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Mutation Strategy of Gamma Ray Irradiation for Increasing the Growth of Rose Tomato Plants (*Solanum lycopersicum* var. Rose)

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ABSTRACT

Rose tomatoes, scientifically known as *Solanum lycopersicum* var. Roses are a type of tomato characterized by its small, vibrant red fruits. Gamma rays, a form of electromagnetic radiation with a very short wavelength and high energy, can cause plant mutations, leading to genetic variations that could potentially enhance the quality and quantity of crops. This study aimed to investigate the impact of gamma-ray irradiation on the growth of rose tomatoes. The research was conducted at the Irradiation and Instrumentation Laboratory on Jalan Lebak Bulus Raya, Jakarta, and the Green House of Labuhanbatu University, Rantauprapat City, Labuhanbatu Regency, North Sumatra Province. The experiment took place from December 2023 to March 2024. utilizing a single factor Completely Randomized Design with 4 levels and 5 replications, precisely gamma-ray radiation doses of 0 Gy, 100 Gy, 200 Gy, and 300 Gy. The findings revealed that the highest germination parameters were observed at a dose of 300 Gy, while the control treatment exhibited the lowest germination. However, the gamma irradiation treatment did not significantly impact plant height and the number of leaves.

Keywords: *Gamma Rays, Genetic Variation, Mutation, Rose Tomato, Rose Tomato Growth*

1. INTRODUCTION

Rose tomatoes (*Solanum lycopersicum* var. rose) are a variety of tomatoes known for their rose-petal-like shape. Their bright red color and small size make them an attractive choice for culinary purposes, both as a garnish and as a main ingredient in salads and other dishes. Rose tomatoes (*Solanum lycopersicum* var. rose) have a sweet, slightly sour taste, making them a favorite among tomato lovers. In addition, these tomatoes are rich in nutrients such as vitamin C, vitamin A, and lycopene, which are beneficial for body health.(Sri et al., 2022).

Rose tomatoes, scientifically known as *Solanum lycopersicum* var. rose, are classified under the *Solanum lycopersicum* species and exhibit growth characteristics akin to other tomato cultivars. These plants thrive in regions with warm climates and necessitate meticulous attention to yield optimal fruit production. Adequate lighting, consistent watering, and appropriate fertilization are essential for rose tomato plants' healthy growth and maturation. Furthermore, disease and pest resistance play a crucial role in cultivating rose tomatoes, underscoring the importance of selecting disease-resistant varieties for cultivation (Nur Alfiah et al., 2023) (Gusti, 2019).

Rose tomato varieties (*Solanum lycopersicum* var. rose) often exhibit limited genetic diversity, leading to reduced disease resistance, suboptimal productivity, inconsistent fruit quality, and limited adaptability to environmental changes. To address these shortcomings, gamma ray treatment induces mutations and increases genetic diversity, ultimately enhancing disease resistance, productivity, fruit quality, and plant adaptability. Gamma rays can induce mutations in plant DNA, resulting in new genetic variations that were not present in the original population. These mutations can give rise to favorable traits such as heightened disease resistance, increased yield, and improved ability to adapt to changing environmental conditions. Consequently, gamma rays represent an effective strategy in the breeding program for rose tomato varieties, aimed at fortifying the genetic foundation and enhancing plant quality (Yanti & Rasyad, 2020).

Gamma rays are a form of electromagnetic radiation with a very short wavelength and very high energy. These rays are usually produced from nuclides' radioactive decay or other nuclear reactions (Insani & Anwar, 2022). Because of their high energy, gamma rays have the potential to cause ionization, which means they can damage molecules in cells, including DNA (Haris et al., 2016).

Studies conducted on the effects of gamma-ray treatments on growth have yielded intriguing findings. Specifically, research on eggplant has demonstrated that exposure to gamma rays can increase genetic variation, ultimately resulting in improved fruit quality and higher yields. Notably, a dosage of 300 Gy has been identified as the most effective in promoting vigor and germination rates (Cardellicchio et al., 2023). It is well-established that gamma rays can induce mutations in plants, thereby contributing to genetic diversity that has the potential to enhance crop quality and quantity. Furthermore, in the case of rose tomatoes, gamma ray treatment at specific dosages has been found to elevate germination rates and early plant growth. In particular, higher doses, such as 300 Gy, have been associated with optimal germination rates and increased plant vigor during the initial stages of growth (Manurung & Gultom, 2018).

