JUATIKA
JURNAL AGRONOMI TANAMAN TROPIKA
VOL. 6 NO. 3 September 2024

DOI :https://doi.org/10.36378/juatika.v6i3.3809
eissn 2656-1727
pissn 2684-785X
Hal : 801 – 808

Growth and Production Character Response of Kuantan Singingi Local Rice Mutants Resulting from Gamma Irradiation

Gusti Marlina[1,2], Auzar Syarif[1,*] , Gustian[1], Yusniwati[1]
[1]Universitas Andalas
Jl. Limau Manis, Pauh Distric, Padang City, Sumatera Barat, Indonesia 25175
[2]Universitas Islam Kuantan Singingi
Jl. Gatot Subroto KM 7, Kebun Nenas, Teluk Kuantan, Sungai Jering Distric, Kuantan Singingi Regency, Riau, Indonesia 29562
*Email : auzar_syarif@yahoo.com

ABSTRACT

Rice (*Oryza sativa* L.) is a crucial crop with significant importance in various regions. In Riau, specifically in Kuantan Singingi Regency, it ranks as the fourth largest area for rice production, showcasing numerous local rice varieties with substantial development potential. This study aimed to generate mutants exhibiting early maturity and reduced plant height through gamma-ray induced mutations. A non-factorial Randomized Block Design (RAK) was employed, with the primary factor being the irradiation dose: R0 served as the control group without radiation, while the experimental group received an irradiation dose of 300 Gy, determined to be effective in prior research. Each treatment was replicated five times, utilizing a total of 600 plants per treatment. The findings indicated that rice plants subjected to 300 Gy irradiation exhibited shorter heights compared to those in the control group. Additionally, the stem circumference of plants irradiated with 300 Gy was significantly greater than that of the non-irradiated plants. Furthermore, the number of productive tillers was higher in the 300 Gy group compared to the control. However, the harvest age for rice plants exposed to 300 Gy was extended relative to those without radiation. Conversely, the length of the flag leaf in rice plants irradiated at 300 Gy was shorter than that of the control group. There remains a considerable need for data on the desired characteristics of rice mutants to facilitate advanced breeding efforts.

Keywords: Gamma Rays, Irradiation, Kuantan Singingi, Local Rice, Mutant Character

1. INTRODUCTION

Rice (Oryza sativa L.) is a crucial agricultural crop that holds significant importance in various regions around the world. In Indonesia, rice serves as the primary commodity and a vital source of carbohydrates for the population. Consequently, the Indonesian populace exhibits a strong reliance on this crop; however, rice production levels in the country remain notably low. According to data from BPS (2023), Indonesia's rice production reached 53.63 million tons of GKG, a decline from the previous year's output of 54.75 million tons of GKG. This reduction can be attributed primarily to the predominance of local rice varieties being cultivated.

Notably, the majority of these local rice varieties are sourced from Kuantan Singingi, where 26 distinct local genotypes have been identified (Ezward et al., 2020). Kuantan Singingi is recognized as the central hub for rice production in the Riau province. In 2023, Riau's rice production was reported at 209.19 thousand tons of GKG, a decrease from the 213.56 thousand tons of GKG produced in the preceding year. This trend of declining rice production is evident not only at the national level but also within the Riau province..

The reduction in production can be attributed to the limitations of local rice varieties, which yield only 1.59 tons per hectare and exhibit a height of 135.51 cm (Afdila et al., 2021). This height predisposes the plants to lodging during strong winds, particularly when the grains are mature, leading to potential crop failures. Nevertheless, the local Kuantan Singingi rice possesses several beneficial traits, including resistance to brown planthopper pests and drought tolerance (Ezward et al., 2022). It is noteworthy that the region of Kuantan Singingi is characterized by numerous rain-fed rice fields, which can only retain water during rainfall events. Consequently, the local Kuantan Singingi rice variety holds significant promise for development in alignment with the prevailing environmental conditions (Marlina et al., 2023).

Strategies to enhance local rice production may involve the application of gamma ray irradiation to induce mutations. The technique of mutation breeding through gamma ray irradiation has been extensively explored in various research contexts (Marlina et al., 2023). In earlier phases of research, the local Kuantan Singingi rice was subjected to gamma ray irradiation to determine an effective dosage.

