density of seeds attached to rice panicles.

Table 3. Panicle density index of Mentik Wangi M5 rice from 100 gray gamma irradiation.

| M5 line              | Average number of grains (gr) | Average length of panicle (cm) | Range of panicle density index | Average of panicle density index |
|----------------------|--------------------------------|-------------------------------|--------------------------------|---------------------------------|
| M-MW1-G35-02-06-19   | 153.06                          | 26.48                         | 4.6–6.77                       | 5.68±1.09                      |
| M-MW1-G35-02-06-20   | 124.16                          | 25.48                         | 4.04–5.68                      | 4.86±0.82                      |
| M-MW1-G35-02-06-13   | 126.56                          | 26.01                         | 4.27–5.44                      | 4.85±0.59                      |
| M-MW1-G35-02-06-01   | 130.82                          | 26.19                         | 4.25–5.68                      | 4.96±0.72                      |
| M-MW1-G12-01-18-01   | 111.48                          | 25.20                         | 3.70–5.11                      | 4.40±0.70                      |
| M-MW1-G12-01-18-19   | 119.12                          | 25.21                         | 3.66–5.68                      | 4.67±1.01                      |
| M-MW1-G12-01-18-05   | 111.34                          | 24.65                         | 3.72–5.36                      | 4.54±0.82                      |
| M-MW1-G80-11-08-15   | 104.46                          | 24.34                         | 3.75–4.80                      | 4.28±0.53                      |
| M-MW1-G89-20-03-01   | 108.16                          | 24.19                         | 3.83–5.11                      | 4.47±0.64                      |
| M-MW1-G89-20-12-17   | 137.36                          | 24.86                         | 4.00–6.92                      | 5.46±1.46                      |
| Control              | 97.90                           | 24.28                         | 3.34–4.37                      | 3.86±0.51                      |

The results in Table 3 show that Mentik Wangi M5 generation from 100 gray gamma-ray irradiation has a higher average panicle density index value compared to control rice plants (without irradiation). The panicle density index is determined by the total number of grains and panicle length. The highest range of panicle density index was found in the M-MW1-G35-02-06-19 strain of 4.6–6.77, while the shortest range of the panicle density index was found in the M-MW1-G12-01-18-05 strain of 3.75–4.8. The highest panicle density index was obtained when the total number of grains of the panicle was high [12].

3.4. Seed yield per clump

The yield of seeds per clump can also be used as a method to calculate rice productivity from the yields obtained for a certain area of land. Clump weight is influenced by the balance between the source and sink of the grain filling process [13]. The agronomic characters of rice plants that have a positive relationship with productivity are the number of pithy grains per panicle, the number of grains per panicle, and the number of empty grains per panicle [14].
3.5. M5 mutant Selection

Table 4. Seed yield per clump of Mentik Wangi M5 rice from 100 gray gamma irradiation.

| M5 line          | Seed Yield per Plant (gram) | Average (Ton/Ha) |
|------------------|-----------------------------|-------------------|
| M-MW1-G35-02-06-19 | 34.59                       | 5.53              |
| M-MW1-G35-02-06-20 | 32.15                       | 5.14              |
| M-MW1-G35-02-06-13 | 30.89                       | 4.94              |
| M-MW1-G35-02-06-01 | 31.08                       | 4.97              |
| M-MW1-G12-01-18-01 | 37.16                       | 5.95              |
| M-MW1-G12-01-18-19 | 29.83                       | 4.77              |
| M-MW1-G12-01-18-05 | 32.55                       | 5.21              |
| M-MW1-G80-11-08-15 | 34.82                       | 5.57              |
| M-MW1-G89-20-03-01 | 30.41                       | 4.87              |
| M-MW1-G89-20-12-17 | 32.55                       | 5.21              |
| Control          | 23.63                       | 3.78              |

The results in Table 4 show that the Mentik Wangi M5 generation resulting from 100 gray gamma-ray irradiation has a higher productivity value than the control plants. Irradiation causes mutations in plants resulting in increased plant diversity of rice grain weight per clump [15]. The highest level of plant productivity was found in the M-MW1-G12-01-18-01 strain, which was 5.95 tons/ha, the lowest productivity level was in the M-M-W1-G12-01-18-19 strain of 4.77 ton/ha. Mutations can increase production up to 15–23% of the control population [16].

