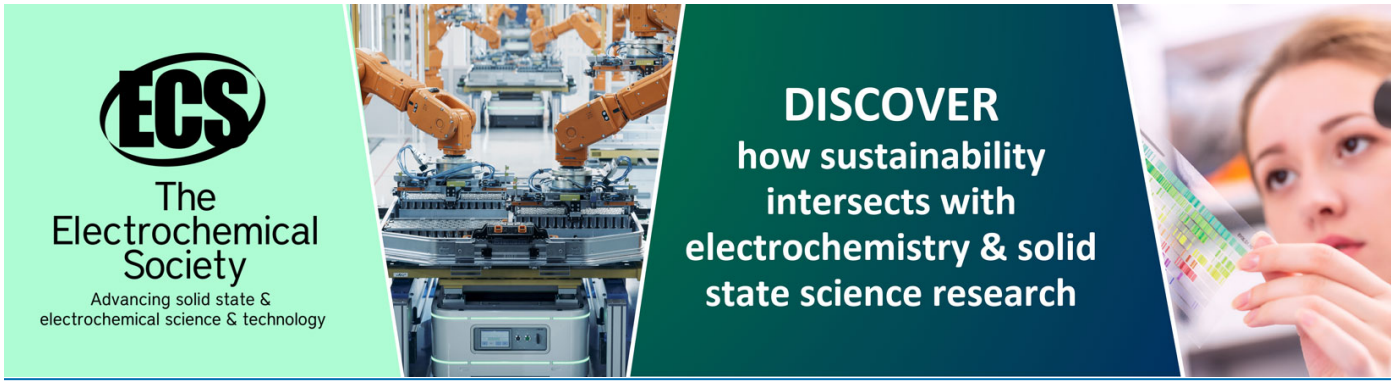
The performance of M2 generation of *Mentik Wangi Susu* rice resulted from gamma ray iradiation



The performance of M2 generation of *Mentik Wangi Susu* rice resulted from gamma ray iradiation

A Yunus[1], Parjanto[1] and I Y Pratama [2]
[1]Lecturer of Agrotechnology Studi Program, Agriculture Faculty, Universitas Sebelas Maret, Surakarta, Indonesia
[2]Student of Agrotechnology Studi Program, Agriculture Faculty, Universitas Sebelas Maret, Surakarta, Indonesia

Email : yunus.uns7@yahoo.com

Abstract. This research is about the morphology of *Mentik Wangi Susu* rice M2 generation rice after gamma ray irradiation. The research objective is to create second generation with new and better properties of plant growth and lifespan trough mutation. The study was conducted in farming land of Klumprit Village, Mojolaban Sub-District, Karanganyar District at April to July in 2016. The dosage of gamma ray used in this study were 0,1 kGy; 0,2 kGy; 0,3 kGy and control (without irradiation). The result showed that mutation occured in the gamma-irradiated plant as indicated by shorter plant and harvesting time compared to without irradiation.

1. Introduction

The innovation of new rice varietiy was expected to increase the productivity of rice production. The innovative approach to improve the rice farming efficiency is trough combination of technology components that have synergistic effects on is the mutual supportive and gives better effect on growth as well as productivity.

Mentik Wangi Susu is one of local rice variety that has some good properties. Previous study [1] was stated that *Mentik Wangi Susu* rice is a local variety originated from Magelang Central Java Indonesia. *Mentik susu* rice has a resistentcy to collapse and tasty rice. The rice is characterized with white and milk looks like color. *Mentik Wangi Susu* rice often called the Indonesian's Japan rice due to its good taste and sticky but not as same as sticky rice. However, *Mentik Wangi Susu* rice is similiar with other local rices which have some disadvantages. The rice has long cultivation period, and low rice yield, in contrast with national rice varieties that have short harvesting time and high productivity [2]. To geta local rice variety could be served by plant mutation using gamma ray radiation. This method has been frequently used to induce plants to mutate. This gamma ray has the ability to penetrate in deep to plant tissue. Mutation induction was directed to alter one or more important characters while other original characters are retained [3].