The effective dose required for each local rice variety varies significantly. According to the findings of Sari et al. (2023), the effective dose for the Mandang Pulau and Putiah Papanai rice varieties was determined to be 300 Gy, whereas the Banang Kuning variety required an effective dose of 200 Gy. Additionally, research conducted by Marlina et al. (2024) identified the effective dose of gamma rays for the local Kuantan Singingi rice at 300 Gy. This variation in effective dose requirements can be attributed to the differing levels of genetic resistance to radiation among the plant varieties. Following the determination of the effective dose in the field, the researcher advanced to the cultivation phase, where the radiation-induced symptoms became evident.

In light of these observations, the author is motivated to undertake research aimed at eliciting the desired phenotypic responses in local Kuantan Singingi rice plants as a result of gamma ray exposure.

2. MATERIAL AND METHODS

This research was conducted from November 2023 to April 2024. The research location was in the rain-fed rice fields of Pebaun Hulu Village. Kuantan Mudik District, Kuantan Singingi Regency (Figure 1).

The materials used in this study were rice seeds from gamma ray radiation with an effective dose of 300 Gy (effective dose from the previous research stage) and a dose of 0 Gy (control/without radiation as a comparison) of the Singgam Putih genotype. Manure, NPK fertilizer, herbicides, insecticides. While the tools used were Inseknet, harva net (for fences), barbed wire, handspayer, nails, hammers, plows, hoes, ropes, meters, labels, scissors, and other stationery as well as supporting agricultural inputs.

Figure 1. The coordinates of Pebaun Hulu Village, Kuantan Mudik District, Kuantan Singingi Regency

