

## Performance of Mentik Wangi rice (*Oryza sativa*, L.) M<sub>2</sub> generation from gamma ray irradiation

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**Abstract.** The objective of this research is to produce Mentik Wangi rice with shorter flowering age, shorter rice stem and high yield. This research was conducted in Palur Village, Mojolaban Sub-district, Sukoharjo District, from April to August 2016. This research used descriptive method, performed by observing each individual and comparing to the control average. Observational variables included plant height, total number of tillers, number of productive tillers, panicle length, number of grain per panicle, panicle density index, 1,000 filled seed weight, seed weight of cluster, flowering age and M<sub>2</sub> mutant selection. The results showed that there were several plants indicated mutation, there were 7 plants indicate short stem mutation with height 85 cm to 97 cm. The plants which indicated short flowering age were 5 weeks after planting up to 6 weeks after planting. The mutated plants indicating of the highest number of productive tillers which were 27 up to 36. Each component result includes total number of tillers, number of productive tillers, number of grain of panicle as well as the weight of 1000 seeds in the plant indicated some mutation that has a high level of diversity in each treatment.

### 1. Introduction

Rice is a staple food for all Indonesian people. This increase in demand of rice per year can reach up to 2-3% which is considered to be a very high [1], thus, there is necessary to increase the production and quality improvement of rice by plant breeding on developed rice and local rice. Local rice plant breeding is now widely practiced, by developing local superior properties and removing the weakness of the rice.

Mentik Wangi rice varieties are local rice originating from Magelang, Central Java. Mentik Wangi has a characteristic that is fragrant aroma, besides the soft texture and white color that gain interest in society. Mentik Wangi variety also has a harvest age of 4 months. The trunk is not solid and it is easily collapsed by the wind [2]. One way can be done to improve the quality and reduce or eliminate the weakness of Mentik Wangi rice is through breeding mutation. Breeding mutation uses gamma ray irradiation by irradiating the rice seeds that will be planted with gamma rays in several dosages. Nuclear Power Agency (BATAN) has produced 15 new varieties of rice planting. Experiments using gamma ray irradiation aimed to produce new varieties by improving the superior properties possessed by one of such Mentik Wangi rice.



## 2. Methods

### 2.1. Location and time research

The experiment was conducted at Experimental Field of Faculty of Agriculture, Sebelas Maret University, Palur, Mojolaban Sub-District, Sukoharjo District. The study was conducted from April to August 2016.

### 2.2. Materials

The material used in this research was the second generation of fragrant rice generated from the first generation that has been treated gamma ray radiation in BATAN.

### 2.3. Research design and data analysis

The study was conducted using descriptive design with observation treatment on each individual of each radiation dose by comparing the average value with control treatment to know the difference and the effect of irradiation on the growth of Mentik Wangi rice. The data obtained were analyzed descriptively by comparing each individual plant at each radiation dose with average control.

## 3. Result and Discussion

### 3.1. General condition of field

Based on the Central Statistics Agency data, the total area of Mojolaban sub-district is 3,554 Ha or about 7.65% of the total sukoharjo regency (46,666 Ha). The area consists of 2,169 Ha (61.03%) of paddy fields and 1,385 Ha (38.97%) instead of paddy fields. Non-wetland area used for the yard is 89.1% of the total area not the rice field. The percentage is not another wetland. Geographically, Sukoharjo District located in the position: 110° 57 '33.7' E to 110° 42' 06.79' E, 7° 32 ' 17.00" S, 7° 49' 32.00" S. The soil in this experimental field is included in alluvial soil types. Alluvial soil is one type of soil formed by the result of sediment. This land is formed in the area of rivers, lakes in lowland areas or basins that usually occur soil sediment

The altitude of the experimental field was 104 meters above sea level, so that this land has a sloping to hilly structure. The annual rain intensity is 1,052 mm with average annual rainfall intensity of 19 mm. Mojolaban area has a fairly high amount of rainfall, which every year reaches 1,422 mm and topographically Mojolaban is a low plain. The results of the laboratory analysis showed that the soil in the experimental field has a total N content of 0.28%, KPK of 18.05%, organic C 1.16%, organic matter content of 2.00%, pH of 5.70 and C/N ratio of 4.14%. Organic matter content was high where the soil concluded as a healthy soil. The pH of 5.70 indicated that the soil belongs to a neutral soil, since it has a pH greater than 5.5 and less than 8.0. The pH of a soil may be affected by soil temperature, climate or rainfall, vegetation, internal soil drainage and human activity.

