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Article

Performance and Selection of Short Life and High Yield Black Rice M3 Gamma Ray Irradiation 200 Gray

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Abstract: Black rice is one of Indonesia's genetic resources as a functional food source. Black rice is rich in antioxidants, iron, amino acids, potassium and calcium. Long lifespan and low yields are obstacles that reduce farmers' interest in cultivation. To overcome this weakness, mutation induction was carried out with 200 Gray gamma ray irradiation. This research aims to determine the performance and select plants with early maturity and high yields on M3 black rice irradiated with gamma rays. The research was conducted from March 2023 to June 2023 in the rice fields of Pakahan Village, Jogonalan, Klaten. The selection method uses pedigree with a completely randomized design without replication. The materials used in this research were M2 mutant black rice seeds resulting from 200 Gray gamma ray irradiation and Cempo Ireng elders as control plants. The results of the research revealed that the M3(GH8')-12 line had an average difference with Cempo Ireng in the characteristics of flowering age, productive tillers, seed weight per hill, and grain yield. So the 200 Gray gamma ray irradiation treatment had an effect on the lifespan and results shown in the M3(GH8')-12 line. 17 plants of the M3 line were obtained from selection based on the criteria of flower age and high yield. The M3(GH8')-12-1-2 line can be further developed to flower at 64 DAP with seeds weight per plant of 102.2 grams.

Keywords: Age, mutant black rice, performance, selection, yield

1. Introduction

Indonesia, with its abundant genetic resources, needs to be preserved and developed. The advancement of technology from year to year makes researchers move to develop natural potential. In this way, it will be achieved according to demand and needs.

One of the genetic resources possessed is black rice. Indonesian black rice germplasm includes Melik Bantul, Jlitheng and Cempo Ireng Sleman, Magelang black rice, Sragen black rice, Wonosobo black rice, Wulung Surakarta, Laka

Manggarai, Pae Biyu Nggolopua Kendari, Tana Toraja Rentepau, and Pulut Hitam Dayak [1]. Black rice contains higher levels of antioxidant compounds such as phenolics and flavonoids than white rice [2]. The iron content of black rice is three times higher than white rice. Black rice calories are lower than white rice, only 362 kcal per 100 grams [3].

Even though it has many advantages, black rice has disadvantages so it needs genetic improvement. These shortcomings include a long plant life of 145 days [4] and low yields. The ripening of flowers and seeds needs to be shortened to speed up harvest. So farmers don't need to spend more money on maintenance.

Mutation breeding is a way to improve plant quality. One step is gamma ray irradiation. Through gamma ray irradiation, genetic diversity is obtained to select plants. Through this selection, superior varieties can be obtained such as early maturity, high grain production [5], short stems, resistance or tolerance to pests and diseases, and the ability to grow under certain environmental stress conditions.

The M3 mutant plants in this study were the result of planting the selected M2 line. The previous generation, namely M1 mutant plants and M2 mutant plants, was carried out and then selected according to the desired criteria. This research aims to determine the performance and selection on flower age and high yield of M3 generation mutant black rice resulting from 200 Gray gamma ray irradiation.

2. Materials and Methods

This research was conducted from March 2023 to June 2023. The 200 Gy gamma ray irradiation treatment was carried out in March 2021 at the Center for Isotope and Radiation Applications, Jakarta. Planting and observing plants was carried out in rice fields in Pakahan Village, Jogonalan District, Klaten Regency, Central Java Province. The method used for selection is the pedigree method. The design used was a completely randomized design without replication.

The materials used in this research were M2 mutant black rice seeds resulting from 200 Gray gamma ray irradiation and Cempo Ireng elders as control plants. The tools that will be used are sickles, stakes, scissors, calipers, rulers, digital scales and rice characterization guides. The first stage of this research is seeding. Transplanting is carried out at the age of 28 days after sowing (DAS). The planting distance used is 20 × 20 cm. 1 seed is planted in each hole. The distance between genotypes is 100 × 100 cm. Variable parameters observed included flower age, productive tillers, seed weight per hill, and grain yield. Flower age is the initial stage when selecting plants. The analysis used is descriptive analysis. The T test at the 0.05 level was carried out to compare the M3 and Cempo Ireng genotypes.

3. Results and Discussion

3.1 Age of Flowers

In table 1, the fastest flowers to appear in genotype M3(GH8')-12 have a range of 55-70 days after planting (DAP) with an average of 65 ± 3.20 DAP. The slowest flowers appeared on genotype M3(GH51')-12 with an average of 70 ± 0.00

DAP. Flowers in the M3 population appeared faster than the control cempo ireng plants with an average of 89 DAP.

Flowers appeared more quickly due to genetic changes after 200 Gray gamma ray irradiation [6]. For example, the Sigupai M5 mutant rice flowered more quickly than the Mustajab variety as a control plant [7]. Other research shows that mutant rice flowers appeared earlier than control plants [8]. Sambay M4 rice resulting from 250 Gray gamma ray irradiation had earlier flower maturity than its parents [9].