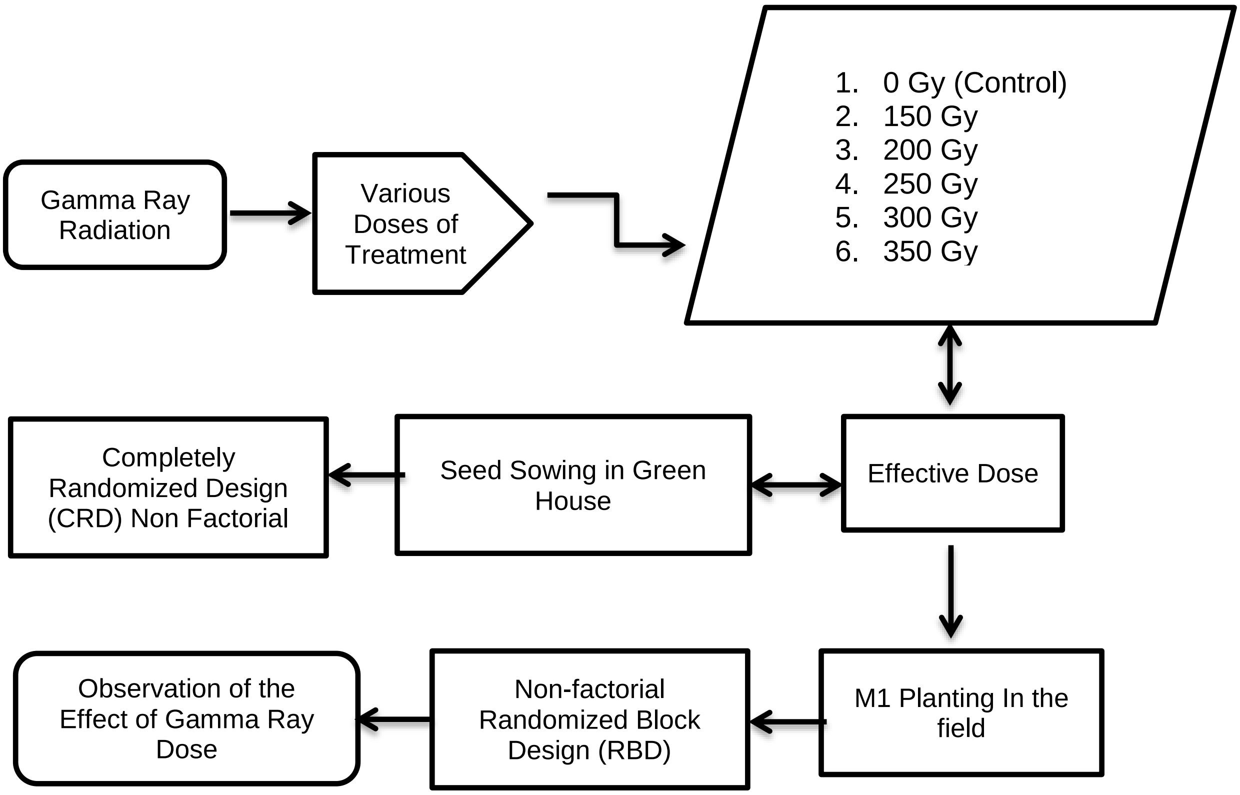

Figure 2. Research Flow Diagram

The methodology employed in this investigation was a non-factorial Randomized Block Design (RBD). The experimental factors included a dose of 300 Gy, derived from prior research findings, and a control group receiving 0 Gy for comparative analysis. The experiment was conducted over five iterations, encompassing a total of 200 seedlings, resulting in 1000 seedlings per treatment condition (see Figure 1).

Observation:

1. Plant height is measured every 2 weeks, starting from when the plant is 2 weeks old until the first flower appears. Measurement is conducted from the base of the stem to the tip of the longest leaf.

2. The number of productive tillers is observed by counting the number of productive tillers indicated by the presence of flowering panicles.

3. Stem circumference is measured using a caliper.

4. Harvest age is calculated by counting the number of days required for the plant to flower, mature, and reach the harvestable stage.

5. The length of the flag leaf is measured on the leaf closest to the rice panicle. Measurement is carried out with a ruler, measuring from the base of the leaf to the tip of the leaf..

The observation data were analyzed using analysis of variance with an F test. If the treatment F test is greater than the F table at 5%, it is followed by the Honest Significant Difference (HSD) test. Data analysis was conducted using MS Excel and the STAR (Statistical Tool for Agricultural Research) software, version 2.0.

3. RESULTS AND DISCUSSION

3.1 Plant Height (cm)

Data from observations of the height of local Kuantan Singingi rice plants are presented in Table 1. The results of the analysis of variance show that the use of radiation on local Kuantan Singingi rice plants has no significant effect on Plant Height.

Table 1. Response of Growth Character and Production of Local Kuantan Singingi Rice to Gamma Ray Radiation Results at Mutant Stage 1 in the Field

Irradiation Dose (Gy)	Plant Height (cm)	Number of Productive Offshoots (Stem)	Stem Diameter (cm)	Harvest Age (Days)	Flag Leaf Length (cm)
0	138,00±771,25	6,40±14,35	0,70±0,06 b	103,00±966,25	78,00±85,00 a
300	127,00±771,25	13,00±14,35	1,20±0,06 a	110,00±966,25	66,00±85,00 b
KK	1, 53	0,99	0,16	1,91	0,69

Notes: Numbers in the same column followed by the same letter are not significantly different in the 5% F Test.

The results of the 5% f test in Table 1. Table 1 show that the highest average plant growth at an irradiation dose of 0 Gy, which is 138.00 cm high, is not significantly different from the 300 Gy dose, which is 127.00 cm high. This is thought to be because the genotype response will be different and show a different appearance after interacting with the environment and the cultivation techniques used. In line with the opinion of (Boceng et al., 2017), it shows that the best plants at a radiation dose of 300 Gray are not significantly different from 200 Gray but are significantly different from 0 Gray.

Tumanggor et al., (2022) said that the lowest rice plant height was in the G4 treatment (111.72 cm) because gamma ray irradiation can inhibit the growth of rice plants, as well as in local Kuantan Singingi rice plants (Figure 4).

3.2 Number of productive shoots (Stems)

The data from the observation of the number of productive tillers of rice plants and its variance, as shown in Table 1, indicates that the use of gamma radiation on local rice plants of Kuantan Singingi does not have a significant effect on the number of productive tillers. The results of the 5% F-test in Table 1 explain that the treatment with a radiation dose of 300 Gy resulted in the highest number of tillers at 13.00, whereas the treatment with a radiation dose of 0 Gy produced only 6.40 tillers. The number of productive tillers increased compared to the control, which is suspected to be related to the improved productivity of the rice plants associated with the quantity of productive tillers (Figure 3).