### 3.2. Variable of plant growth

**3.2.1. Plant height** Based on Table 1, plants that have a low plant height is a plant with 300 Gray radiation with a height of 85 cm. Dose 300 Gray was a very high dose that make plants easily mutated and can even damage the DNA or genes, in order to avoid such high damage and undesirable mutations, the appropriate irradiation dose ranges from 150 Gray to 250 Gray [3]. Irradiation treatment can give effect inhibits plant height [4]. The lowest plant height is the expected, because the short rice contributes to productivity because the rather short stems are more resistant to collapse.

**Table 1.** Plant Height In Various Doses of Gamma Ray Irradiation

Dosage (Gray)	Lowest (cm)	Highest (cm)	Range	Average (cm)
0	118	124	118-124	120.80
100	90	162	90-162	121.62
200	97	150	97-150	119.85
300	85	130	85-130	117.72

**3.2.2. Total Number of Tillers** The total number of tillers is the total number of tillers produced by each clump. Through the calculation of the number of tillers obtained the results presented in Table 2.

**Table 2.** Total Numbers of Tillers In Various Doses of Gamma Ray Irradiation

Dosage (Gray)	Lowest (tillers)	Highest (tillers)	Range	Average (tillers)
0	14	36	14-36	22
100	6	45	6-45	25
200	4	41	4-41	22
300	3	38	3-38	19

The total number of tillers can be calculated when the plant has entered the maximum vegetative phase, which was 50-60 days after planting [5]. Based on the research result, that the lowest tiller number was at 300 Gray irradiation of 3 tillers and the highest total number of tiller shown in 100 Gray irradiation which amounts 45 tillers.

The result of the study of the diversity of the number of tillers per dose of irradiation was evident and has considerable differences due to mutations. The lowest seedlings on the research result were the total number of tillers i.e. 3 tillers at 300 Gray radiation, the least number of tillers according to previous observation that rice plants can be said little if each clump has number of tillers <10 and number of saplings is said to be a lot if every family has number of tillers > 20 [6]. In this study, the most tillers with the amount of 45 tillers one clump on plants with irradiation dose of 100 Gray.

**3.2.3. Number of Productive Tillers** The number of productive tillers determines the amount of grain production in each crop, as each tiller produces one grain panicle. The results of the research showed the results of productive tillers at each irradiation dose treatment can be seen in the Table 3.

**Table 3.** Number of Productive Tillers In Various Doses of Gamma Ray Irradiation

Dosage (Gray)	Lowest (tillers)	Highest (tillers)	Range	Average (tillers)
0	7	30	7-30	16
100	4	36	4-36	16
200	4	29	4-29	15
300	3	27	3-27	13

The plants with the highest average number of productive tillers were on the control treatment and irradiation of 100 Gray with an average of 16 tillers. The results showed that for average number of productive tillers between control and irradiation treatment 100 Gray had the same number of same productive tillers i.e. 16 tillers, while the average number of the lowest tillers on rice with 300 Gray irradiation was 13 tillers. Rice with irradiation 200 Gray had 15 productive tillers.

**3.2.4. Panicle length** The length of panicle can affect the yield of rice grain productivity both pine (fill) and empty grain. The length of panicle in various types of irradiation is presented in Table 4.

**Table 4.** Panicle Length In Various Doses of Gamma Ray Irradiation

Dosage (Gray)	Lowest (cm)	Highest (cm)	Range	Average (cm)
0	19.8	26.8	19.8-26.8	25.18
100	18.2	32.2	18.2-32.2	25.73
200	18.8	28.6	18.8-28.6	24.22
300	16.2	29.8	16.2-29.8	25.11

The treatment which had the highest panicle length of 32.2 cm was shown by 100 Gray irradiation treatment. Types of panicles are divided into two: panicles and heavy panicles. The type of heavy panicle has a slight panicle but is large and long, whereas many type panicles have many small and short panicles. Most of the high yielding varieties with high yields include many panicle types, while local varieties include heavy panicle types.

**3.2.5. Number of seed per panicle** The amount of grain content of each panicle of rice is an indicator of a rice production. The perfect grain indicates that the results obtained in rice farming is very good. Observation of the number of grains of this malai content as a comparison of empty grain and grain contents generated on every malai. The calculation of the number of grains per panicle can be seen in Table 5.

**Table 5.** Number of Seeds per Panicle of Mentik Wangi Rice In Various Doses of Gamma Ray Irradiation

Dosage (Gray)	Lowest (seeds)	Highest (seeds)	Range	Average (seeds)
0	98	170	98-170	140
100	73	186	73-186	140
200	98	167	98-167	137
300	43	217	43-217	136

Studies in cereals irradiated with gamma rays at doses of 100 Gray and 200 Gray have a high generative growth which is supposed to be in similar with another cerealia crops such as rice and sorghum [7]. Giving various doses to a seed affects the rate of mutation that occurs. If irradiation doses are too low, the resulting mutation is low, but if the irradiation dose is too high it can turn off the mutation material or become sterile.