Based on the issues mentioned earlier, the researcher will study gamma radiation's effects on the growth of rose-variety tomato plants. This research aims to determine the impact of gamma irradiation on the growth of the rose variety tomato (*Solanum lycopersicum* var. rose).

2. MATERIAL AND METHODS

2.1 Research Site and Time

The research was conducted at the Radiation and Instrumentation Laboratory, Jalan Lebak Bulus Raya, Jakarta, with coordinates -6.3075° N, 106.7816° E and the Labuhanbatu University greenhouse with coordinates -2.105° N, 99.8265° E. The research period was from December 2023 to March 2024.

2.2 Tools and Materials

The materials used in this study include plant seeds, black soil, and compost. The tools utilized in this research are a gamma chamber 4000 A, polybags, a digital scale, a measuring tape, writing instruments, and a camera.

Figure 1. 4000 A gamma chamber device

2.3 Research Method

The research method employed is the experimental method using a Completely Randomized Design (CRD) with a single factor (Hasdar et al., 2021), consisting of four treatments: 0. 100. 200. and 300 Gy, with each treatment replicated five times. This results in a total of 20 experiments.

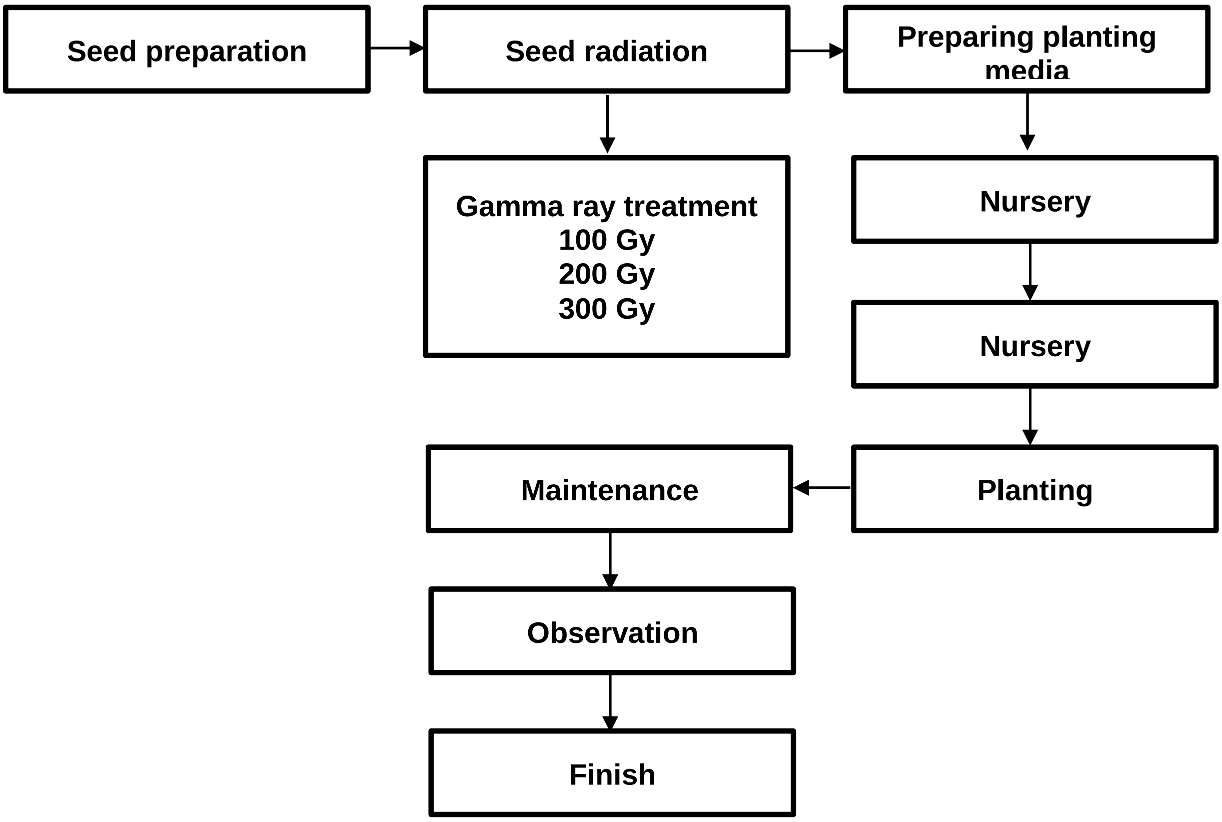

Figure 2. Research flow diagram

2.4 Observation Parameter

The observations observed in this experiment were germination power (%), plant height (cm), and number of leaves (strands).