2. Methods

The research on the performance of *Mentik Wangi Susu* M2 generation produced by gamma ray radiation was held in agricultural land of Klumprit village, Mojolaban sub-district, Sukoharjo regency. The study was conducted for four months from April to July 2016. New variety of *Mentik Wangi Susu* rice was generated through gamma-ray radiation in collaboration with the National Atomic Energy

Agency (BATAN). The materials were used in this study including of *Mentik Wangi Susu* M2 seeds of gamma ray radiation results with a dose of 0.1 kGy; 0.2 kGy; 0.3 kGy and *Mentik Wangi Susu* rice without gamma-ray radiation as a control.

This research was conducted experimentally by planting *Mentik Wangi Susu* rice seeds M2 (M1 yield) of gamma ray radiation result. The planting was consisted of 4 levels of radiation dose, namely: 0.1 kGy; 0.2 kGy; 0.3 kGy and no radiation. The variables were observed including of physiological properties of plants considered as mutant, including of plant height (cm), productive number, average number of productive grain, panicle length, weight of 1000 Grains Asset, Grain per panicle amount, potential result and harvest age (day). The study was used descriptive analysis by comparing rice plants of various doses of gamma irradiation treatment with irradiated control treatment, since the research purpose was selected each individual suspected mutation.

3. Results and Discussion

3.1 General Condition of Research

The height of the experimental field of *metik susu* rice is 104 meters above sea level, so that this land has a sloping land structure to hilly. The one-year rain intensity is 1,052 mm with average of one-year rainfall intensity is 19 mm.

Rice crop is a plant that has the nature of life in a humid place, this plant is not a water plant but a living plant needs a lot of water. This characteristic that makes rice crops planted on soil that can hold water longer, soil that has low pH and high Al affecting rice plant growth. Thus, rice plants grown under these conditions will suffer plant stress resulting in stunted growth of rice crops and results in the first season experiencing drought during the vegetative period. The second season of the plant was an explosion of rice fungus attack

3.2 Growth Modifiers

3.2.1 Plant height Short rice crops were contributed to productivity because the shorter stems are more resistant to collapse [4]. The measurements results of high rice cultivated of *Mentik Wangi Susu* rice are presented in Table 1 and 2 below.

Table 1. Plant Height on Maximum Vegetative Growth of *Mentik Wangi Susu* Rice Based on Mutant Selection of Short Plant

Irradiation Dose (kGy)	Lowest Plants Height (cm)	Highest Plants Height (cm)	Range	Average (cm)
0	105	144	105-144	130.87
0.1	94	141	94-141	116.90
0.2	81	133	81-133	103.88
0.3	81	107	81-107	93.33

Based on measurement result in TTable 1, the highest of plant height average is control group (without irradiation) that is 130.87 cm. The height average of irradiated plant was shorter than the control group that is of dose of 0.1 kGy with a height of 116.90 cm and a dose of 0.2 kGy with a height of 103.88 cm, while the lowest of plant height average was a dose of 0.3 kGy with height of 93.33 cm. *Mentik Wangi Susu* rice were irradiated with gamma rays is more collapse resist to the *Mentik Wangi Susu* rice without irradiation (control).

The measurement results also shown the highest plant is the control group of 144 cm. The height of the irradiated plant was shorter than control that is dose of 0.1 kGy with a height of 141 cm and a dose of 0.2 kGy with a height of 133 cm, while the lowest of plant height average was a dose of 0.3 kGy

with 107 cm height. *Mentik Wangi Susu* rice was irradiated with gamma rays is more collapse resistant than *Mentik Wangi Susu* rice without irradiation (control).

Table 2. Plant Height of Maximum Vegetative Growth of *Mentik Wangi Susu* Rice Based on Mutant Selection of Tiller Number

Irradiation Dose (kGy)	Lowest Plants Height (cm)	Highest Plants Height (cm)	Range	Average (cm)
0	105	144	105-144	130.87
0.1	91	163	91-163	107.83
0.2	69	142	69-142	106.67
0.3	81	107	81-107	93.33

Based on measurement result of Table 2, the highest plant height average is control (without irradiation) of 130.87 cm. The average height of the irradiated plant was shorter than the control, i.e. the dose of 0.1 kGy with height of 107.83 cm and the dose of 0.2 kGy with the height of 106.67cm, while the lowest plant height average is 0.3 kGy with height of 93.33 cm. *Susu Mentik* rice that in irradiated with gamma rays is more collapse resistant than *Mentik Wangi Susu* rice that is not in irradiation (control).