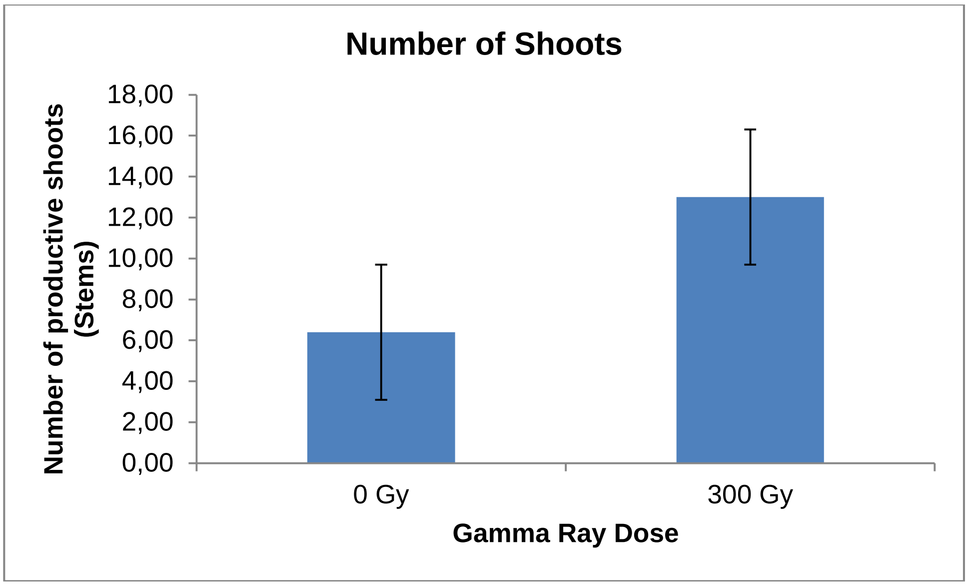

Figure 3. The effect of gamma ray irradiation dose on the number of local rice tillers of Kuantan Singingi Singgam Putih genotype

The availability of nutrients will influence the plant's ability to form productive tillers, along with the genetic factors of the plants themselves. According to Rahayu et al. (2020), the average number of productive tillers in both varieties was less than 10, thus categorizing them as few, except for the Mira-1 variety at a dose of 0 Gy, which had an average of 11.25 productive tillers.

Regarding the 300 Gy dosage in the treatment of the local rice genotype Kuantan Singingi, this represents an effective dosage; therefore, increasing the dosage further will result in a decrease in the number of productive tillers. In line with the opinion of Tumanggor et al. (2022), it is also explained that with each treatment of gamma ray irradiation dosage, there is a decline in the number of productive tillers in rice plants.

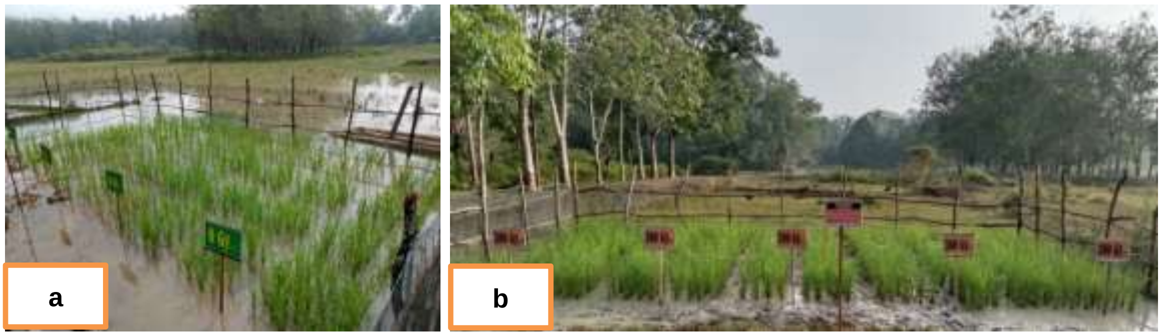

Figure 4. Height of rice plants at 30 DAT in the 0 Gy treatment (a), and in the 300 Gy treatment (b).

3.3 Stem Diameter (cm)

The circumference of the local Kuantan Singingi rice stem has increased compared to the control plants. The average circumference in table. 1 can be seen that the plants that underwent the stem circumference treatment were 1.20 cm, while the control plants had a stem circumference of 0.70 cm. This is suspected that the gamma irradiation treatment was able to change the shape of the rice stem to be larger.

According to the opinion of (Mailala et al., 2016), it shows that gamma ray irradiation treatment of upland rice plants can affect the phenotype of upland rice plants.

