Selection of short stem Mentik Susu rice M3 from gamma ray irradiation

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Abstract. Mentik Susu is one of a local rice variety, which is not widely cultivated due to some unfavourable traits which were relatively high plant height and long harvest age. Efforts were done to overcome the problems such as planting mutation-induced plants through the utilization of gamma-ray irradiation. The objective of this research was to observe and select M3 mutants of Mentik Susu from gamma ray irradiation and obtain short-stemmed mutant plants. The research was conducted by simple design experiments (SDR). Established experimental plots for every irradiation doses and comparing the treatment result with the control to identify the effect of irradiation on the growth of Mentik Susu. The result showed that there were several strains with potential mutant traits based on the positive character of each individual. The M-MS2-15-3 strain with an irradiated dose of 200 grays has the shortest plant height of 92.10 cm with the highest productive tiller of 27.40 stems, has the highest seed yield per plant of 91.00 gram and has the shortest harvest age of 88 days. The M-MS2-15-4 strain with 200 gray irradiation dose has the longest panicle length of 26.83 cm.

1. Introduction
Local rice varieties are starting to gain interest in both from the community and from the government. Mentik Susu rice is one of the original local rice varieties of Indonesia which derived from Magelang region. This rice variety has sweet-smelling milk-like fragrance which is preferred for its scent and texture. However, as most of the local rice in general, this variety also has some weaknesses. This rice has a relatively long life cycle of about 5 months with a low average yield of 5-6 tons/ha [1]. The main problems of Mentik Susu were found in plant height and relatively long harvest age. Plant breeding is one of the ways to change the genetic makeup of individual and plant population for a purpose, to obtain more beneficial plants traits [2]. One method to overcome the problem of Mentik Susu local rice variety was through mutation breeding. It is stated that mutation breeding is highly beneficial for the repair of some traits by not changing most of the original properties of the plant [3]. Gamma ray irradiation is expected to be one of the solutions in improving unfavorable traits and to gain profitable result in an effort to increase the productivity and welfare of the farmers. Mutations breeding can be useful for the improvement of some plant properties that most of the original plant trait are not changed. The objective of this research is to observe and select M3 mutants of Mentik Susu from gamma ray irradiation and obtain short-stemmed mutant plants.
2. Materials and methods
This research was conducted in Jaten Village, Jaten Sub-district, Karanganyar District in March to November 2017. The materials used in this research were Mentik Susu variety (untreated) as control and seeds of 12 strains of M3 (the result of M3 selection of gamma ray irradiation with various dosage). The experiment was conducted by making experimental plots. Observations were conducted on all irradiated treated plants and compared with control plants in order to identify the difference and the effect of irradiation on rice growth of Mentik Susu. The data obtained were analyzed descriptively by comparing each individual plant in each dose of irradiation with control average and select individuals suspected of mutation.

3. Result and description

3.1. Plant height
Plant growth is a process of plant size enlargement. The use of gamma ray irradiation can affect the plant height, which mostly can be seen by relatively shorter plant [4].

| M3 Line       | Range (cm) | Average (cm) |
|---------------|------------|--------------|
| M- MS1-15-5   | 116 – 122  | 118.80 ± 3.01|
| M- MS1-39-17  | 117 – 125  | 121.00 ± 3.74|
| M- MS1-11-22  | 116 – 124  | 120.10 ± 3.78|
| M- MS1-9-13   | 121 – 129  | 124.90 ± 3.60|
| M- MS1-22-31  | 95 – 105   | 100.00 ± 5.21|
| M- MS2-15-3   | 88 – 96    | 92.10 ± 3.98 |
| M- MS2-15-4   | 103 - 109  | 106.20 ± 3.05|
| M- MS2-16-5   | 103 – 110  | 106.60 ± 3.17|
| M- MS3-10-4   | 110 – 121  | 115.30 ± 5.60|
| M- MS3-27-17  | 113 – 122  | 117.60 ± 4.35|
| M- MS3-15-20  | 115 – 123  | 119.10 ± 3.75|
| Control       | 128 – 138  | 132.90 ± 4.65|

Induced gamma ray irradiation was done to get the rice crop of Mentik Susu variety with shorter morphology to prevent the occurrence of plant collapse which reduce the productivity of rice. The changes of characteristic of shorter plant height in Mentik Susu indicate a mutation with better properties from gamma ray irradiation treatment provided. Plant height in M-MS2-15-3 strain with irradiated dose of 200 gray has the lowest height compared with control average of 30.7%. This is in accordance with a study stating that the ideal plant height is about 90 cm to 100 cm [5].