Table 5. M5 Mentik Wangi from 100 gray gamma-ray irradiation mutant selection.

| M5 line          | Selected plant number | Plant height (cm) | Harvest age (DAP) | Grain yield per clump (gram) | Productivity (ton/ha) |
|------------------|-----------------------|-------------------|-------------------|-----------------------------|-----------------------|
| M-MW1-G35-02-06-19 | 70                    | 98                | 108               | 35.35                       | 5.66                  |
|                  | 81                    | 108               | 108               | 55.16                       | 8.83                  |
| M-MW1-G35-02-06-20 | 82                    | 105               | 108               | 39.92                       | 6.39                  |
|                  | 76                    | 109               | 108               | 37.50                       | 6.00                  |
| M-MW1-G35-02-06-13 | 90                    | 107               | 108               | 30.56                       | 4.89                  |
| M-MW1-G35-02-06-01 | 105                   | 116               | 108               | 43.41                       | 6.95                  |
| M-MW1-G12-01-18-01 | 88                    | 104               | 111               | 40.00                       | 6.40                  |
|                  | 86                    | 101               | 111               | 35.47                       | 5.68                  |
|                  | 109                   | 102               | 111               | 36.73                       | 5.88                  |
| M-MW1-G12-01-18-19 | 70                    | 98                | 111               | 36.85                       | 5.90                  |
| M-MW1-G12-01-18-05 | 8                     | 115               | 111               | 48.40                       | 7.74                  |
|                  | 69                    | 97                | 111               | 36.73                       | 5.88                  |
|                  | 41                    | 100               | 111               | 47.66                       | 7.63                  |
| M-MW1-G80-11-08-15 | 20                    | 101               | 112               | 40.12                       | 6.42                  |
|                  | 29                    | 101               | 112               | 40.51                       | 6.48                  |
|                  | 50                    | 100               | 112               | 42.19                       | 6.75                  |
|                  | 15                    | 100               | 112               | 40.59                       | 6.49                  |
| M-MW1-G89-20-03-01 | 11                    | 98                | 113               | 38.63                       | 6.18                  |
|                  | 21                    | 104               | 113               | 40.30                       | 6.45                  |
| M-MW1-G89-20-12-17 | 33                    | 102               | 114               | 32.37                       | 5.18                  |
|                  | 76                    | 118               | 114               | 43.15                       | 6.90                  |
| Control          | -                     | 141               | 123               | 23.63                       | 3.78                  |
Selection is a process in breeding by separating individuals or groups of plants from mixed populations. The ultimate goal of plant breeding is to improve traits and increase yield. The positive correlation value and the high heritability value of the character can be used for the yield selection process so that the traits can be inherited to the next generation [17]. Mutation induction is a way that is done by humans to change plant genetics that contributes to better improvement than the original plant genetic traits of the plant [18]. The results of the selection were 21 Mentik Wangi M5 rice plants as a result of 100 gray gamma-ray irradiation (Table 5).

The results of the selection there are 21 individual M5 plants of Mentik Wangi from 100 gray gamma irradiation. The results of plant selection (Table 5) of the M5 generation had a plant height range of 97-118 cm. Gamma-rays with the right dose will have a good influence on agriculture, such as having good traits such as early maturity, resistance, and high productivity [19]. The mutant plants with the lowest plant height were in the M-MW1-G12-01-18-05 strain, with plant number 69 having a plant height of 97 cm. The mutant plants that had the highest productivity were found in the M-MW1-G35-02-06-19 strain plant number 81, which had the highest productivity level, namely 8.83 tons/ha with seed yields per clump of 55.16 grams. Selection carried out in plant breeding is used to create new varieties that have good traits [20]. The selected M5 Mentik Wangi rice plants will be replanted to be continued as the M6 generation to find out more about the quality of production yields, quality of pest and disease resistance, and also the quality of resistance in several seasons and locations.

4. Conclusion

The conclusion of this study are The Mentik Wangi M5 generation rice plants resulting from 100 gray gamma-ray irradiation had better performance in the variable plant height (which ranged from 96–126 cm), flowering age (which ranged from 55–63 DAS), and harvest age (which ranged from between 108–114 DAS), compared with plants without irradiation or control (plant height ranging from 136–146 cm, flowering age 71 DAS, and harvesting age 123 DAS). There are 21 selected M5 generations of Mentik Wangi rice mutant plants that have short stems, have short lives, and have high productivity. The strains that have the potential as superior mutants from the 10 selected strains are M-MW1-G35-02-06-19, M-MW1-G35-02-06-20, M-MW1-G12-01-18-05, M-MW1-G80-11-08-15, and the M-MW1-G89-20-03-01 strains which can be used as planting material for further research.

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