JUATIKA
JURNAL AGRONOMI TANAMAN TROPIKA
VOL. 7 NO. 2 May 2025

DOI :https://doi.org/10.36378/juatika.v7i2.4775
eissn 2656-1727
pissn 2684-785X
pages : 671 – 674

RESEARCH ARTICLE Open Access

The Effect of Gamma Ray Radiation on the Growth of Local Rice Plants (*Oryza sativa* L.) Silumat Variety

Danu Lasmana[1,*], Siti Hartati Yusida Saragih[1], Ika Ayu Putri Septyani[1], Yusmaidar Sepriani[1]

Abstract

Rice is a staple food and a primary ingredient for many communities. The available rice supply is expected to meet the growing demand. This study aims to investigate the effects of gamma-ray radiation on the growth of rice plants of the Silumat variety and to determine the optimal gamma-ray radiation dose for their growth. The research employs an experimental method using a non-factorial Randomized Block Design (RBD) with 10 treatment levels: R0 = Control (No Radiation), and radiation doses of 50, 100, 150, 200, 250, 300, 350, 400, and 450 Grey. The results showed that gamma radiation significantly affected the viability, plant height, and number of tillers in the local rice variety Silumat (*Oryza sativa* L.). Low doses, particularly 50 Gy and 100 Gy, exhibited a stimulating effect (hormesis), enhancing germination, plant height, and tillering. In contrast, higher doses (>150 Gy) tended to reduce all parameters due to physiological and genetic damage. This study provides specific information on the optimal gamma radiation dose range to stimulate the growth of the Silumat variety, which can serve as a reference for plant breeding programs based on induction treatment.

Keywords: Gamma Radiation, Local Rice, Mutation, Plant Growth, Silumat Variety

1. Introduction

Rice (*Oryza sativa* L.) is a cereal plant belonging to the genus Oryza, which is part of the Poaceae (Gramineae) family. It serves as a staple food for nearly 40% of the world's population and is especially important in Southeast Asia. In Indonesia, rice is a key commodity and the primary staple food. As the main staple, rice availability must keep pace with the growing needs of Indonesia's population, which was 237 million in 2010, making it the world's fourth most populous country. With an annual population growth rate of 1.5%, the government must continually strive to meet the increasing demand for rice, Indonesia's primary staple food (Carolina, 2010).

Rice is a strategic food crop in Indonesia, supplying 80% of the population's carbohydrate needs. Stable and high-quality rice production is essential to achieving food security. Therefore, the development of superior rice varieties, such as Silumat, is crucial. The Silumat variety is one of the superior rice strains developed by the Center for Rice Research and Development (BBPPT) in Indonesia.

Farmers are always seeking rice varieties that offer high yields and early maturity. In developing superior new varieties, germplasm is expected not only to adapt well to the growing environment but also to produce high yields. Using wild rice and local rice as parent lines to develop new rice types is anticipated to result in improved morphological and physiological traits, such as fewer empty grains, leading to higher production yields, reduced grain loss, and increased resistance to major pests and diseases (Singh et al., 2017).

So far, rice cultivation has primarily focused on paddy fields or flooded land, while dry land has received little attention. However, if the potential of dry land were optimally utilized for rice cultivation, the area under rice cultivation would increase, leading to higher national rice production (Rice, 2024) The development of rice, especially varieties grown in dry fields, has been challenging due to the limited availability of rice varieties adapted to dry conditions and the generally low productivity of such lands. Additionally, dry climatic conditions further hinder the progress of rice production in local agriculture.

Several factors influence the growth and productivity of rice plants, including the main internal factors, such as

*Correspondence: danulasmana88@gmail.com
1) Universitas Labuhanbatu - Jl Sisingamangaraja No. 126-A, KM. 3,5, Aek Tapa, Rantauprapat, Kabupaten Labuhanbatu, Sumatera Utara 21415, Indonesia

enzymes and hormones, which are low-concentration organic compounds that can be biologically active in living things. The main external factors are sunlight intensity, humidity, and water availability.

Currently, the development of gamma irradiation technology for increasing agricultural crop productivity is growing rapidly. The use of appropriate irradiation technology can yield optimal results, which are expected to be beneficial for human welfare. According to Haris (2016), the term Gamma ray radiation refers to high-energy electromagnetic radiation produced by energy transitions resulting from electron acceleration. The effects of gamma ray radiation can cause genetic changes in somatic cells (somatic mutations) that can be inherited and can cause phenotypic changes. In general, it appears that gamma ray irradiation with doses of 10,000 rad (100 Gy), 20,000 rad (200 Gy), and 30,000 rad (300 Gy) causes many mutations in rice plants.

The effects of gamma ray irradiation depend on the irradiation dose, exposure time and the amount of substance exposed to gamma ray irradiation. By combining these factors, we can identify the optimal combination that can be applied to enhance the quality of a specific product.