Table 1. Age of M3 black rice flowers resulting from 200 Gray gamma ray irradiation

Genotype Number	Flower Age (HST)			
	Lowest	Highest	Range	Average±Std
M3(GH8')-12	55	70	55-70	65±3,20 *
M3(GH8')-18	55	70	55-70	69±3,34 *
M3(GH51')-12	70	70	70-70	70±0,00
M3(GH52')-22	55	70	55-70	69±3,01 *
Control	89	89	89-89	89±0,00

Information. The (*) sign after the number means it is significantly different from control after carrying out a t test at the 0.05 level

Grouping of rice based on harvest age, namely, deep mature rice (>151 DAS); medium (125- 150 DAS); early maturity (105-124 DAS); very early maturing (90-104 DAS); and ultra early maturity (<90 DAS) [10]. The appearance of flowers is an important character for plant selection. The sooner the plant flowers, the sooner the plant can be harvested. In this study, transplanting was carried out at the age of 28 DAS. The M3(GH8')-12 genotype with an average of 65 ± 3.20 DAP can be used as a selection target for development[11].

3.2 Productive Tillers

In table 2, the highest number of productive tillers is in genotype number M3(GH51')-12 with a total of 28 tillers with a range of 7-28 tillers. The lowest number of productive tillers is M3(GH8')-18 with a total of 4 tillers with a range of 4-22 tillers. The number of productive tillers on the control Cempo Ireng plants ranged from 4-20 tillers with an average of 10 ± 4.33 tillers which was less than the M3 genotype plants. On average, M3 genotype plants had more productive tillers than control plants. Productive tillers is done to measure how much rice yields and predict the number of rice panicles desired for each plant that grows [12].

Table 2. Productive tillers of M3 black rice resulting from 200 Gray gamma ray irradiation

Genotype Number	Productive Tillers			
	Lowest	Highest	Range	Average±Std
M3(GH8')-12	8	25	8-25	16±4,61 *
M3(GH8')-18	4	22	4-22	11±4,10
M3(GH51')-12	7	28	7-28	14±4,65
M3(GH52')-22	5	27	5-27	15±5,14
Control	4	20	4-20	10±4,33

Information. The (*) sign after the number means it is significantly different from control after carrying out a t test at the 0.05 level

Genetic damage occurs because 200 Gray gamma ray irradiation can increase the number of productive tillers. Environmental conditions also influence productive tillers, such as sunlight, nutrient factors, and other environmental conditions [13]. Apart from environmental conditions, plant genetics also influence the number of tillers [14].

The number of productive tillers can influence the high and low grain yields [15]. There are three categories for the number of tillers, namely few (1-10), medium (10-15), and many (>15). Grain yield is obtained from calculating the weight of seeds per plant, planting distance, and population size per hectare. High rice productivity is closely related to productive tillers, where the tillers give rise to panicles from which rice seeds emerge [16]. The higher the grain production per hectare, the higher the results obtained by farmers[17].

3.3 Seed Weight per Plant

In table 3, the highest seed weight per plant is genotype number M3(GH8')-12 with a weight of 102.2 gram with a range of 14.3-102.2 gram. The average seed weight per plant of M3(GH8')-12 was 49.82 ± 18.36 gram. The lowest seed weight per plant is genotype number M3(GH8')-18 with a weight of 8.6 gram with a range of 8.6-66.9 gram. The average seed weight per plant of M3(GH8')-18 weighed 34.29 ± 14.04 gram. In the control cempo ireng plants, the average seed weight per plant weighed 23.72 ± 10.00 gram with a range of 9.8-45.5 gram. The average seed weight per plant in the M3 population was higher than the control plants.

Table 3. Seed weight per plant of M3 black rice resulting from 200 Gray gamma ray irradiation

Genotype Number	Seed Weight per Plant (gram)			
	Lowest	Highest	Range	Average±Std
M3(GH8’)-12	14,3	102,2	14,3-102,2	49,82±18,36 *
M3(GH8’)-18	8,6	66,9	8,6-66,9	34,29±14,04
M3(GH51’)-12	17,8	70,2	17,8-70,2	39,09±13,06 *
M3(GH52’)-22	9,3	94,9	9,3-94,9	44,19±19,42 *
Control	9,8	45,56	9,8-45,5	23,72±10,00

Information. The (*) sign after the number means it is significantly different from control after carrying out a t test at the 0.05 level

The more nutritious the grain, the more biomass there is in the grain [13]. If the seed weight per plant is high[18], production yields will also increase. Post-flowering conditions also influence the weight of rice seeds[19]. The effect of this condition can affect the supply of carbohydrates obtained from photosynthesis which is related to the size and weight of rice seeds [20].

