Selection of M5 short-stemmed mutants from 200 gray gamma ray irradiation in Mentik Wangi rice

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Abstract. Mentik Wangi rice is native to Indonesia, it has an oval round shape of rice, yellow brown rice, and fragrant aroma. Mentik Wangi has a weakness that is relatively long harvest time, the plant is too high so it easily fell. This research aims to determine the performance of M5 generation of mutant rice and to select M5 generation of mutant plants resulted from 200 gray gamma irradiation which has short stems with high productivity. The research was carried out by planting 36 genotypes, namely 35 M4 lines of 200 gray gamma ray irradiation and control plant (without irradiation). Observation data were analyzed descriptively and t test to determine differences in M5 generation of Mentik Wangi rice from 200 gray gamma ray irradiation with control plants (without irradiation). Based on the research results that Mentik Wangi rice plants with gamma ray irradiation 200 Gray have better performance compared to control plants (without irradiation) and there are 28 individuals M5 Mentik Wangi rice mutants selected by short-stemmed plants and have high productivity.

1. Introduction
Mentik Wangi rice is one of the original local variety of Indonesia. Mentik Wangi rice has characteristic features such as oval round rice, brownish yellow rice, and fragrant rice aroma. As in general, Mentik Wangi rice has lower production potential than new superior varieties of rice. Flavored rice and fragrant aroma make Mentik Wangi rice highly favored by the community, so the demand for Mentik Wangi rice in Indonesia is increasing. In addition to having advantages, local varieties of rice also have weaknesses including a relatively long harvest age, plants are too tall so it easily falls when exposed to wind and land is too flooded [1].

Based on these problems, there are several ways to overcome the problems in local rice varieties of Mentik Wangi, one of the modern ways to increase crop yields and eliminate weaknesses from Wangi Mentik rice is by mutating plants using gamma ray irradiation. The use of gamma ray irradiation can help the process of plant breeding. Irradiation is radiation with radioactive rays that can cause mutations. Mutations with radiation can increase genetic variation. Cells that are exposed to radiation will undergo several physiological or genetic changes. These changes can produce plants that have better characteristics than before [2]. The success rate of irradiation in increasing population diversity
is largely determined by the irradiated plant genotype because the level of radiosensitivity between genotypes and the condition of the plants when irradiated varies greatly [3].

The purpose of this study is to determine the performance of the M5 generation of mutant rice after being influenced by 200 Gray gamma ray irradiation in Mentik Wangi rice and select the M5 generation of gamma ray irradiated results in Wangi Mentik rice to produce short-term mutant rice with high productivity.

2. Materials and methods

The research was conducted in November 2018 - April 2019 in the Faculty of Agriculture Experiment Field located in Palur Village, Mojolaban District, Sukoharjo Regency. The materials used in this study were M4 generation of Mentik Wangi rice seeds which were irradiated by 200 Gray gamma ray irradiation and control Mentik Wangi rice seeds (without irradiation). The research was carried out by planting 36 genotypes, namely 35 M4 strains of 200 gray gamma ray irradiations and control plant (without irradiation). Observation data has been selected from 35 strains to 10 best strains. The research’s result data were analyzed descriptively and went through t-test to determine the difference between Mentik Wangi rice M5 generation from 200 Gray gamma ray irradiation with control plants.

3. Results and discussion

3.1. Plant height

Plant height is a plant size that is often observed as an indicator of growth. According to [4], plant height is a parameter that is used to determine environmental influences and the treatments applied. (Table 1)

| Strain               | Range (cm) | Average (cm) |
|----------------------|------------|--------------|
| M5-MW2-G79-16-03-6   | 93–101     | 96.20 ± 3.03*|
| M5-MW2-G01-02-17-14  | 92–106     | 98.40 ± 5.94*|
| M5-MW2-G01-02-17-2   | 97–103     | 99.60 ± 2.41*|
| M5-MW2-G35-25-01-7   | 92–106     | 100.00 ± 5.61*|
| M5-MW2-G79-16-03-14  | 96–112     | 100.60 ± 6.54*|
| M5-MW2-G35-25-03-1   | 98–104     | 101.80 ± 2.39*|
| M5-MW2-G70-01-14-19  | 95–108     | 101.80 ± 5.54*|
| M5-MW2-G35-25-03-17  | 96–105     | 101.80 ± 3.42*|
| M5-MW2-G70-01-14-1   | 97–105     | 102.00 ± 4.12*|
| M5-MW2-G70-01-14-4   | 93–106     | 102.60 ± 5.41*|
| Control              | 130–144    | 138.00 ± 6.20*|