3.2. Number of productive tiller
Productive tillers are tillers that produce the filled rice panicle and one of the components to determine the productivity of rice plant. According to [6] mutation breeding is an alternative to obtain new varieties based on local varieties (Table 2).
Table 2. Number of productive tillers of Mentik Susu rice varieties from gamma ray irradiation of various doses

| M3 Line          | Range | Average    |
|------------------|-------|------------|
| M- MS1-15-5      | 15 - 23 | 19.20 ± 3.71 |
| M- MS1-39-17     | 17 - 25 | 20.80 ± 3.77 |
| M- MS1-11-22     | 20 - 27 | 23.40 ± 3.53 |
| M- MS1-9-13      | 16 - 21 | 18.50 ± 2.17 |
| M- MS1-22-31     | 20 - 29 | 24.20 ± 4.77 |
| M- MS2-15-3      | 23 - 32 | 27.40 ± 4.12 |
| M- MS2-15-4      | 22 - 26 | 23.80 ± 2.04 |
| M- MS2-16-5      | 23 - 30 | 26.40 ± 3.13 |
| M- MS3-10-4      | 21 - 31 | 25.80 ± 5.29 |
| M- MS3-27-17     | 19 - 28 | 23.50 ± 4.84 |
| M- MS3-15-20     | 13 - 20 | 16.70 ± 3.37 |
| Control          | 13 - 15 | 13.70 ± 1.11 |

Based on the description of varieties, Mentik Susu has a number of productive tillers about 13 to 15 stems. The highest productive tillers were found in M-MWS2-15-3 strain with 200 gray irradiation by 27.40 strands. Based on these data, it can be concluded that gamma ray irradiation can increase the number of productive tillers on rice, by high number of productive tillers, potentially on the number of grains per panicle is also higher [7].

3.3. Flowering and harvest age

The majority of farmers want a relatively fast harvest time with high yields. Harvest age is an indication of the plant cultivation [8]. The short maturity age is the preferred trait by the farmer. Harvest age (days) was calculated as 90% of the grain on each line was ripe [9]. Age of flowering were related to harvest age of the plant. The faster the flowering age, the faster harvesting time will come. Gamma-ray irradiation can affect the flowering age of M3 rice strains of Mentik Wangi Susu variety. According to [10] giving gamma ray irradiation can change the genetic makeup of agronomic trait, one of which is speeds up the time of flowering and harvest age (Table 3).

Rice plant that has a mature age in the rice plant with gamma irradiation treatment of 200 gray has the earliest harvest age of 88 to 89 days, while the control plants have a harvest age of 130 days. This is in accordance with study which shows that irradiation with a dose of 200 gray has the potential to produce a shorter mutant and a faster harvest [11]. It is also reinforced by [12] which states that 200 gray irradiation doses could potentially produce a short-lived mutant. Mutation breeding will continue to be carried out in order to develop varieties, especially rice plants [13].
Table 3. Flowering and Harvesting Age of Mentik Susu rice varieties from gamma ray irradiation of various doses

| M3 line         | 80% flowering (days) | Harvest time (days) |
|-----------------|-----------------------|---------------------|
| M- MS1-15-5     | 52                    | 97                  |
| M- MS1-39-17    | 52                    | 97                  |
| M- MS1-11-22    | 53                    | 98                  |
| M- MS1-9-13     | 53                    | 98                  |
| M- MS1-22-31    | 53                    | 98                  |
| M- MS2-15-3     | 43                    | 88                  |
| M- MS2-15-4     | 43                    | 88                  |
| M- MS2-16-5     | 44                    | 89                  |
| M- MS3-10-4     | 54                    | 99                  |
| M- MS3-27-17    | 54                    | 99                  |
| M- MS3-15-20    | 54                    | 99                  |
| Control         | 90                    | 130                 |