The stem circumference greatly affects the resistance of rice plants to wind blows in the field. If the stem is small, while the fruit and leaves are abundant, it will be easier to break or fall. In line with the opinion of (Tumanggor et al., 2022), that gamma ray irradiation can inhibit the growth of plant height so that it will form shorter stems and enlarge the rice stem circumference.

Another opinion also states (Sholikhah et al., 2024) that gamma ray irradiation treatment on rice plant growth can increase enzyme activity, so that the formation of stem rings in irradiated rice will be greater when compared to without irradiation.

3.4 Harvest Age (day)

Observations of the harvest age of local Kuantan Singingi rice show a faster/shorter harvest age presented in table .1. Where the irradiated rice plants require longer days to be harvested, namely 110.00 (dap) at a dose of 300 Gy. When compared to plants without 0 Gy treatment, it is 103.00 (dap). This is suspected that rice at a dose of 300 Gy experiences a lot of emptiness which results in a longer harvest, because empty seeds are unable to absorb sunlight properly. (Figure 5)

Harvest age requires great attention, because in optimizing the frequency of land use. In assembling early maturing varieties and short plants, planting frequency can be increased.

Kadir et al., (2022) said that the harvest age of the mutant genotype ranged from 100.7-102.0 dap, while the IR-64 and Situ Bagendit varieties were 107.0 and 110 dap, respectively. In line with the opinion of (Tumanggor et al., 2022), the fastest harvest age was in the G4 treatment (123.96 days) and said that radiation mutation can have an effect on the harvest age, making the plants more precocious.

Figure 5. Morphological form of local Kuantan Singingi rice panicles irradiated with gamma rays (a), and the number of full grains obtained in one panicle (b).

3.5 Flag Leaf Length (cm)

The results of the analysis of variance demonstrated that the impact of gamma ray irradiation treatment had a statistically significant effect on the length of the flag leaf. The mean length of the flag leaf is presented in the table 1. The flag leaf exerts a profound influence on rice harvest yields. The flag leaf is capable of supplying photosynthate, which is directly related to the rice panicle.

Table 1 states that local Kuantan Singingi rice resulting from gamma ray irradiation gets a short flag leaf length at a dose of 300 Gy, namely 66.00 cm. While rice plants without 0 Gy radiation have a flag leaf length of 78.00 cm.

In addition, the flag leaf also plays a role as a producer of assimilates during the seed cooking process. Mardiyah et al., (2022) said that the results of observations of the length of the flag leaf due to gamma ray irradiation treatment provide an illustration that there is no significant difference in the morphological characteristics of upland rice plants of the Aarias kuning cultivar that are irradiated and without irradiation, but the value is close to the idiotype.

Based on research (Saputra et al., 2021) shows that the shortest flag leaf length is in the K4 treatment (30.80 cm) and the longest is in the K2 treatment (33.80 cm), the flag leaf is very directly related to the formation of the crown structure.

The flag leaf on the M2 black rice mutant was stated to be shorter only at a length of 27.33 cm (Mirantika et al., 2023).

4. CONCLUSION

The findings of the study indicated that the observations of plant height, the number of productive tillers, and the harvest age exhibited no statistically significant differences between the treatment and the control groups. The observations of stem circles and flag leaf length exhibited a statistically significant difference from the treatment. Plants treated with a dose of 300 Gy demonstrated a larger stem circle than those not subjected to treatment. The observation of flag leaf length in rice plants with a dose of 300 Gy revealed a reduction in flag leaf length compared to the control group.

REFERENCES

Afdila, D., Ezward, C., & Haitami, A. (2021). Karakterisasi tinggi tanaman, umur panen, jumlah anakkan, dan berat panen pada 12 genotipe padi lokal Kabupaten Kuantan Singingi. *Sain Agro, 6*(1), 1–9. http://www.tjyybjb.ac.cn/CN/article/downloadArticleFile.do?attachType=PDF&id=9987

Badan Pusat Statistik. (2023). Luas panen dan produksi padi di Indonesia 2023 (angka sementara). *Badan Pusat Statistik, 2023*(68), 1–8. https://www.bps.go.id/pressrelease/2023/10/16/2037/luas-panen-dan-produksi-padi-di-indonesia-2023--angka-sementara-.html#:~:text=Produksi beras pada 2023 untuk,sebesar 31%2C54 juta ton.

