Selection of mutant short stem M5 from 200 Gy gamma ray irradiation on Mentik Susu rice

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Abstract. Mentik Susu rice is one of Indonesian local rice variety that is less attractive to farmers because of its high stems and low yield. One method of using physical mutagen is gamma ray radiation. The purpose of this research is observing the performance of mutated M5 generation of mentik susu rice which already irradiated with 200 Gy gamma ray and selecting the short-stemmed ones which have high productivity. The research was conducted in November 2018-April 2019 on Palur Village, Mojolaban, Sukoharjo Regency. The experiment was done by planting 35 individual M5 and control seeds. The variables observed were plant height, harvest age, number of productive tillers, panicle intensity index, seed yield per plant. Data were analyzed descriptively and compared the performance of mentik susu rice M5 with control via T test analysis. The results showed that there was a difference in the performance of the M5 mutants of mentik susu rice as result of 200 Gy gamma ray irradiation compared to control mentik susu rice. There are 22 selected mutant plant individuals in the M5 generation with 200 Gy gamma ray radiation. The induced mutations will cause genetic diversity in the plants.

1. Introduction
Mentik Susu is a medium-aged cultivar that has broad leaves, medium panicles and relatively little pithy rice. Mentik susu rice has medium-sized tillers, amounting to between 13-20 sticks per clump. This variety produces slim, milky white in color with a fragrant and fluffier aroma that is favored by consumers [1]. Mentik susu rice has a high crop performance with low yields. This variety has long harvest time or different from national varieties that relatively short with high productivity. Various breeding efforts have been carried out to increase the productivity of dairy rice [2].

Based on these problems, there are several ways to overcome the performance in Mentik Susu rice varieties, one modern way to increase yields and eliminate the weaknesses of Mentik Susu rice is by mutating the plants using gamma ray irradiation. Radiation is one of the techniques used in plant breeding. Mutation breeding by irradiation is carried out with the aim of eliminating plant weaknesses and bringing out superior plant characteristics. The induced mutations will cause genetic diversity in the plants.
plants. One of the obvious benefits of induced mutations is the increase in rice productivity. Mutation breeding is widely used because it can improve plant character without changing the original nature of the preferred plant. In addition, mutation relative to breeding requires a short time in plant purification [3]. The use of radiation with the right dose can create diversity within a species [4]. The objective of this research was to learn the performance of the M5 generation of mutant rice influences the results of 200 Gy gamma ray irradiation in Mentik Susu rice and select the M5 generation of mutant rice resulting from 200 Gy gamma ray irradiation in Mentik susu rice to get short- stemmed mutant rice with high productivity.

2. Materials and methods
This Research was conducted in a trial field of Agriculture Faculty, Universitas Sebelas Maret, Palur Village, sub-District of Mojolaban, Sukoharjo Regency in November 2018 to April 2019. The materials used in this research were the seed M5 (the result of the selection of M4 Mentik susu rice plants results of of 200 Gy gamma ray irradiation), seed paddy Mentik susu control (without irradiation), organic cow dung fertilizer, Urea, KCl, SP36 and ZA. The tools used in the research were hoe, tractor, roller meter, scissors, tools stationery, rope raffia, plastic, labels, scales analytic, stakes, stake, board labels, paper envelopes, sickle, tarpaulins and camera. The research was conducted through trial field by planting 36 genotype, they were 35 strains M4 results of 200 Gy gamma ray irradiation and varieties Mentik susu without irradiation as control in amount of 50 plants for each strain to test the performance / genotypes of all strains. Data results of the observations were analyzed descriptively and T test to determine the differences of Mentik Susu rice generation M5 results irradiation of gamma ray 200 Gy with plant control. The variables were observed, namely plants height, harvest age, number of productive tillers, panicles density index and seed yield per plant. The plant height was measured during the maximum vegetative phase, that is, before flowering time. The harvest age and number of productive tillers were determined when the sample plants were harvested. Panicles density index was obtained from the thickness ratio of the seeds in the panicle to the length of the panicle. The seed yield per plant were obtained from the weight of seeds produced per plant clump.