3.4. Panicle length

The panicle length of rice plants depends on the cultivated rice varieties that will affect the number of seeds per panicle [14]. Panicle in rice plants is very important as a place for the development of grains, so the length of desired panicle has a maximum length. Based on (Table 4) the longest panicle length was found in M-MS2-15-4 strain irradiation of 200 gray with panicle length of 26.83 cm.

Table 4. Panicle Length of Mentik Susu rice varieties from gamma ray irradiation of various doses

| M3 Line         | Range (cm)        | Average (cm)  |
|-----------------|-------------------|---------------|
| M- MS1-15-5     | 20.83 – 25.91     | 23.37 ± 2.54  |
| M- MS1-39-17    | 21.20 – 26.99     | 24.13 ± 2.86  |
| M- MS1-11-22    | 21.41 – 27.12     | 24.27 ± 2.85  |
| M- MS1-9-13     | 20.93 – 26.73     | 23.83 ± 2.90  |
| M- MS1-22-31    | 19.49 – 26.48     | 22.97 ± 3.51  |
| M- MS2-15-3     | 24.83 – 27.17     | 26.00 ± 1.17  |
| M- MS2-15-4     | 25.19 – 28.48     | 26.83 ± 1.64  |
| M- MS2-16-5     | 24.64 – 28.62     | 26.63 ± 1.99  |
| M- MS3-10-4     | 2172 – 27.75      | 24.73 ± 3.02  |
| M- MS3-27-17    | 21.73 – 27.13     | 24.43 ± 2.70  |
| M- MS3-15-20    | 21.20 – 26.80     | 24.00 ± 2.80  |
| Control         | 22.00 – 29.00     | 25.40 ± 3.61  |

The length component of panicle is a major supporting factor in the yield potential, the longer panicle bear more rice grain, and the grain content may be higher too [15]. Based on the average result
of panicle length, it can be concluded that the effect of irradiated dose contributes to the panicle length. This is in accordance with the opinion of [16] as the emergence of mutant plants or plants that have positive properties were not determined by average panicle length value but each individual plants that can potentially become mutant plants.

3.5. **Number of seed per panicle**

Grain or rice seed is the main component of rice yield. The calculation of the number of seeds per panicle is done by counting the number of rice grains attached to the panicle of rice. Gamma ray irradiation can provide broad genetic diversity among individual plants. Irradiation doses can determine the increase in productivity in plants [17]. [18] states that the number of seeds per panicle is affected by the panicle length and the number of branches per panicle (Table 5).

| M3 Line       | Range   | Average         |
|---------------|---------|-----------------|
| M- MS1-15-5   | 102 - 195| 148.40 ± 46.32 |
| M- MS1-39-17  | 111 - 224| 167.07 ± 56.51 |
| M- MS1-11-22  | 108 - 204| 156.20 ± 47.89 |
| M- MS1-9-13   | 112 - 191| 151.63 ± 39.24 |
| M- MS1-22-31  | 78 - 152 | 114.83 ± 36.69 |
| M- MS2-15-3   | 129 - 164| 146.67 ± 17.70 |
| M- MS2-15-4   | 146 - 188| 166.90 ± 20.76 |
| M- MS2-16-5   | 129 - 182| 155.33 ± 26.67 |
| M- MS3-10-4   | 86 - 163 | 124.27 ± 38.26 |
| M- MS3-27-17  | 109 - 206| 157.57 ± 48.85 |
| M- MS3-15-20  | 99 - 175 | 137.10 ± 38.14 |
| Control       | 94 - 197 | 145.57 ± 51.86 |

Gamma ray irradiation treatments can provide wide genetic diversity among plant individuals. The best plant strain on the number of seeds per panicle was found in M-MW1-39-17 strain with irradiated dose of 100 gray by 167.07 grains. As [19] stated that the characteristic of the number of grains per panicle has a positive correlation with grain content and panicle length. The high number of grains per panicle and long-sized panicles will produce a high percentage of grain content.