Measurement results also showed the highest plant height is the dose of 0.1 kGy with a height of 163 cm. Control with height of 144 cm. The height of the irradiated plant was shorter than the control, i.e. the dose of 0.2 kGy with height of 133 cm, while the lowest plant height average is 0.3 kGy with height of 107 cm. *Mentik Wangi Susu* rice that in irradiated with gamma rays is more collapse resistant than *Mentik Wangi Susu* rice that is not in irradiation (control). This suggests that the administration of gamma ray irradiation in the *Mentik Wangi Susu* rice seedlings occurred gene mutation that controls the height of the plant.

3.2.2 *Total Tiller Number* Tiller is an important agronomic trait that ultimately determined the number of panicles, seeds and grains in a certain area. The number of tiller productive is the number of panicles that appear in a clump of rice plants and one of the parameters to measure the crop productivity. Through the calculation of the tiller number was obtained the results presented in Table 3 and 4 below.

Table 3. Total Tiller Number of Mentik wangi susu Rice based on mutant selection of short plant

Irradiation Dose (kGy)	Lowest Tiller Number	Highest Tiller Number	Range (plant)	Average
0	9	20	9 - 20	11
0.1	8	38	8 - 38	17
0.2	6	24	6 - 24	15
0.3	5	25	5 - 25	15

Mentik wangi susu rice that has been studied has the highest tillers number total is dose of 0.1kGy with 17 tillers with a range of 8-38 productive tillers of each plant. Dose of 0.2 kGy with the tillers number average is 15. Dose of 0.3 kGy with the average of tillers number is 15 not different with the tillers number of dose of 0.2 kGy. This was influenced by the plants number observed that is control group only 30 plants.

Mutation induction is one of way to improve the plants diversity, the tillers number was formed in a single clump of plants were determined by plant genetic [2]. This means that rice with irradiation gives better total tiller number than irradiated rice, then based on the productive tillers number was selected the best 30 plants at each dose that exceeds the control presented in the Table 4.

Table 4. Total Number of Tillers of *Mentik Wangi Susu* Rice based on Mutant Selection of Tillers Number

Irradiation Dose (kGy)	Lowest Tiller Number	Highest Tiller Number	Range (plant)	Average
0	9	20	9 – 20	11
0.1	9	26	9 – 26	14
0.2	7	23	7 – 23	14
0.3	5	25	5 – 25	15

Mentik wangi susu rice that has been studied based on the observation of the tillers number has the highest tillers number is dose of 0.2 kGy with 15 tillers with range of 5-25 tillers productive each plant. Dose of 0.2 kGy with the average of tiller number is 14. Dose of 0.3 kGy with the average tillers number is 14 is the lowest. This was influenced by the number of plants observed that is control only 30 plants and dose 0.3 kGy only 24 plants. [5] argued that the tillers number productive depends on the number of formed tillers. Another factor that influenced the formation of productive tillers is the factors of soil, soil with high moisture level can stimulated the plant roots development as in accordance to [6] reported the development of tillers number will be high if the condition of aerobic soil and roots grow well. The dried soil can push the roots deeper and increase the compactness of the soil surface and the strength of the soil that produces more growing plants.

3.2.3 *Average of Panicles Productive Number* The number of panicles productive was calculated based on the number of tillers that produce panicles and rice grains. The calculation of the number of grains per panicle can be seen in the following Table 5 and 6.

Table 5. Average of Panicles of *Mentik Wangi Susu* Rice based on Mutant Selection of Short Plant

Irradiation Dose (kGy)	Lowest of Panicle Number	Highest of Panicle Number	Range	Average
0	5	21	5 - 21	40
0.1	10	72	10 – 72	21
0.2	9	42	9 - 42	19
0.3	11	62	11 - 62	28

An important factor for obtaining high grain yield is dependent on the formation of tillers number that determined the panicles number. Based on the observation results on Table 5, the lowest of productive grain number average of *Mentik Wangi Susu* rice is in the dose of 0.2 kGy with 19 panicles whereas the highest is the dose of 0.3 kGy with 28 panicles. The average of productive grain number on doses of 0.1 kGy, 0.2 k Gy and 0.3 kGy are lower than the control group so that the irradiation given an effect to the average of productive grains number of *Mentik Wangi Susu* rice.