3. Results and discussion

3.1. Plant height
Plant height affects panicle length and crop production rate. Observation of plant height can be done by measuring the plant from the base to the tip of the plant while straightening the plant upwards [5] (Table 1).

| M5 Strain          | Range (cm) | Average (cm) |
|--------------------|------------|--------------|
| M-MS2-G15T3-5-2    | 80–90      | 86.40 ± 4.16 |
| M-MS2-G15T3-4-15   | 76–98      | 88.40 ± 8.02 |
| M-MS2-G15T3-2-5    | 83–98      | 89.20 ± 6.53 |
| M-MS2-G18T7-4-4    | 79–103     | 89.80 ± 10.08|
| M-MS2-G18T7-4-12   | 88–95      | 90.40 ± 2.79 |
| M-MS2-G17T17-13-9  | 83–94      | 90.80 ± 4.55 |
| M-MS2-G18T7-4-9    | 84–103     | 91.60 ± 7.30 |
| M-MS2-G15T3-2-18   | 81–107     | 92.00 ± 10.72|
| M-MS2-G15T3-2-14   | 84–100     | 92.20 ± 5.93 |
| M-MS2-G18T3-6-13   | 85–99      | 93.60 ± 5.37 |
| Control            | 128–144    | 134.40 ± 6.35|
Table 1 shows that the plant height in strain control (without irradiation) has an average height of 134.40 with a range of 128–144 cm. The shortest plant height is 76 cm found in the M-MS2-G15T3-4-15 strain with an average of 88.40 and a range of 76–98 cm. The longest plant height is 107 cm found in the M-MS2-G15T3-2-18 strain with an average of 92.00 and a height range of 81–107 cm. According to [6], height of rice plant can be classified into three classes, namely short (<110 cm), medium (110–130 cm) and high (> 130 cm). Character changing of plants height on Mentik Susu rice result of 200 Gy gamma ray irradiation indicates that the enhancement in the character becomes better. According to [7], by giving a dose of gamma ray irradiation in rice plants will increase the effect of deterministic effects so the growth of plant height will be inhibited.

3.2. Harvest age
Harvest age can be identified by the flowering time of crop. Flowering age has a very significant correlation with the harvest age where the faster the plants flower, the faster the harvest age will be. Harvest age is one of the most important indicators in selecting the desired mutant characteristics of rice plant [8] (Table 2).

| Table 2. Harvest age of Mentik Susu rice variety M5 generation result from 200 Gy gamma ray irradiation |
|-------------------------------------------------|-------------------|--------------------|
| M5 Strain                                      | Range             | Average            |
| M-MS2-G15T3-5-2                                | 108–108           | 108                |
| M-MS2-G15T3-4-15                               | 107–107           | 107                |
| M-MS2-G15T3-2-5                                | 106–106           | 106                |
| M-MS2-G18T7-4-4                                | 108–108           | 108                |
| M-MS2-G18T7-4-12                               | 108–108           | 108                |
| M-MS2-G17T17-13-9                              | 110–110           | 110                |
| M-MS2-G18T7-4-9                                | 108–108           | 108                |
| M-MS2-G15T3-2-18                               | 106–106           | 106                |
| M-MS2-G15T3-2-14                               | 106–106           | 106                |
| M-MS2-G18T3-6-13                               | 109–109           | 109                |
| Control                                        | 135–135           | 135                |

Table 2 shows that the harvest age of Mentik Susu rice generation M5 results of 200 Gy gamma ray irradiation has a rapidly harvest age than the plants in strain control (without irradiation). The lowest age harvest is 106 days in 3 strains, they are M-MS2-G15T3-2-5, M-MS2-G15T3-2-18, M-MS2-G15T3-2-14 with an average of 106 days and a range of 106–106 days. The highest age harvest is 110 days in strain M-MS2-G17T17-13-9 with an average of 110 days and the range of 110–110 days. Harvest age is the main character in variety assessment because it affects the yield potential and plant productivity [9]. Radiation applied to rice plants affects changes in the structure of the plant to its offspring. The irradiated rice is completely safe without carrying radioactive elements. Irradiation is not affected by external environmental factors, but rather develops the unique characteristics of the plants [10].