This study aimed to determine the effect of gamma ray radiation on the growth of silumat variety rice plants and to determine the optimal dose of gamma ray radiation for the growth of silumat variety rice plants.

2. Material and Methods

2.1. Place and time of research

The research was conducted at the Irradiation and Instrumentation Laboratory, Jalan Lebak Bulus Raya, Jakarta and Aek Hitoras Village, Hamlet (nine), Marbau District, North Labuhan Batu Regency, North Sumatra Province 2°15′38.5711″N 99°49′38.7563″E, 26.89 meters above sea level. The research was conducted from January to June 2025.

2.2. Materials and tools

The materials used in this study were rice seeds of the Silumat variety, black soil and compost. The tools used in this research were a 4000 A gamma chamber, polybags, digital scales, meters, stationery and cameras.

2.3. Research methods

The research method used is an experimental method using a non-factorial Randomized Block Design (RAK) consisting of 10 levels, namely R0 = Control (No Radiation), 50 Gray Radiation, 100 Gray Radiation, 150 Gray Radiation, 200 Gray Radiation, 250 Gray Radiation, 300 Gray Radiation, 350 Gray Radiation, 400 Gray Radiation, 450 Gray Radiation.

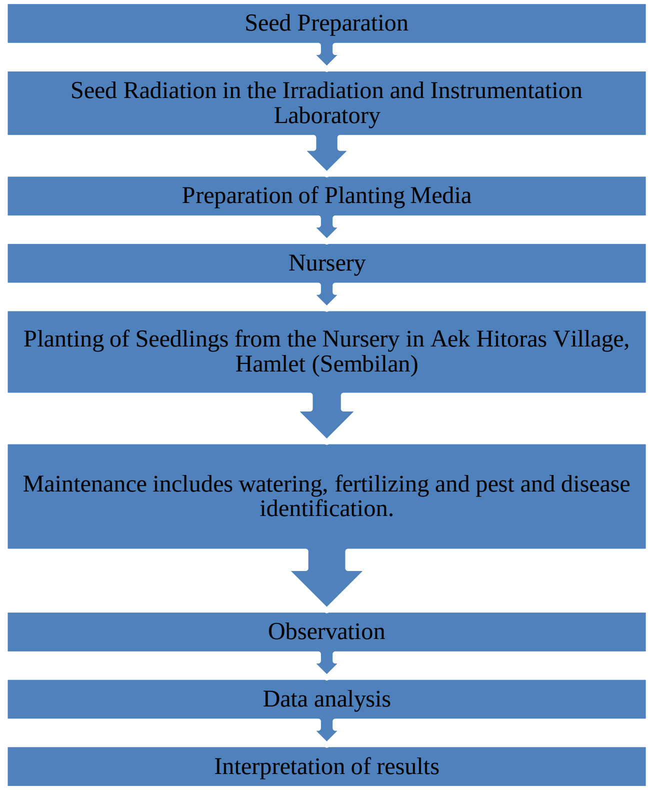

Figure 1. Research flow diagram

2.4. Observation Parameters

1. Germination power
2. Plant height
3. Number of offspring

2.5. Data analysis

The data obtained will be analyzed using analysis of variance (ANOVA) to determine differences between the treatments. If significant differences are found, further testing will be conducted using the DMRT test using SPSS version 25 software.

3. Results and Discussion

3.1. Germination Power

Based on field observations and analysis of germination power in the growth of local rice seeds of the Silumat variety, the results are presented in Figure 2. Based on observation data, it can be seen that the germination power of local rice seeds (*Oryza sativa* L.) of the Silumat variety decreased as the dose of gamma radiation increased. In the non-irradiation treatment (0 Gy), germination rate reached 100%, indicating optimal seed viability. Low doses of radiation, such as 50 Gy and 100 Gy, still maintained a relatively high germination rate of 95% and 90%, respectively. However, at medium to high doses (150–450 Gy), germination rate decreased significantly, with the lowest value being 48% at 450 Gy. This pattern indicates an adverse effect of gamma radiation on seed germination, with higher doses causing physiological and genetic damage that inhibits germination.