Table 1 shows that the height of the 200 Gray gamma ray irradiations treatment plants in Mentik Wangi rice in general had a significantly different effect on the control plants. The average height of the control plant is 138 cm. The shortest plant height is 92 cm, which were found in the M5-MW2-G01-02-17-14 strain. The longest plant height is 112 cm, which were found in the M5-MW2-G79-16-03-14 strain. Changes in plant height’s character in Mentik Wangi rice resulting from 200 Gray gamma ray irradiations indicate a change in nature for the better. This is consistent with the statement with the previous report [5], that plant breeding by means of gamma ray irradiation can cause changes in morphological, anatomical, and genetic characteristics to get better genotypes according to the target through selection. According to the previous study [6], found that changes in the character of plants to obtain genetic diversity will generally occur in the next generation.
3.2. Number of productive tiller

Productive tillers are saplings that produce rice panicles in a clump. The number of productive tillers is an indicator that is related to the yield capacity of grain production. [7] states that the number of productive tillers can increase the potential of a plant to produce higher production (Table 2).

| Strain                | Range | Average    |
|----------------------|-------|------------|
| M5-MW2-G79-16-03-6   | 17 – 27 | 21.20 ± 3.63* |
| M5-MW2-G01-02-17-14  | 11 – 24 | 17.80 ± 5.22* |
| M5-MW2-G01-02-17-2   | 26 – 38 | 31.40 ± 4.45* |
| M5-MW2-G35-25-01-7   | 13 – 29 | 20.80 ± 6.72 |
| M5-MW2-G79-16-03-14  | 14 – 19 | 16.60 ± 1.82* |
| M5-MW2-G35-25-03-1   | 15 – 31 | 22.40 ± 6.47* |
| M5-MW2-G70-01-14-19  | 14 – 30 | 19.20 ± 6.38 |
| M5-MW2-G35-25-03-17  | 15 – 24 | 19.00 ± 3.81* |
| M5-MW2-G70-01-14-1   | 14 – 22 | 18.80 ± 2.95* |
| M5-MW2-G70-01-14-4   | 13 – 20 | 16.40 ± 2.70 |
| Control              | 6 – 17  | 9.40 ± 4.39 |

Table 2 shows that the number of productive tillers of M5 Mentik Wangi rice produced by 200 Gray gamma ray irradiations has higher average values compared to control plants. [8] states that gamma ray irradiation can cause genetic mutations that affect the number of tiller. The highest number of productive tillers was 38 which were found in the M5-MW2-G01-02-17-2 strain. The lowest number of productive tillers was 11 which were found in the M5-MW2-G01-02-17-14 strain. According to [9], criteria for the number of productive tillers are divided into scores which include: very large (score 1 > 25 tillers), large (score 3 = 20-25 tillers), moderate (score 5 = 10-19 tillers), and few (score 7 = 5-9 tillers). Based on the observations of the number of productive tillers of Mentik Wangi M5 rice, the result of 200 Gray gamma ray irradiations was classified as very moderate to very large.

3.3. Harvest age

Harvest age is a parameter that is often used as a reference for farmers to determine the variety to be planted. According to [10], rice which has an early age is preferred because the harvest can be done faster (Table 3).

| Strain                | Harvest Age (HST) |
|----------------------|-------------------|
| M5-MW2-G79-16-03-6   | 109               |
| M5-MW2-G01-02-17-14  | 110               |
| M5-MW2-G01-02-17-2   | 110               |
| M5-MW2-G35-25-01-7   | 112               |
| M5-MW2-G79-16-03-14  | 108               |
| M5-MW2-G35-25-03-1   | 111               |
| M5-MW2-G70-01-14-19  | 111               |
| M5-MW2-G35-25-03-17  | 111               |
| M5-MW2-G70-01-14-1   | 111               |
| M5-MW2-G70-01-14-4   | 111               |
| Control              | 123               |
The results showed that the harvest age of M5 Mentik Wangi rice produced by 200 Gray gamma ray irradiations had a faster harvest age compared to control plants.[11], said that genetic changes resulting from induced mutations can accelerate flowering plants so that the age of harvest is faster. Based on the results of this study, it can be seen that the control plants have a harvest age of 123 days. The lowest harvest age of 108 days is found in the M5-MW2-G79-16-03-14 strain. The highest harvest age is 112 days found in the M5-MW2-G35-25-01-7 strain. According to [12], the age of rice harvesting has criteria that are divided into three groups, namely early maturing (<100-125 days), moderate (125-145 days) and deep (> 145 days). Based on the observations of the age of the Mentik Wangi M5 rice, the results of gamma ray irradiation of 200 Gray are relatively early.