3.3. Number of productive tillers
Number of productive tillers is the number of plants tillers that produce panicles in one clump. The number of productive tillers will affect the level of grain production, [11] that the number of productive tillers affects producing grain of panicles. The formation of productive tillers is influenced by the interaction of genes and the plant's growing environment (Table 3).
The panicle density index was calculated using a ratio of panicle length to the number of seeds per panicle. Based on observational data, the panicle density index can be obtained through the high total number of grains in panicles per paddy clump (Table 3).

Table 3. Productive tillers of Mentik Susu rice variety M5 generation result from 200 Gy gamma ray irradiation

| M5 Strain   | Range  | Average     |
|-------------|--------|-------------|
| M-MS2-G15T3-5-2 | 20–28  | 23.60 ± 3.29 |
| M-MS2-G15T3-4-15 | 20–32  | 24.80 ± 5.07 |
| M-MS2-G15T3-2-5  | 28–38  | 31.60 ± 4.04 |
| M-MS2-G18T7-4-4   | 25–32  | 28.40 ± 3.05 |
| M-MS2-G18T7-4-12  | 20–36  | 29.60 ± 6.54 |
| M-MS2-G17T17-13-9 | 19–36  | 27.80 ± 6.83 |
| M-MS2-G18T7-4-9   | 26–36  | 30.20 ± 4.15 |
| M-MS2-G15T3-2-18  | 20–33  | 29.00 ± 5.34 |
| M-MS2-G15T3-2-14  | 24–53  | 33.80 ± 11.21|
| M-MS2-G18T3-6-13  | 22–34  | 27.80 ± 5.54 |
| Control          | 11–15  | 14.00 ± 1.73 |

Table 3 shows that the number of productive tillers plants in strain control (without irradiation) has an average of 14.00 with a range of 11–15 stems. Number of highest productive tillers is 53 tillers were found in strains of the M-MS2-G15T3-2-14 with an average of 33.80 and a range of 24–53 stems. Number of lowest productive tillers are 19 tillers were found in strains of the M-MS2-G17T17-13-9 with an average of 27.80 and a range of 19–36 stems. According to [12], the number of productive tillers can be categorized into three classes, namely little (1–10), medium (10–15) and many (> 15). Based on observational data on productive tillers of Mentik Susu rice generation M5 results of 200 Gy gamma ray irradiation was classified as many. According to [13], the number of productive tillers depends on the number of tillers formed. Each clump of plants has a different ability to form productive tillers. Non-productive tillers will die because the photosynthesis results will focus on the formation of grains and its contents.

3.4. Panicle density index

The panicle density index is a very important indicator in determining the yield of rice crops. The panicle thickness index was calculated using a ratio of panicle length to the number of seeds per panicle. According to [14] that a high panicle density index can be obtained through the high total number of grains in panicles per paddy clump (Table 4).

Table 4. Panicle density index of Mentik Susu rice variety M5 generation result from 200 Gy gamma ray irradiation

| M5 Strain   | Range  | Average     |
|-------------|--------|-------------|
| M-MS2-G15T3-5-2 | 3.55–4.76 | 4.15 ± 0.56 |
| M-MS2-G15T3-4-15 | 3.63–5.88 | 4.59 ± 0.85 |
| M-MS2-G15T3-2-5  | 3.57–5.53 | 4.62 ± 0.75 |
| M-MS2-G18T7-4-4   | 2.55–5.68 | 4.45 ± 1.19 |
| M-MS2-G18T7-4-12  | 4.28–4.96 | 4.61 ± 0.30 |
| M-MS2-G17T17-13-9 | 4.83–7.34 | 5.73 ± 0.97 |
| M-MS2-G18T7-4-9   | 3.56–5.92  | 4.97 ± 1.06 |
| M-MS2-G15T3-2-18  | 3.57–5.78  | 4.36 ± 0.98 |
| M-MS2-G15T3-2-14  | 4.51–5.18  | 4.78 ± 0.27 |
| M-MS2-G18T3-6-13  | 4.53–5.33  | 5.12 ± 0.33 |
| Control          | 4.03–5.65  | 4.86 ± 0.59 |
Table 4 show that panicle density index plant in strain control (without irradiation) has an average of 4.86 with a range of 4.03 to 5.65. The highest of panicle density index is 7.34 which is contained in the strain M-MS2-G17T17-13-9 with an average of 5.73 and a range of 4.83 to 7.34. The lowest of panicle density index is 2.55 which is contained in the strain M-MS2-G18T7-4-4 with an average of 4.45 and a range of 2.55 to 5.68. According to [15] that rice panicles have a closely related with crop productivity. Qualitative and quantitative values of mutant rice can be used to compare with values of control rice (without irradiation). [16] states that the higher the total grain per rice plant panicle, the higher the panicle density index. The results of T-test with a level of confidence of 0.05 indicates that the panicle density index treatment of paddy Mentik susu generation M5 results of 200 Gy gamma ray irradiation was not significantly different from control plants (without irradiation). This happened because the panicle density index of Mentik susu rice generation M5 results of 200 Gy gamma ray irradiation was lower than the control plant. Although there were no significantly different strain, the data showed that there were three strains that on average had a much higher strains than the control plants (without irradiation). The strains are M-MS2-G17T17-13-9 with an average of 5.73, M-MS2-G18T7-4-9 with an average of 4.97 and M-MS2-G18T3-6-13 with an average 5.12.