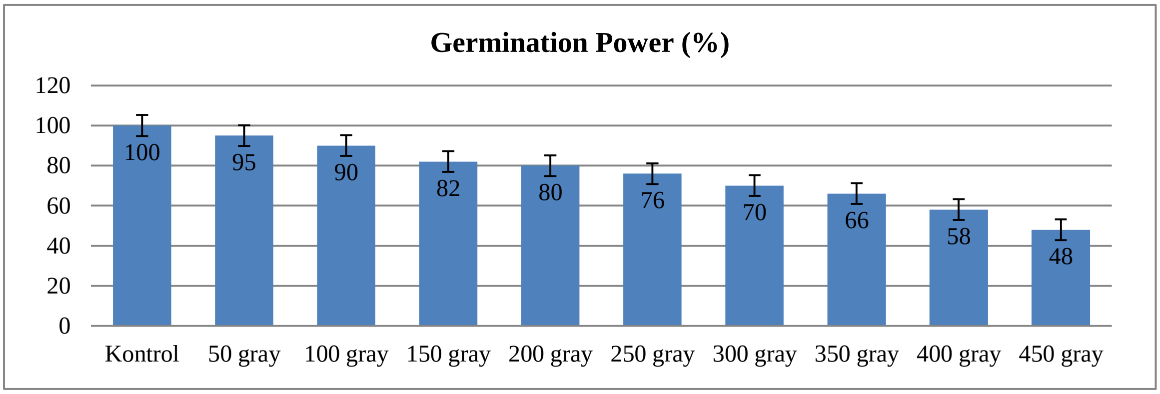

Figure 2. Results of the Germination Power of Local Rice Seeds of the Silumat Variety

3.2. Plant height

Based on field observations and data analysis, the height of local rice plants, the Silumat variety, is presented in Table 1. Based on the results of observations of the height of local rice plants (*Oryza sativa* L.) of the Silumat variety at the ages of 2, 4, 6, and 8 WAP, it is clear that the administration of gamma radiation has a significant effect on plant growth. Low-dose treatments, especially 50 Gy and 100 Gy, showed the highest growth in each observation phase, with maximum values at 100 Gy (13.3 cm, 28.8 cm, 43.9 cm, 59.4 cm), indicating a stimulating effect (hormesis) on vegetative growth.

Table 1. High Yield of Local Rice Plants of the Silumat Variety

Treatment	Plant Height			
	2 MST	4 MST	6 MST	8 MST
Control	12.3±0.14f	26.4±0.23f	40.5±0.28f	55.5±0.28f
50 gray	12.9±0.20g	27.9±0.23g	42.5±0.28g	58±0.23g
100 gray	13.3±0.14g	28.8±0.14h	43.9±0.20h	59.4±0.23h
150 gray	13±0.11g	27.8±0.14g	42.8±0.14g	58±0.11g
200 gray	12.2±0.14f	26.5±0.17f	40.6±0.23f	55.5±0.17f
250 gray	11.5±0.17e	24.8±0.14e	38.1±0.20e	52.2±0.14e
300 gray	10.5±0.17d	23±0.11d	35.6±0.23d	48.8±0.14d
350 gray	9.5±0.17c	21.2±0.08c	33.5±0.17c	45.2±0.14c
400 gray	8.5±0.17b	19.5±0.17b	30.8±0.14b	41.8±0.14b
450 gray	7.2±0.14a	17.5±0.17a	28.2±0.14a	38.2±0.14a

Description: Numbers followed by the same letter in the same factor column are not significantly different in the Duncan's distance test at level A=5% with 10 treatments and three replications.

Conversely, increasing radiation doses above 150 Gy caused a gradual decrease in plant height, with the lowest value observed at a dose of 450 Gy (7.2 cm, 17.5 cm, 28.2 cm, 38.2 cm), indicating a significant inhibitory effect. This pattern confirms that gamma radiation at low doses can stimulate growth, but at high doses it is damaging to plant tissue, thus inhibiting the development of plant height. This study is in line with (Dash & Kujur, 2024) which showed that low doses of gamma radiation (around 50–100 Gy) increased chlorophyll, flavonoid, and phenolic content compared to the control; while higher doses caused growth reduction and physiological imbalances—chlorophyll increased at 50–100 Gy, but decreased at 150–200 Gy. However, this study differs from Choi et al. (2021), which found that even low doses (100 Gy) caused DNA damage and oxidative stress, especially with long-term exposure. The leading causes of growth inhibition were decreased photosynthetic efficiency and the accumulation of free radicals.

3.3. Number of Offspring

Based on field observations and data analysis of the growth of local rice plants of the Silumat variety, the results are presented in Table 2. Based on the results of observations of the number of tillers of local rice (*Oryza sativa* L.) of the Silumat variety at 2, 4, 6, and 8 WAP, it was seen that gamma radiation significantly affected tiller formation. Low doses, especially 50 Gy and 100 Gy, produced the highest number of tillers in all growth phases, with a maximum value at 100 Gy (3.3; 6; 12; 17.3 tillers), indicating a stimulatory effect on tiller formation. Conversely, increasing the dose above 150 Gy gradually decreased the number of tillers, and at very high doses (450 Gy), the number of tillers became the least at each observation stage (1; 1; 3; 6 tillers).