Factors that influence the height and weight of grain are the panicles formed and environmental conditions which are related to nutrient uptake[21]. When nutrient uptake is not smooth, grain filling will be difficult, causing a lot of empty grain [22]. Genetic traits inherited from parents and environmental factors can have an effect on plant growth and yield [23]. Apart from that, the weight of the filled grain, the number of panicles, and the weight of 1000 grains also have a significant effect on the weight of the grain per plant [12].

3.4 Weight of 100 Seeds

Table 4 shows that the highest weight of 100 seeds is genotype number M3(GH8')-12 with a range of 1.3-2.6 gram with an average of 2.35 ± 0.24 gram. The lowest grain yield was found in genotype number M3(GH52')-52 with a range of 1.6-2.7 gram with an average of 2.28 ± 0.25 gram. The control plants produced an average of 2.25 ± 0.08 gram with a range of 2.1-2.4 gram. The average weight of 100 seeds in the M3 population was higher than in control plants[24].

A dose of 200-300 Gray is the optimal dose for genetic improvement. When the dose is higher, there will be increase in sterility so that more empty grains appear than filled grains [25]. Genetic and physiological damage to plants also increases due to damaged cells and chromosomes [9].

Table 4. Weight of 100 seeds of M3 black rice resulting from 200 Gray gamma ray irradiation

Genotype Number	Weight of 100 Seeds (gram)			
	Lowest	Highest	Range	Average±Std
M3(GH8')-12	1,3	2,6	1,3-2,6	2,35±0,24
M3(GH8')-18	2	2,7	2-2,7	2,32±0,17
M3(GH51')-12	1,6	2,7	1,6-2,7	2,34±0,27
M3(GH52')-22	1,6	2,7	1,6-2,7	2,28±0,25
Control	2,1	2,4	2,1-2,4	2,25±0,08

Information. The (*) sign after the number means it is significantly different from control after carrying out a t test at the 0.05 level

Genetic characteristics when producing plant products are not visible due to limiting environmental factors. So human effort is needed to manage and regulate suitable environmental conditions so that genetic capabilities can be achieved [26]. Harvest yields can be influenced by other yield components such as productive tillers, number of panicles and amount of filled grain. The optimal inclusion of nutrients also has a positive effect on grain yield [27]. Several things that can influence the high or low grain yield per hectare are the selection of superior varieties, plant care, appropriate fertilization, control of pests, diseases and weeds, smooth irrigation, as well as environmental elements such as weather, temperature, rainfall and sunlight [12].

3.5 Individual Selection of Plants

Mutations can occur randomly in genetic material (genome, chromosomes, genes) and cannot be predicted. Mutations cannot be directed at a specific gene [12]. The variations resulting from mutations are more diverse. This diversity is used for the selection process to obtain the desired individuals.

The number of genotype numbers in the M3 population is 113 numbers. Of this number, 17 plants were selected. Selection is made based on the earliest flowers to appear and high yields[28].

Table 5. Selection of M3 black rice lines irradiated with 200 Gray gamma rays

Genotype Number	Flower Age (DAP)	Productive Tiller	Seed Weight per Plant (gram)
M3(GH8')-18-1-4	55	9	28,7
M3(GH8')-12-7-7	55	13	14,3
M3(GH8')-12-1-2	64	25	102,2

M3(GH8')-12-7-12	64	25	59,9
M3(GH8')-12-7-8	64	19	75,6
M3(GH8')-12-1-1	64	19	66,1
M3(GH8')-18-4-1	64	19	54,7
M3(GH8')-12-1-6	64	17	60,4
M3(GH8')-18-3-1	64	16	51
M3(GH52')-22-10-11	70	27	94,9
M3(GH8')-12-1-5	70	22	85,6
M3(GH52')-22-10-6	70	22	78,2
M3(GH51')-12-1-1	70	18	70,2
M3(GH51')-12-1-6	70	13	32,2
M3(GH51')-12-5-8	70	22	65,4
M3(GH51')-12-6-7	70	28	50,7
M3(GH52')-22-9-11	70	18	47,6

Information. Plant selection starts from the age of the flower.

Black rice plants from the M3 population that have been selected have earlier flower ages than control plants by comparing them. The 9 selected plants were in the early maturing category and 8 plants were in the medium category. The time it takes for flowers to appear can cause a decrease in the yield of filled grain. The faster the flower ages, the shorter the plant height.

The success of irradiation on plants can be influenced by various aspects, including genotype, part of the plant used, stage of plant cell development, number of chromosomes, tissue age, oxygen, temperature and irradiation dose [20]. Prolonged vegetative growth can reduce the supply of assimilate so that only empty grains appear rather than filled grains [29]. Low grain yields can occur due to photosynthate which is initially stored by the grain, which is often exploited by pests and diseases [30].

4. Conclusion

From the performance and selection results in the M3 black rice population resulting from 200 Gray gamma ray irradiation, 17 lines were selected. The 17 lines consist of 9 plants in the early maturing category. Based on these two criteria, the M3(GH8')-12-1-2 line can be further developed to flower at 64 DAP with seeds weight per plant of 102.2 gram.

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