Table 6. The average of Panicles Number of *Mentik Wangi Susu* Rice based on Mutant Selection of Tillers Numbers

Irradiation Dose (kGy)	Lowest of Panicle Number	Highest of Panicle Number	Range	Average
0	5	21	5 - 21	40
0,1	9	39	9 - 39	18
0,2	5	32	5-32	17
0,3	11	62	11 - 62	28

The productive panicles number based on the observation of mutant selection of tillers numbers is the number of panicles that appear in a clump of rice plants and is one of the parameters to measure

the crop productivity. Based on the results of observation on Table 7 the lowest of productive grain number average on *Mentik Wangi Susu* rice is at the dose of 0.2 kGy with 17 panicles number while the highest is the dose of 0.3 kGy with 28 panicles numbers. The average of productive grain number on doses of 0.1 kGy, 0.2 kGy and 0.3 kGy are lower than the control group so that the irradiation given effect on the average of productive grains number of *Mentik Wangi Susu* rice.

3.2.4 *Weight of 1000 Field out Grain* The weight of 1000 field out grains is one of the parameters were used in research to determine the crop quantitative character. Based on observation result of weight of 1000 field out grains can be seen in Table 7 and 8 below.

Table 7. Weight of 1000 filled grains per panicle of*Mentik Wangi Susu* Rice Based on Mutant Selection of Short Plant

Irradiation Dose (kGy)	Lowest of 1000 grains weight	Highest of 1000 grains weight	Range	Average
0	18.5	23.8	18.5 -23.8	22.223
0.1	19.9	28.8	19.9 -28.8	22.057
0.2	20	31.1	20 – 31.1	24.992
0.3	12.6	26.7	12.6 -26.7	21.917

The lowest of 1000 grain weight is 0.3 kGy dose of 12.6 grams and the highest is 0.2 kGy dose of 31.1 grams. The of 1000 grains weight of 0.2 kGy doses is heavier than the weight of the highest of 1000 grains weight of the control group, i.e. 23.8 grams, this proven that irradiation has a good effect on the grain weight because grain weight was related to rice production. Gamma ray radiation has the potential to create diversity to obtain mutants with morphological characteristics and desirable agronomic characteristics such as low plants, short life and high production.

Table 8. The Weight of 1000 Filled Grainsper Panicle of *Mentik Wangi Susu* Rice based on Mutant Selection of Tiller Number

Irradiation Dose (kGy)	Lowest of 1000 grains weight	Highest of 1000 grains weight	Range	Average
0	18,5	23,8	18,5 - 23,8	22,22
0,1	19	27,90	19 - 27,90	23,69
0,2	19,60	27,20	19,6-27,20	23,27
0,3	12,6	26,7	12,6 - 26,7	21,92

The lowest of 1000 grain weight is 0.3 kGy dose of 12.6 grams and the highest is 0.1 kGy dose of 27.90 grams. The 1000 grains weight of 0.1 kGy doses is heavier than the highest of 1000 grain weight of the controls group, i.e. 23.8 gram. It was proven that irradiation has a good effect on grain weight because grain weight was related to rice production. Rice productivity was highly dependent on the number of productive tillers and panicle length. Crop productivity on a certain land was expected to determine the varieties results that can adapt to the environment [7].

3.2.5 *Number of Grain per Panicle* Number of grains per panicle is one of components to determine the potential of rice crops [6]. The grains number per panicle can be seen in Tables 9 and 10 below.