3.4. Panicle thickness index
The panicle thickness index is an indicator that can be used to see the yield of rice crop production. The panicle flash index is related to the panicle length and also the number of heads per panicle. [13] states that panicle thickness is determined by the number of total grain and panicle length. The panicle thickness index was determined based on a comparison between the number of panicles per panicle and panicle length. The panicle dense index can be used to determine the density of seeds attached to the rice panicle (Table 4).

| Strain              | Panicle Thickness Index |
|---------------------|-------------------------|
| M5-MW2-G79-16-03-6  | 5.92 ± 0.70             |
| M5-MW2-G01-02-17-14 | 5.50 ± 0.60             |
| M5-MW2-G01-02-17-2  | 6.99 ± 0.20*            |
| M5-MW2-G35-25-01-7  | 5.83 ± 0.73             |
| M5-MW2-G79-16-03-14 | 5.06 ± 0.91             |
| M5-MW2-G35-25-03-1  | 5.77 ± 0.57             |
| M5-MW2-G70-01-14-19 | 5.60 ± 0.46             |
| M5-MW2-G35-25-03-17 | 5.10 ± 0.44             |
| M5-MW2-G70-01-14-1  | 6.33 ± 0.39             |
| M5-MW2-G70-01-14-4  | 6.08 ± 0.70             |
| Control             | 5.70 ± 0.55             |

Table 4 shows that the panicle dense index in control plants had an average of 5.70 with an average number of 136.56 seeds per panicle with an average length of 23.97 cm. The highest panicle flash index was 6.99 found in the M5-MW2-G01-02-17-2 strain with an average number of 175.88 seeds per panicle and an average length of 25.19 cm. The lowest panicle flash index was 5.06 which was found on the M5-MW2-G79-16-03-14 strain with an average number of 132.40 seeds per panicle and an average length of 26.08 cm. The higher number of seeds per panicle, the higher the panicle flash index [14].

3.5. Weight of seeds per clump
Weight of seeds per clump is the total weight of all seeds per plant produced. According to [15], many grains produced in one family determine the weight of grain per family (Table 5).
Plant selection through plant breeding techniques is done to produce individual plants with better properties than their parents. Mutation selection used to obtain targeted and desired strains [18]. Selection is done by comparing the observational variables between individual plants in each strain with control plants. The purpose of the Mentik Wangi rice plants selection is to produce M5 mutant plants with short stems, and high productivity (Table 6).

From the results of the M5 mutant selection of Mentik Wangi rice as a result of 200 Gray gamma ray irradiations in Table 6, it can be seen that there are 28 plants selected. Selection of the best plant individuals based on the desired character [19]. Selected plants are plants that have better observation variables compared to control plants (without irradiation) as well as mutant plants in other strains.

Table 5 shows that the weight of seeds per clump in control plants has an average of 27.54 grams. The highest seed weight per clump was 94.73 grams found in the M5-MW2-G01-02-17-2 strain. The lowest seed weight per clump is 24.87 grams found in the M5-MW2-G01-02-17-14 strain. T-test results with a confidence level of 0.05 indicate that the weight of seeds per clump of 200 Gray gamma ray irradiations treatment in Mentik Wangi rice in general had a significantly different effect on control plants. Mutation induction using gamma ray irradiation can change the character of rice plants to be better than their parents [16]. Weight per plant family is strongly influenced by sunlight and photosynthesis. In accordance with the statement of [17], that the better the panicle initiation process, the greater the chance of grain formation will be achieved.

### Table 5. Weight of seeds per clump M5 generation of Mentik Wangi rice which were irradiated by 200 Gray gamma ray irradiations

| Strain          | Range       | Average (gram) |
|-----------------|-------------|----------------|
| M5-MW2-G79-16-03-6 | 35.95 – 51.46 | 44.39 ± 6.89*  |
| M5-MW2-G01-02-17-14 | 24.87 – 66.73 | 45.49 ± 18.18* |
| M5-MW2-G01-02-17-2  | 41.69 – 94.73 | 69.02 ± 20.00* |
| M5-MW2-G35-25-01-7   | 27.10 – 57.92 | 42.32 ± 11.69* |
| M5-MW2-G79-16-03-14  | 32.79 – 48.40 | 39.95 ± 6.51*  |
| M5-MW2-G35-25-03-1   | 30.77 – 67.60 | 47.79 ± 14.77* |
| M5-MW2-G70-01-14-19  | 37.87 – 59.78 | 47.37 ± 8.11*  |
| M5-MW2-G35-25-03-17  | 28.26 – 43.09 | 38.17 ± 6.57*  |
| M5-MW2-G70-01-14-1   | 38.85 – 51.87 | 45.05 ± 6.29*  |
| M5-MW2-G70-01-14-4   | 31.98 – 58.03 | 45.98 ± 12.22* |
| Control             | 22.32 – 41.08 | 27.54 ± 7.80   |