This pattern indicates that low doses of gamma radiation can stimulate vegetative growth by increasing tiller formation, while high doses tend to damage meristem tissue and thus inhibit tiller development. This study aligns with Abdelnour-Esquivel et al. (2020), who demonstrated that low doses of gamma radiation can stimulate growth through callus induction, an analogy of tillering stimulation. A different study (Wahyudi & Indrawanis, 2025) found that radiation had no significant effect on the number of tillers. Although a 200 Gy dose slightly increased tiller number compared to the control and 100 Gy doses, this was not statistically significant. This result contrasts with low doses, which do stimulate tiller formation.

Table 2. Results of the Number of Tillers of Local Rice Plants of the Silumat Variety

Treatment	Number of offspring			
	2 MST	**4 MST**	**6 MST**	**8 MST**
Control	2.3±0.33c	4.3±0.33d	9.3±0.33f	14.3±0.33f
50 gray	3±0.33d	5.3±0.33d	11.3±0.33g	16.3±0.33g
100 gray	3.3±0.33d	6±0.33d	12±0.33h	17.3±0.33h
150 gray	3±0.33d	5.3±0.57d	11±0.33g	16±0.33g
200 gray	2±0.33c	4.3±0.33d	9.3±0.33f	14.3±0.33f
250 gray	2±0.33c	3.7±0.33c	8±0.33e	12.3±0.33e
300 gray	1.7±0.33c	3±0.33b	6.3±0.33d	10.3±0.33d
350 gray	1.3±0.33b	2.3±0.57b	5±0.33c	8.3±0.33c
400 gray	1±0.33a	1.7±0.33b	4±0.33b	7±0.33b
450 gray	1±0.33a	1±1.00a	3±0.33a	6±0.33a

Description: Numbers followed by the same letter in the same factor column are not significantly different in the Duncan's distance test at level A=5% with 10 treatments and three replications.

Figure 2. Research documentation

4. Conclusion

This study demonstrates that gamma radiation has a significant influence on the viability, plant height, and number of tillers in local rice (*Oryza sativa* L.) of the Silumat variety. Low doses, particularly 50 Gy and 100 Gy, exhibit a stimulating effect (hormesis) that enhances germination, plant height growth, and tiller formation. In contrast, higher doses (>150 Gy) tend to reduce all these parameters due to physiological and genetic damage. The findings provide specific information on the optimal gamma radiation dose range to stimulate the growth of the Silumat variety, which can serve as a reference for plant breeding programs based on induced mutations.

References

Abdelnour-Esquivel, A., Perez, J., Rojas, M., Vargas, W., & Gatica-Arias, A. (2020). Use of gamma radiation to induce mutations in rice (*Oryza sativa* L.) and the selection of lines with tolerance to salinity and drought. *In Vitro Cellular & Developmental Biology - Plant, 56*(1), 88–97. https://doi.org/10.1007/s11627-019-10015-5

Choi, H. I., Han, S. M., Jo, Y. D., Hong, M. J., Kim, S. H., & Kim, J. B. (2021). Effects of acute and chronic gamma irradiation on the cell biology and physiology of rice plants. *Plants, 10*(3), 1–14. https://doi.org/10.3390/plants10030439

Dash, S., & Kujur, M. (2024). Impact of gamma irradiation on biochemical and physiological characteristics of black rice. *Current Agriculture Research Journal, 11*(3), 813–825. https://doi.org/10.12944/carj.11.3.12

Haris, J., Meliala, S., Basuki, N., & Seogianto, A. (2016). The effect of gamma irradiation on phenotypic changes in upland rice plants (*Oryza sativa* L.). *Jurnal Produksi Tanaman, 4*(7), 585–594.

Carolina, Y., & Salsinha, F. (2010). Pengaruh iradiasi sinar γ (gamma) Co-60 terhadap pertumbuhan padi. *Prosiding Seminar Nasional Pertanian*, 1(1), 1–7.

Rice, W. (2024). Dosis iradiasi sinar gamma terhadap pertumbuhan padi Mentik Wangi generasi M7 [Dosage of gamma ray irradiation on the growth of M7 generation Mentik]. *Jurnal Ilmu Pertanian, 21*(2), 171–177.

Singh, R. K., Singh, U. S., & Kush, G. S. (2017). Keanekaragaman hayati: Pemanfaatan plasma nutfah padi varietas lokal dalam perakitan varietas unggul. Retrieved April 20, 2025, from https://mukariagriculture.blogspot.com/2017/04/v-behaviorurldefaultvmlo.html

Wahyudi, & Indrawanis, E. (2025). Response of total number of tillers, plant height, and dry straw weight of Jangguik rice genotypes (*Oryza sativa*) with gamma ray irradiation treatment. *Jurnal Agronomi Tanaman Tropika (JUATIKA), 7*(1). https://doi.org/10.36378/juatika.v7i1.4126