3.5. Seed yield per plant
Seed yield per plant is an important indicator in determining yield. The weight of seed per plant is measured by weighing the whole seeds of the plant in one clump. According to [17] the weight of seeds per clump is closely related to the number of tillers, panicles and seeds per plant (Table 5).

| Strain          | Range   | Average     |
|-----------------|---------|-------------|
| M-MS2-G15T3-5-2 | 30.58–56.49 | 43.99 ± 9.18 |
| M-MS2-G15T3-4-15| 37.73–61.92 | 43.81 ± 10.32 |
| M-MS2-G15T3-2-5 | 37.13–66.2  | 51.49 ± 10.87 |
| M-MS2-G18T7-4-4 | 25.88–89.7  | 45.34 ± 25.29 |
| M-MS2-G18T7-4-12| 39.23–52.77 | 45.62 ± 5.95  |
| M-MS2-G17T17-13-9| 32.75–55.81 | 44.96 ± 9.22  |
| M-MS2-G18T7-4-9 | 34.59–99.09 | 62.19 ± 27.69 |
| M-MS2-G15T3-2-18| 23.6–99.46  | 47.61 ± 29.78 |
| M-MS2-G15T3-2-14| 32.52–81.66 | 48.99 ± 18.98 |
| M-MS2-G18T3-6-13| 30.3–72.7  | 50.98 ± 19.56 |
| Control         | 24.91–28.83 | 27.13 ± 1.65  |

Table 5 show seed yield per clump plant in strain control (without irradiation) has an average of 27.13 grams with a range from 24.91 to 28.83 grams. The highest seed weight per clump is 99.46 grams found in the M-MS2-G15T3-2-18 strain with an average of 47.61 grams and a range of 23.6–99.46 grams. The lowest seed weight per clump is 23.6 grams found in the M-MS2-G15T3-2-18 strain with an average of 47.61 grams and a range of 23.6–99.46 grams. According to [18] seed yield per plant has a positive correlation with grain yield per hectare. The higher the number of seeds per clump achieved the higher the grain yield value per hectare.

3.6. M5 mutant selection results
Selection of plants through the techniques of breeding crops were carried out to obtain the best of individuals. According to [19] that the selection method on high heritability can use the pedigree selection method. Selection is carried out at the beginning of the generation of rice plants by prioritizing selected traits based on high heritability. Selection was carried out by comparing the observed variables of each individual plant in each strain against control plants (without irradiation).
The purpose of the selection of mentik susu rice was to obtain M5 mutants with short stem traits, short life, and high productivity (Table 6).