2.5 Data Analysis

The effect of the treatment was analyzed using Excel with analysis of variance (ANOVA). If the F test results at the 5% significance level indicate a significant difference, further investigation is conducted to determine which treatment yielded the best results (Xie & Yan, 2023). Data analysis proceeds with the Least Significant Difference (LSD) test at the 5% level (Prosky et al., 1984).

3. RESULT AND DISCUSSION

3.1 Germination (%)

The number of seeds that germinated from the total seeds planted in this study can be used to calculate the germination percentage. Figure 2 presents data on the germination percentage of rose tomato plants treated with gamma radiation at doses ranging from 0 to 300 Gy.

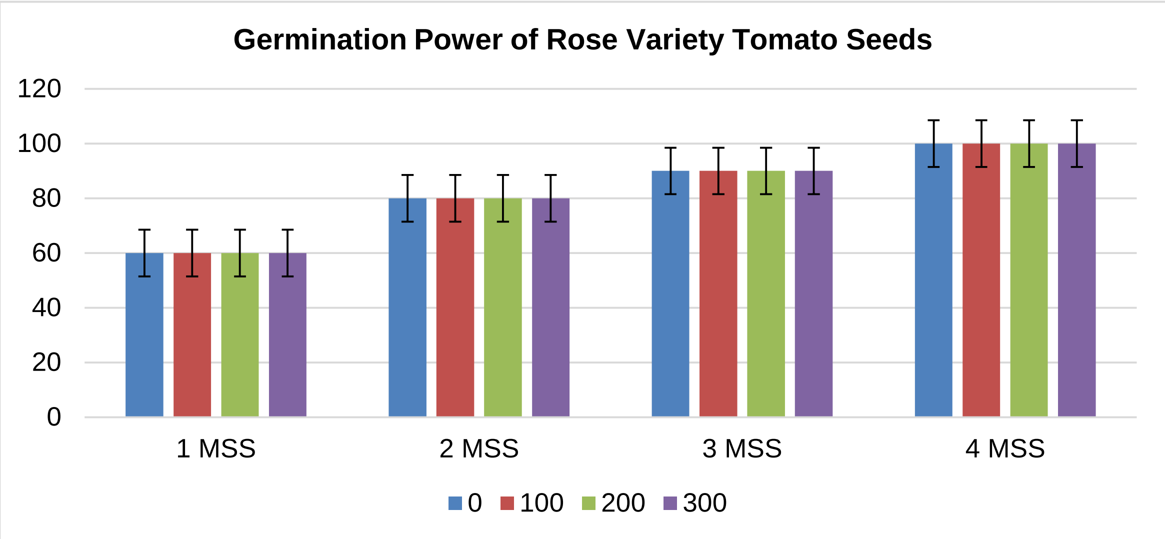

Figure 2. Germination power of rose variety tomato seeds

Based on the information provided in the graph, it is evident that the level of gamma-ray irradiation administered to rose tomato seeds directly impacts the germination rate, displaying a discernible trend. As the dosage of irradiation increases, a corresponding rise in the percentage of successful germination is observed. Nevertheless, escalating the irradiation dosage also heightens the likelihood of detrimental effects on the seeds, such as failed germination or seed mortality, particularly at higher levels like 100 Gy, where only a 60% germination rate is achieved. These findings align with the premise that gamma-ray irradiation can influence the genetic makeup of plants by disrupting chromosomes within genes responsible for hereditary traits, leading to genetic alterations that can influence the characteristics of rose plants as they grow (Oktaviani, 2020). According to Tanasib et al. (2020), this research aligns with the assertion that gamma-ray doses can alter the genetic properties of plants by impacting the structure of chromosomes and genes that control hereditary traits. The genetic variations resulting from irradiation can lead to differences in the characteristics of growing plants, as evidenced by the variation in the germination percentage between doses of 300 Gy and 100 Gy in rose tomato plants in this study. The standard seed germination rate, which typically reaches 85%, indicates optimal conditions for plant germination. However, gamma irradiation can cause an increase or decrease in this percentage, depending on the applied dose. Higher doses, such as 300 Gy, often result in more significant effects on altering genetic characteristics and plant traits compared to a dose of 100 Gy, which may impact germination, early growth, and overall plant vigor.