Boceng, A., Haris, A., & Tjoneng, A. (2017). Karakter mutan padi lokal Ase Banda hasil iradiasi sinar gamma. *Agrokompleks, 16*(1), 42–45.

BPS Riau. (2022). Luas panen dan produksi padi di Provinsi Riau 2022 (angka sementara). *BPS, 2023*(21), 1–20.

Ezward, C., Indrawanis, E., Haitami, A., & Wahyudi. (2020). Penampakan karakter agronomi pada 26 genotipe padi lokal Kabupaten Kuantan Singingi. *Sain Agroo, 5*(2).

Ezward, C., Suliansyah, I., Rozen, N., & Dwipa, I. (2022). Resistance of local rice genotypes against brown planthopper pest in Kuantan Singingi Regency. *Juatika, 4*(1), 166–176.

Kadir, A., Jahuddin, R., Pratama, T., & Halim, N. (2022). Penampilan genotipe mutan padi gogo hasil iradiasi sinar gamma di lahan sawah pada musim tanaman kering. *Agroecotech*.

Mailala, J. H., Basuki, N., & Seogianto, A. (2016). Pengaruh iradiasi sinar gamma terhadap perubahan fenotipik tanaman padi gogo (*Oryza sativa* L.). *Jurnal Produksi Tanaman, 4*(7), 585–594.

Mardiyah, A., Wandira, A., & Syahril, M. (2022). Viabilitas dan heritabilitas populasi padi gogo kultivar Aarias Kuning generasi mutan-1 hasil iradiasi sinar gamma. *Inovasi Penelitian, 3*(2), 4827–4838.

Marlina, G., Andriani, D., Jayalaksamana, M., & Pramana, A. (2023). Potensi keragaman sumber daya genetik padi lokal di Kabupaten Kuantan

Singingi, Provinsi Riau. *Pangan, 32*(2), 103–110.

Marlina, G., Syarif, A., Gustian, & Yusniwati. (2023). Tren penelitian pemuliaan mutasi pada tanaman padi: Analisis bibliometrik. *Agrotekma Jurnal Agroteknologi dan Ilmu Pertanian, 7*(2), 94–104. https://doi.org/10.31289/agr.v7i2.9716

Marlina, G., Syarif, A., Gustian, & Yusniwati. (2024). Orientation of effective irradiation dosage in local genetic rice improvement (*Oryza sativa* L.) Kuantan Singingi District using induced mutation. *Juatika, 6*(1).

Mirantika, D., Nurhidayah, S., Nasrudin, N., & Rahayu, S. (2023). Pendugaan keragaman genetik dan heritabilitas mutan padi hitam (*Oryza sativa* L.) generasi M2 hasil iradiasi sinar gamma. *Jurnal Agroteknologi, 13*(2), 91. https://doi.org/10.24014/ja.v13i2.21439

Rahayu, S., V, D., & Dasumiati. (2020). Keragaan malai mutan padi generasi M1 hasil iradiasi gamma. *Jurnal Ilmiah Aplikasi Isotop dan Radiasi, 16*(2).

Saputra, J., Syahril, M., & Murdhiani. (2021). Keragaan dan keragaman antar populasi padi kultivar Sileso generasi mutan-1 hasil iradiasi sinar gamma pada fase vegetatif. *Agrosamudra, 8*(1), 34–40.

Sari, H. P., Suliansyah, I., Dwipa, I., & Hervani, D. (2023). Orientasi dosis iradiasi efektif pada perbaikan genetik padi (*Oryza sativa* L.) lokal Padang Pariaman melalui mutasi induksi. *Jurnal Produksi Tanaman, 11*(6), 408–421.

Sholikhah, N., Amalia, T. C. N., Febrianty, W., Sabila, S. R. B., Anggraini, M. A. S., Prihandono, T., & Mahmud, K. (2024). Potensi penggunaan radiasi sinar gamma pada pertumbuhan tanaman padi. *OPTIKA: Jurnal Pendidikan Fisika, 8*(1), 36–46. https://doi.org/10.37478/optika.v8i1.3427

Tumanggor, G. E., Iswahyudi, & Mardiyah, A. (2022). Pertumbuhan, produksi dan karakter genetik padi kultivar Sileso generasi M-2 hasil iradiasi sinar gamma. *Jurnal Penelitian Agrosamudra, 9*(2), 31–40. https://doi.org/10.33059/jupas.v9i2.6519