**Table 6. Results of selection of individual M5 generation of mentik susu rice plants as a result of 200 Gy gamma irradiation**

| M5 Strain  | Number | Height | Weight |
|------------|--------|--------|--------|
| M-MS2-G15T3-5-2 | 18 | 90 | 44.61 |
|            | 25 | 90 | 44.73 |
|            | 16 | 85 | 56.49 |
|            | 8 | 87 | 43.53 |
| M-MS2-G15T3-4-15 | 10 | 87 | 61.92 |
| M-MS2-G15T3-2-5 | 56 | 83 | 47.03 |
|            | 18 | 87 | 66.2 |
|            | 9 | 94 | 50.22 |
| M-MS2-G18T7-4-4 | 11 | 82 | 35.5 |
| M-MS2-G18T7-4-12 | 15 | 95 | 52.77 |
|            | 13 | 91 | 48.64 |
|            | 18 | 89 | 47.82 |
| M-MS2-G17T17-13-9 | 23 | 91 | 55.81 |
|            | 21 | 94 | 47.23 |
|            | 29 | 94 | 50.32 |
| M-MS2-G18T7-4-9 | 17 | 89 | 58.05 |
|            | 12 | 94 | 99.09 |
| M-MS2-G15T3-2-18 | 35 | 81 | 41.32 |
| M-MS2-G15T3-2-14 | 28 | 90 | 42.6 |
|            | 61 | 84 | 41.57 |
|            | 36 | 92 | 81.66 |
| M-MS2-G18T3-6-13 | 17 | 89 | 58.05 |
| Control | 128 | 28,83 | 128 |

The result of the selection of mutant M5 Mentik susu rice generation M5 results of 200 Gy gamma ray irradiation on the table 6 can be seen that there are 22 plants were selected. According to [20] states that selection is an activity of choosing individual plants based on their superior traits. Selection of superior traits must be precise based on the value of genetic parameters such as heritability and correlation coefficient values. The selected plants were plants with better observation variables than control plants (without irradiation) as well as with other mutant plants in other strains. Plants selected is the strain M-MS2-G15T3-5-2 with a number of plants 18,25,16,8, strain M-MS2-G15T3-4-15 with a number of plants 10 strains of M-MS2-G15T3-2-5 with plant number 56, 18, 9, strain M-MS2-G18T7-4-4 with plant number 11, M-MS2-G18T7-4-12 with plant number 15, 13, 18, strain M-MS2-G17T17-13-9 with plant number 23, 21, 29, strain M-MS2-G18T7-4-9 with plant numbers 17 and 12, strain M-MS2-G15T3-2-18 with plant number 35, strain M-MS2-G15T3-2-14 with the number of plants 28, 61, 36, and strain M-MS2-G18T3-6-13 with a number of plants 35. According to [21] in the development of high yielding cultivars requires knowledge of cultivar variety. Every variation of the cultivar needs to be observed and selected. The coefficient of genotypic variation, high heritability and genetic diversity need to be selected in order to develop superior characteristics of rice plants.

The results of the selection of the M5 mutant had a plant height range of 81–95 cm. Individual mutant plants with the lowest plant height were in the M-MS2-G15T3-2-18 strain with plant number 35 which had a height of 81 cm. According to [22] that short plant height is the morphological character selected by breeders. The plants chosen have an ideal height in the range of 90–105 cm because they are easy to care for and are resistant to falling. Individual mutant plants with the highest clump weight were found in the M-MS2-G18T7-4-9 strain with plant number 12 which had a clump weight of 99.09 grams. According to [16] stated that high grain production per plant clump is a
desirable character for plant breeding. The result of plant breeding activities is an increase in plant productivity both in quality and quantity.

4. Conclusion
The objective of this study was achieved that the M5 generation of Mentik Susu rice plants which were irradiated by 200 Gy gamma rays had better performance, namely plants with short stems and high productivity compared to control plants (without irradiation). There are 22 plants mutant rice Mentik susu M5 is the result of the selection of plants that have short stem and high productivity.

Plants that are in strain M-MS2-G15T3-5-2 with a number of plants 18,25,16,8, strain M-MS2-G15T3-4-15 with a number of plants 10 strains of M-MS2-G15T3-2-5 the number of plants 56, 18, 9, strain M-MS2-G18T7-4-4 with a number of plants 11 strains of M-MS2-G18T7-4-12 with a number of plants 15, 13, 18, strain M-MS2-G17T17- 13-9 with a number of plants 23, 21, 29, strain M-MS2-G18T7-4-9 with a number of plants 17, 12, strains of M-MS2-G15T3-2-18 with a number of plants 35, strain M-MS2-G15T3 -2-14 with a number of plants 28, 61, 36, and strain M-MS2-G18T3-6-13 with a number of plants 35.

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