3.2 Plant Height (Cm)

Based on observations conducted at the greenhouse of Universitas Labuhanbatu, the measured plant height data has been compiled in Table 1.

Based on the study's findings, the statistical analysis conducted using the ANOVA test followed by the BNT test at a significance level of 5% revealed that the dosage of gamma rays administered did not significantly impact the plant height as measured in this research. This suggests that the response of plants to radiation treatment may be influenced by various physiological factors, including the growth stage during treatment administration, the radiation tolerance of the plant variety, and the plant's ability to adapt to radiation-induced stress. While gamma-ray treatment may have a notable effect on other plant characteristics, such as germination or fruit production, the results about plant height demonstrate a degree of variability in the physiological reaction of plants to the radiation treatment administered. The BNT test results indicate that numerical data with the same letter are not statistically different, whereas numerical data without the same letter are statistically different. Smith et al. (2019) also concluded that there were no significant differences in plant growth among different treatments. Conversely, Jones et al. (2020) found significant differences in plant growth among different treatments, suggesting that factors such as plant type, treatment doses, or study environments may have contributed to these variations. The BNT test results confirm no significant difference between treatments and no significant effect between replications.

3.3 Numbers of Leaves (blades)

Based on the observations conducted in the greenhouse of Labuhanbatu University, the data regarding the number of leaves measured has been compiled in Table 2.

Table 1. Average results of plant height and BNT test at 5% level

Dosage	Plant Height (Cm)						
	1 MST	2 MST	3 MST	4 MST	5 MST	6 MST	7 MST
0	8.6±4.7a	14.8±5.2a	14.8±8.9a	60.7±14.3a	77±12.4a	89.6±12.2a	104.4±8.1a
100 Gy	9.6±4.7a	16.5±5.2a	16.5±8.9a	64.5±14.3a	81.4±12.4a	99.2±12.2a	112.4±8.1a
200 Gy	9.4±4.7a	15.7±5.2a	15.7±8.9a	63.7±14.3a	81.4±12.4a	96.6±12.2a	111.2±8.1a
300 Gy	11.9±4.7a	15±5.2a	15±8.9a	59.2±14.3a	76.6±12.4a	93.4±12.2a	107.4±8.1a

Table 2. Average results of the number of leaves and the results of the BNT test at 5% level

Dosage	Numbers of Blade (Leaves)						
	1 MST	2 MST	3 MST	4 MST	5 MST	6 MST	7 MST
0	3±-36.9a	5.2±0.9a	8±1.2a	11.2±1.7a	16.8±2.2a	23±2.8a	29.2±2.8a
100 Gy	3±-36.9a	5.6±0.9a	8±1.2a	11.2±1.7a	16.4±2.2a	21±2.8a	28.2±2.8a
200 Gy	3±-36.9a	6±0.9a	8.4±1.2a	12.8±1.7a	18.6±2.2a	23±2.8a	30±2.8a
300 Gy	3±-36.9a	6±0.9a	8.2±1.2a	12.8±1.7a	19±2.2a	24.2±2.8a	31.8±2.8a

Based on the analysis of variance (ANOVA) for plant height followed by the BNT (Least Significant Difference) test at a significance level of 5%, the number of leaves parameter did not exhibit any significant effect. Data showing numbers followed by the same letter indicate no significant difference between treatments or between replications. This suggests that the genetic condition of the plant may moderate its effect on physiological responses, such as the number of leaves produced. Plant genotype variations can affect plants' ability to respond differently to certain environmental factors or treatments, such as gamma radiation, in this study. Thus, although treatments may potentially alter genetic characteristics, physiological responses to parameters such as the number of leaves may vary depending on the genetic traits and adaptation of the plant to the treatment given. The BNT test confirmed that each treatment had similar results regarding the number of leaves so that no significant variation could be identified. According to Perez et al. (2019), lettuce plants also showed that gamma irradiation did not produce significant differences in leaf development. Differences in methodology and plant species may affect the study's final results. Although there was no significant difference in the number of leaves between treatments, it is essential to consider other factors such as plant genetic factors, growing environment, and the complex interactions between them.

4. CONCLUSION

The study findings indicated that the most favorable germination power outcomes were observed at a radiation dose of 300 Gy, while the control treatment exhibited the least germination power. The application of gamma-ray radiation did not significantly impact plant height and leaf count metrics.

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