* The highest seed weight per clump
* The lowest seed weight per clump

3.6. **Plant selection**

Plant selection through plant breeding techniques is done to produce individual plants with better properties than their parents. Selection is done by comparing the observational variables between individual plants in each strain with control plants. The purpose of the Mentik Wangi rice plants selection is to produce M5 mutant plants with short stems, and high productivity (Table 6).
Table 6. Plant selection of M5 generation of Mentik Wangi rice which were irradiated by 200 Gray gamma ray irradiations

| Strain M5          | No. | Height (cm) | Weight (gram) |
|--------------------|-----|-------------|---------------|
| M5-MW2-G79-16-03-6 | 84  | 101         | 51.46         |
|                    | 14  | 95          | 47.89         |
|                    | 16  | 95          | 48.54         |
| M5-MW2-G01-02-17-14| 10  | 102         | 66.73         |
| M5-MW2-G01-02-17-2 | 8   | 98          | 41.69         |
|                    | 45  | 97          | 62.54         |
|                    | 59  | 101         | 80.74         |
|                    | 87  | 103         | 94.73         |
|                    | 13  | 99          | 65.42         |
| M5-MW2-G35-25-01-7 | 19  | 97          | 57.92         |
|                    | 38  | 104         | 49.09         |
| M5-MW2-G79-16-03-14| 71  | 100         | 44.88         |
| M5-MW2-G35-25-03-1 | 18  | 103         | 67.60         |
|                    | 46  | 104         | 43.79         |
|                    | 54  | 98          | 57.73         |
| M5-MW2-G70-01-14-19| 75  | 105         | 47.17         |
|                    | 26  | 104         | 43.27         |
|                    | 2   | 97          | 48.75         |
| M5-MW2-G35-25-03-17| 85  | 103         | 42.52         |
|                    | 39  | 105         | 43.09         |
|                    | 46  | 103         | 42.45         |
| M5-MW2-G70-01-14-1 | 18  | 105         | 41.84         |
|                    | 41  | 105         | 51.79         |
|                    | 2   | 105         | 51.87         |
|                    | 12  | 97          | 40.88         |
| M5-MW2-G70-01-14-4 | 19  | 93          | 49.91         |
|                    | 51  | 105         | 58.03         |
|                    | 8   | 104         | 55.91         |
| Control            | 144 |             | 27.31         |

M5 mutant selection results have a range of 93-105 cm plant height. The ideal height of rice plants are ranged from 90-105 cm, making it easier for farmers to take care of it and the plants won’t fall easily [20]. Mutant plants which have the lowest plant height are found in the M5-MW2-G70-01-14-4 strain with plant number 19 which has a height of 93 cm. Mutant plants which have the highest clump weight are found in the M5-MW2-G01-02-17-2 strain with plant number 87 which has a clump weight of 94.73 cm. The selected M5 mutant plants will later be replanted to be continued as M6.

4. Conclusion
Mentik Wangi M5 generation with gamma ray irradiation 200 Gray has better performance compared to control plants (without irradiation). There are 28 individuals Mentik Wangi M5 rice mutants from the selection of plants that are short-stemmed and have high productivity. The plants are found in the M5-MW2-G79-16-03-6 (84), (14), (16) strain, M5-MW2-G01-02-17-14 (10) strain, M5-MW2-G01 strain -02-17-2 (8), (45), (59), (87), (13), M5-MW2-G35-25-01-7 lines (19), (38), M5-MW2 lines -G79-16-03-14 (71), line M5-MW2-G35-25-03-1 (18), (46), (54), line M5-MW2-G70-01-14-19 (75), (26), (2), M5-MW2-G35-25-03-17 (85) lines, (39), (46) M5-MW2-G70-01-14-1 lines (18), (41), (2), (12), and M5-MW2-G70-01-14-1 lines (19), (51), (8).

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