**3.2.6. Panicle density index** Panicle is a generative part of rice, panicle is formed when rice starts flowering. The index of panicle indicated how solid the panicle is filled by the grains of grain. The observation of Malai Strain Index on Wangi Mentik rice research can be seen in Table 6.

**Table 6.** Panicle Density Index In Various Doses of Gamma Ray Irradiation

Dosage (Gray)	Lowest	Highest	Range	Average
0	3.98	7.83	3.98-7.83	5.63
100	3.05	6.81	3.05-6.81	5.40
200	4.11	7.88	4.11-7.88	5.67
300	2.65	7.27	2.65-7.27	5.38

The panicle density index is obtained from the number of grains per panicle divided by panicle length. The ideal rice has long panicle and dense seed grain. The greater the number of grains per panicle, the higher the index of panicle density.

**3.2.7. The 1000 filled seed weight** Pithy weight of 1000 seeds is the total weight prediction at harvest, because the weight of 1000 seeds is an indication that the seed weight is ideal. Weight of 1000 seeds is a physical quality test on a seed, while the physiological quality tests include, germination, strength and growth power [8]. Weighing results of 1000 Seeds on Mentik Wangi research can be seen in Table 7.

**Table 7.** Weight of 1000 Filled Seed In Various Doses of Gamma Ray Irradiation

Dosage (Gray)	Lowest (g)	Highest (g)	Range	Average (g)
0	19.3	38.2	19.3-38.2	30.00
100	14.0	36.5	14.0-36.5	26.24
200	11.4	38.3	11.4-38.3	24.13
300	10.8	42.2	10.8-42.2	23.87

Gamma-ray radiation has the potential to obtain mutants with morphological and desirable agronomic characters such as short plant, short life-span and high production [9]. Each of these generations is a valuable mutant source that must be selected according to the characteristics that approximate the desired properties [10].

**3.2.8. Seed weight per cluster** Grain is a fruit of rice covered lemma and palea. This fruit is formed after the pollination and fertilization of lemma and palea and other parts will form the skin of rice. Grains of grain are endosperm containing starch and partly occupied by embryos located in central or lemma. The weight of grain per plant clump is influenced by number of tillers, number of tillers, number of grain and percentage of pithy rice. The weight of Mentik Wangi is presented in Table 8.

**Table 8.** Seed Weight per Cluster In Various Doses of Gamma Ray Irradiation

Dosage (Gray)	Lowest (g)	Highest (g)	Range	Average (g)
0	18.24	98.74	18.24-98.74	51.47
100	6.49	126.40	6.49-126.40	53.14
200	10.85	86.11	10.85-86.11	48.51
300	4.82	86.51	4.82-86.51	39.50

The weight of grain per cluster is influenced by number of tillers, number of productive tillers, number of grain and percentage of filled rice seed. The weight of rice grain is the yield per hectare component. Based on the observation of the seed weight per cluster of this stock, it shows that the contour has the highest average weight shown in the irradiation treatment of 200 and 300 Gray with a weight of 51.47 g. The lowest average weight is on the 300 Gray irradiation treatment which is 39.50 g. Rice with irradiation 200 Gray has an average weight of 48.51 g, almost 10 g lower than than 300 Gray irradiation result. For irradiation control treatment, 100 Gray, 200 Gray and 300 Gray that has the highest average of rice is in the 100 Gray irradiation with weight of 53.14 g. Seed weight per cluster of 100 Gray irradiation has a weight ranged from 6.49 g to 126.40 g, for irradiation 200 Gray has a weight ranged from 10.85 g to 86.11 g. Irradiation 300 Gray has a weight range per cluster of 4.82 g to 86.51 g.

**3.2.9. Flowering age** The plants flower during the maximum vegetative phase. Measurement of

flowering age is done by observing the population of each flowering plant every week. Rice is said to flower overall if 50% of the population is already flowering. The observation result on the age of flowering of Mentik Wangi is presented in Table 9.