Table 9. Average number of grains per panicle of *Mentik Wangi Susu* Rice Based on Mutant Selection of Short Plant

Irradiation Dose (kGy)	Lowest average	Highest average	Range	Average
0	87	235	87 – 235	181
0.1	78	236	78 – 236	150
0.2	77	184	77 – 184	125
0.3	69	209	69 - 209	110

The lowest number of productive grain of *Mentik Wangi Susu* rice is at the doses of 0.3 kGy which is equal to 69,667 while the highest is dose of 0,1 kGy which is 236. The number of productive grain of doses of 0.1 kGy and 0.2 kGy is higher than control group so that irradiation given effect to the number of productive grains of *Mentik Wangi Susu* rice. Cereals given doses of gamma rays at doses of 0.1 kGy and 0.2 kGy have a high generative growth, one of the cereals yield produced such as rice and sorghum.

The grains number of per panicle was affected by the panicles length. The ability of plants to express the panicles length was strongly influenced by the period of panicle initiation that was included in the critical period of the plant. Lack of nutrients and water in the panicle initiation period can caused the panicles formation is not maximal so that the affected to the seed will be formed.

Table 10. The average of grains number per panicle on Various Dose of Gamma Rays Irradiation of *Mentik Wangi Susu* Rice Based on Mutant Selection of Tillers Number

Irradiation Dose (kGy)	Lowest number of grains per panicle	Highest number of grains per panicle	Range	Average
0	87	235	87- 235	181
0.1	35	238	35 – 238	133
0.2	76	197	76 -197	131
0.3	69	209	69-209	110

The lowest number of productive grain is Mentik wangi susu rice at the doses of 0,1 kGy that is 35,33 and the highest is doses of 0,1 kGy that is 238. The number of productive grain at doses of f 0,1 kGy and 0,2 kGy is higher than control group so irradiation was given effect to the amount of productive grain of *Mentik Wangi Susu*.

3.2.6 *Potential Results* The potential results in weight of 1000 field out grains is one of the parameters used to measuremen the crop productivity. Based on panicles number, the average of grains number per panicle can be seen in Table 11 and 12.

Table 11. Yield Potential of *Mentik Wangi Susu* Rice per 1000 Seeds Based on mutant selection of short plant

Dose Irradiation (kGy)	Lowest Yield Potential (Gram /Clump)	Highest Yield Potential (Gram /Clump)	Range	Average (Gram / Clump)
0	13.402	105.525	13.402-105.525	42.066
0.1	27.760	180.432	27.760-180.432	66.186
0.2	16.484	102.844	16.484-102.844	51.749
0.3	25.016	280.785	25.016-280.785	71.261

The lowest yield potential is the control dose of 13,402.80 grams and the highest is the dose of 0.3 kGy i.e. 280.785.60 grams. The highest potential yield of 0.3 kGy dose has more potential than

control of 42.066.99. This was proven that irradiation has a good effect to the yield potential of *Mentik Wangi Susu* rice of control group because this yield potential was related to rice production. Gamma ray radiation has the potential to create diversity so obtained mutants with morphological characteristics and desirable agronomic characteristics such as low plants, short life and high production.

Table 12. Yield Potential of *Mentik Wangi Susu* Rice per 1000 Seeds based on mutant selection of tillers number

Irradiation Dosage (kGy)	Lowest Yield Potential (Gram/clump)	Highest Yield Potential (Gram/clump)	Range	Average (Gram/ Clump)
0	13.402	105.525	13.402-105.525	42.066
0.1	15.390	124.616	15.390-124.616	56.730
0.2	16.484	102.844	16.484-102.844	51.749
0.3	25.016	280.785.60	25.016-280.785	71.261

The highest yield potential of observations based on mutant selection of tillers number is 0.3kGy dose of 71.261.63 grams and the lowest yield potential is control dose of 42.066.99 gram. Potential result of dose 0.1 kGy; 02kGy; and 0.3kGy is better than control group of 42.066.99 gram. It was proven that irradiation has a good effect on grain weight because grain weight was related to production.

3.2.7 *Mutant Selection Results of Short Trunk and Tillers Number* Based on observations of various doses of gamma ray irradiation, the treatment based on observations of the short trunk, was presented in the following Table.