3.6. **Seed yield per plant**

The weight of grain per plant tillers is influenced by the number of tillers, number of grain per tillers and percentage of filled seed. If these components were in high value, it will produce high yields, most likely the yield of seeds per plant will also high. As [20] stated that the yield of seeds per plant is a correlation of yield component, including the number of panicles per clusters, the number of grains per panicle, the presentation of grain content and weight of 100 seeds.
Table 6. Yield of seed per plant of Mentik Susu rice varieties from gamma ray irradiation of various doses

| M3 Line     | Range (g) | Average (g) |
|-------------|-----------|-------------|
| M- M5S1-15-5| 23.45 – 69.06 | 46.25 ± 22.81 |
| M- M5S1-39-17| 49.23 – 72.61 | 60.92 ± 11.69 |
| M- M5S1-11-22| 35.46 – 71.56 | 53.51 ± 18.05 |
| M- M5S1-9-13| 38.45 – 59.46 | 48.95 ± 10.51 |
| M- M5S1-22-31| 38.23 – 62.59 | 50.41 ± 12.18 |
| M- M5S2-15-3| 69.80 – 92.20 | 91.00 ± 11.20 |
| M- M5S2-15-4| 57.13 – 76.55 | 66.84 ± 9.1 |
| M- M5S2-16-5| 53.10 – 74.89 | 64.00 ± 10.89 |
| M- M5S2-18-7| 27.68 – 55.21 | 41.44 ± 13.77 |
| M- M5S3-10-4| 25.33 – 61.51 | 43.42 ± 18.09 |
| M- M5S3-27-17| 40.95 – 80.48 | 60.72 ± 19.76 |
| M- M5S3-15-20| 35.39 – 58.75 | 47.07 ± 11.68 |
| Control     | 24.77 – 33.21 | 28.99 ± 4.22 |

Seed yield is a parameter that affects the yield potential [21]. Seed yield per plant data (Table 8) shows the difference in yield between control plants and irradiated crops of various doses. Seeds per plant for control plants was 28.99 g. The highest seed yield per plant was shown by treatment of 200 gray result as much as 91.00 g in M-MWS2-15-3 strain. The yield of seeds per plant is also determined on the content of the grain itself, if the grain is fully loaded then the weight will be high. According to [11] irradiation causes the occurrence of mutations in the plant resulting in an increase in the diversity of grain weight per tillers in the rice plant. [22] also argues that the number of filled seeds, number of seeds per panicle and weight of 100 seeds from gamma-ray irradiation with a dose of 200 gray is more influential on yield and productivity.

4. Conclusion
The conclusions of this study there are some differences in agronomic properties between M3 lines from gamma ray irradiation of various doses compared to control plants (Mentik Susu variety) based on plant height, number of productive tillers, panicle length, number of seeds per panicle, weight of 100 seeds, yield of seeds per plant and harvest age. The treatment of gamma-ray irradiation with doses of 200 and 300 grays produces potentially mutant plants based on positive changes in properties that appear on each plant variables of each individual. The M-MS2-15-3 strain with irradiated dose of 200 gray has the shortest plant height of 92.10 cm with the highest productive tiller of 27.40 stems, has the highest seed yield per plant of 91.00 gram and has the shortest harvest age of 88 days. The M-MS2-15-4 strain with a 200 gray dose has the longest panicle length of 26.83 cm. The M-MS1-39-17 strain with a dose of 100 gray has the highest panicle density index of 6.92. The strain of M-MS1-11-22 with a dose of 100 gray has the highest 100 seed weight of 2.89 g.

Acknowledgment
The authors would like to thank everyone who participated in this research, especially to Faculty of Agriculture of Universitas Sebelas Maret.

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