**Table 9.** Flowering Age In Various Doses of Gamma Ray Irradiation

Dosage (Gray)	Lowest (weeks)	Highest (weeks)	Average (weeks)
0	7	8	8
100	5	8	7
200	5	8	7
300	6	8	8

Flowering age is the age parameter of harvest. Where plant flowering age is mature then the age of harvest is also mature [11]. The longest one is in irradiation 100 Gray and 200 Gray, where the plants flowering early at 5 weeks after planting relative to other treatment. The results showed that the control had a flowering age of 7 weeks to 8 weeks, 2 or 3 weeks longer compared with irradiation treatment of 100 and 200 Gray.

*3.2.10. M2 selection result* The result of M2 mutant selection is obtained in accordance with the objective to obtain Mentik Wangi rice with short flowering age, short stems and high productive tillers that some plants will be replanted as M3.

**Table 10.** M2 Selection Result of Flowering Age Properties

Strain	Flowering Age (weeks after planting)
R1G61T11	5
R2G81T6	5
R2G80T7	5
R3G37T3	6
R1G11T8	6
R2G77T20	6
R3G16T6	6

Observation result shows that there are some plants that indicate mutations where the plant has a shorter flowering age. There are 3 plants from the 7 plants that have shorter flowering age at the age of 5 WAP (Week After Planting), at 100 Gray irradiation there is 1 plant of R1G61T11 strain and at irradiation 200 Gray there are 2 plants of R2G80T7 and R2G81T6 strain. In irradiation 300 Gray has plants indicated mutation with the shortest flowering age of 6 WAP, one of which is on R3G16T6 strain. Irradiation of 300 Gray produces plants that have a flowering age that is not considered short.

**Table 11.** M2 Selection Result of Short Plant Height Properties

Strain	Plant Height (cm)
R3G53T3	85
R3G27T20	89
R1G32T5	90
R1G66T20	91
R3G45T20	93
R2G19T5	97
R1G26T1	97

In accordance with the purpose of this study, one of the objectives is to get a plant that has a short stem, which we know from Rice Seed Center Mentik Wangi rice has a plant height of approximately 120 cm. The shortest plant is R3G53T3 strain, where R3 mean that the plant is in irradiation of 300 Gray. Irradiation 100 Gray has the shortest plant height of 90 cm in R1G32T5 strain, whereas in irradiation of 200 Gray has the shortest plant which 7 cm difference with 100 Gray irradiation which is 97 cm at R2G19T5 strain. Giving doses of irradiation received by plants not only changes the height of the plants but also changes the nature of other morphology and physiological properties [12].

**Table12.** M2 Selection Result of Productive Tillers Properties

Strain	Number of Productive Tillers
R1G33T1	30
R2G70T1	28
R1G1T20	27
R2G1T2	27
R2G89T11	27
R3G6T20	27
R3G39T6	27

The results showed that from all the existing plants, there are 7 plants of mutant selected based on the number of productive tillers. Results from the 7 results mutant selection based on the number of productive tillers, the highest number of productive tillers shown at 100 Gray irradiation of R1G33T1 strain of 30 tillers. On irradiation 200 Gray of all the selected plant crops that have a number of productive tillers as many as 28 tillers in R2G70T1 strain, for plant from irradiation of 300 Gray of mutant selection there is lowest productive tillers with 3 tillers, for 300 Gray irradiation is also have the lowest average with 13 tillers. 200 Gray irradiation has an average number of productive tillers of 15 tillers, 1 tillers difference with 100 gray control and other irradiation treatment. The highest number of productive tillers totaling 27 tillers showed on R3G6T20 and R3G39T6 strain.

#### 4. Conclusion

Conclusion that can be taken from this research of Mentik Wangi Rice M2 Generation From Gamma Ray Irradiation are;

1. Mentik Wangi which has short stems properties are R3G53T3 with height 85 cm, R3G27T20 with 89 cm height, R1G32T5 with height 90 cm, R1G66T20 with height 91 cm, plant number R3G45T20 rod 93 cm, number R2G19T5 and R1G26T1 with a height of 97 cm.
2. Components of the results include the total number of tillers, the number of productive tillers, the number of grain per panicle and the weight of 1000 seeds in the plant occurs indication of mutations that have a high level of diversity in each treatment.



3. There are rice plants that have shorter flowering age compared to controls i.e with 5 weeks flowering age after planting on rice with irradiation of 100 Gray and 200 Gray is shown by R1G61T11, R2G81T16 and R2G80T7 strain, for flowering age 6 weeks after plant shown in R3G37T3, R1G11T8, R2G77T20 and R3G16T6 strain.
4. The result of mutant selection showed that some of the highest number of productive plants were shown by R1G33T1 strain of 36 tillers, R2G70T1 strain with 29 tillers, for number of 27 tillers are shown by R1G1T20, R2G1T2, R2G89T11, R3G6T20.

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