Table 13. Mutant Selection Results of Short Plant of Mentik wangi susu Rice on 0.1 kGy irradiation dosage that have High Yield Potential

Code	High Plant (Cm)	Thillers Number	Panicles Number	Weight of 1000 Seeds (g)	Grain Number Per Panicles	Yield Potential (Gram/Clump)
G14T5	141	11	12	21.5	215.33	55.556
G23T3	135	12	14	19.2	171.33	46.054
G63T11	134	18	20	19.9	107.67	42.85
G15 T5	134	11	11	21.4	222.67	52.415
G39T17	132	8	14	27.2	88.67	33.764
G38T6	132	16	21	21.4	216.00	97.070
G39T10	132	13	21	20.4	114.00	48.837

Table 14. Mutant Selection Results of Short Plant of Mentik wangi susu Rice on 0.2 kGy irradiation dosage that have High Yield Potential

Code	High Plant (Cm)	Thillers Number	Panicles Number	Weight of 1000 Seeds (g)	Grain Number Per Panicles	Yield Potential (Gram/Clump)
G13T2	133	17	31	2	G13T2	133
G3T18	132	14	15	2.38	G3T18	132
G16T5	130	12	20	2.27	G16T5	130
G5T7	127	14	14	2.31	G5T7	127
G3T17	121	13	10	2.65	G3T17	121
G15T4	120	18	15	3.11	G15T4	120
G15T3	118	18	24	2.5	G15T3	118

Table 15. Mutant Selection Results of Short Plant of Mentik wangi susu Rice on 0.3 kGy irradiation dosage that have High Yield Potential

Code	High Plant (Cm)	Thillers Number	Panicles Number	Weight of 1000 Seeds (g)	Grain Number Per Panicles	Yield Potential (Gram/ Clump)
G7T8	107	17	33	19	126.00	79.002
G31T20	107	25	62	21.6	209.67	280.785
G41T4	107	14	37	20.1	108.00	80.319
G17T17	105	19	38	24.6	122.33	114.357
G6T1	103	18	27	19.7	177.00	94.146
G9T6	100	15	21	20.8	103.67	45.28
G26T13	100	20	40	20.3	166.33	135.062

Table 13 to 15 were contained studies based on mutant-selection of short plant selection treated with irradiated doses of 0.1 kGy have a shorter height with other dose treatments. Irradiation of 0.1 kGy dose has 36.862% more superior that irradiation of 0.2 kGy dose of 34.549% and dose of 0.3 kGy with presentasae of 28.588%

Based on observations of various doses of gamma ray irradiation treatment observations based on mutant selection of thiller number, presented in the following Table.

Table 16. Mutant Selection of Thiller Number of Mentik wangi susu Rice of 0.1 kGy Irradiated Dosage that Have High Yield Potential.

Code	Thiller numbers	Panicles Number	Weight of 1000 Seeds (g)	Grain Number Per Panicles	Yield Potential (Gram/ Clump)
G24T31	26	39	23.3	84.00	2.896
G28T6	25	39	20.5	97.67	2.570
G15T11	22	26	23.4	99.33	3.274
G17T13	22	13	23.1	206.67	6.2
G33T16	19	22	23.8	238.00	7.437
G28T4	18	19	22.5	112.67	3.557
G37T22	18	29	26.2	112.67	3.673

Table 17. Mutant Selection of Thiller Number of Mentik wangi susu Rice of 0.2 kGy Irradiated Dosage that Have High Yield Potential.

Code	Thiller Numbers	Panicles Number	Weight of 1000 Seeds(g)	Grain Number Per Panicles	Yield Potential (Gram/ Clump)
G13T20	23	21	19.6	197.67	81.359.60
G9T5	22	19	23.2	195.33	86.102.93
G3T13	21	28	21.7	155.00	94.178.00
G3T20	21	21	22.6	144.67	68.658.80
G17T17	21	14	27.2	101.67	38.714.67
G18T7	20	23	27.1	165.00	102.844.50
G8T6	20	27	22.5	106.67	64.800.00

Table 18. Mutant Selection of Thiller Number of Mentik wangi susu Rice of 0.3 kGy Irradiated Dosage that Have High Yield Potential.

Code	Thiller numbers	Panicles Number	Weight of 1000 Seeds (g)	Grain Number Per Panicles	Yield Potential (Gram/ Clump)
G7T8	17	33	19	126.00	79.002
G31T20	25	62	21.6	209.67	280.785
G41T4	14	37	20.1	108.00	80.319
G17T17	19	38	24.6	122.33	114.357
G6T1	18	27	19.7	177.00	94.146
G9T6	15	21	20.8	103.67	45.281
G26T13	20	40	20.3	166.33	135.062

Table 16 to 18 are the selection result of second-generation of Mentik wangi susu rice that allegedly have mutations with lower plant and large number of tillers. The lower plant was expected the plant will be sturdy and not easily exposed to wind. Number of productive tillers is the number of rice plants that produce panicles. The higher number of productive tillers will have a positive impact on rice productivity. The research results were presented in the above based on the tillers number at many variation of irradiation doses. The dose of 0.3 kGy have the highest impact with the percentage of 36.21%, followed by 0.2 kGy irradiation dosage with percentage of 34,74% and the irradiation dose of 0.1 kGy has the lowest percentage of 30,05%. Table 16 to 18 is the selection result of 30 plants that have more tillers number of than control. The rice of M2 selection results are the next planting material for M3 was expected to have better individual properties that M2 generation.

3.2.8 *Harvest Age* Harvesting was done when the plant is 110 days after planting and when the seeds are ripe physiologically, which is about 90-95% panicles have yellow. Harvest was done by cutting the straw about 20-25 cm above the soil surface, harvested rice was placed or stacked on the tarpaulin, then done threshing rice used pedal treasure. The study began on April 6th with seeding. Seeds of *Mentik Wangi Susu* rice seedlings for 21 days were planted on Tuesday April 26th, 2016 and harvested on August 23, 2016 for controlled treatment, which means that the plant life is 140 days. Irradiation treatment of 0.1 kGy at 135 days harvest age, 0.2 kGy at 134 days harvest age and 0.3 kGy at 132 Days harvest age. The plant was harvested simultaneously per treatment due to the occurrence of pest infestations. It was done to reduce the loss of grain due to pest infestations affected the level of data validity.

4. Conclusion

Based on the research performed, it can be concluded that there are variety of M2 rice plants that is in the strain of short-aged plant from irradiation of 0.1 kGy, which are: G15 T5; G38 T6; G23 T3; G39 T10; G63 T11; G39 T17; G14 T5 strains, and in the treatment with irradiated dose of 0.2 kGy are G5 T7; G3 T17; G13 T2; G15 T3; G15 T4; G16 T5; G3 T18 strains; and in the tillers number properties from irradiation 0.1 kGy are: T4; T22; T31; T16; T6; T11; T13 strain, from the irradiation dose of 0.2 kGy are G18T7; G3T13; G9T5; G8T6; G13T20; G3T20; G17T17 strain and at a dose of 0.3 kGy are T4; T17; T1; T20; T13; T6; T2 strain. Obtained individual plants that allegedly have mutations for the properties of short plants and plentiful tillers

References

[1] Nurmayetti, Atman 2013 Keunggulan kompetitif padi sawah varietas lokal disumatra barat. *Jurnal pengkajian dan pengembangan teknologi pertanian.* **16** (2) : 100-108
[2] Makarim A K, Suhartati E. Morfologi dan Fisiologi Tanaman Padi. Balai Besar Tanaman Padi
[3] Yulianti F C, Martasari, Karsinah dan T. Hartanto 2010 Variasi Genetik Jeruk Keprok (*Citrus reticulata* Blanco) Hasil Radiasi Sinar Gamma Menggunakan Penanda ISSR *Buletin Plasma Nutfah* **16** (2)
[4] Sobrizal, Sanjaya S, Carkum et al 2004 Mutan Padi Pendek Hasil Lradiasi Sinar Gamma 0,2 Kgy Pada Varietas Atomita 4 Puslitbang Technologi Isotop dan Radiasi BATAN
[5] Yusnaweti, Sevindajuta 2012 Uji Beberapa Varietas Dan Jumlah Benih Terhadap Pertumbuhan Dan Produksi Padi Gogo Pada Ultisol
[6] Zhang W, Si-Tu S 1989 Influence of drainage practice on rice yield Pp 65-84 in *Proceeding of the 7 th Afro-Asean egional Conference* vol. D.7 International Commisionon Irrigation and Drainge Tokyo
[7] Kuswanto H 1997*Analisis Benih* (Yoyakarta: Andi)