DOI :https://doi.org/10.36378/juatika.v6i2.3639
JUATIKA
JURNAL AGRONOMI TANAMAN TROPIKA
VOL. 6 NO. 2 May 2024
eissn 2656-1727
pissn 2684-785X
Hal : 562 – 570

Optimizing Tomato Bareto (*Lycopersicum esculentum* MILL) Varieties Growth and Production Using Gamma Ray Radiation Technology

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ABSTRACT

Research is currently being conducted on the impact of gamma-ray radiation on the growth and productivity of the Bareto tomato variety (*Lycopersicum esculentum* Mill), renowned for its sizable, vibrant red fruits and unique sweet flavor. This study aims to establish the most effective dosage of gamma radiation for promoting seed germination, enhancing plant height, and increasing leaf count. The experiment utilized a non-factorial, completely randomized design involving four treatments (0 Gy, 100 Gy, 200 Gy, and 300 Gy) with five replications. The findings indicated that doses of 200 Gy and 300 Gy led to a significant enhancement in seed germination, demonstrating a consistent improvement in the viability of Bareto tomato seeds. However, the height of the plants displayed a negligible rise at radiation doses of 200 Gy and 300 Gy compared to the control and 100 Gy, suggesting that the impact of radiation dosage on plant height development may not be significant. In contrast, there was a notable increase in the quantity of leaves at dosages of 200 Gy and 300 Gy during observations at 2 and 3 weeks after planting (WAP). This suggests that elevated levels of gamma radiation had a favorable impact on leaf growth.

Keywords: *Barito tomatoes, Gamma Rays, Genetic Variation, Growth of Barito tomatoes, Mutations*

1. INTRODUCTION

Bareto tomato variety (*Lycopersicum esculentum* Mill) is popular for tomato cultivation, particularly in regions with warm to temperate climates. Its large, vibrant red fruits and delightful sweet flavor distinguish this variety. The growth of Barreto tomato plants is typically robust and rapid, often reaching an optimal height for optimal fruit development. Farmers frequently opt for this variety due to its high yield potential and consistent fruit production throughout the growing season. Despite its numerous benefits, Bareto tomato plants may encounter various challenges during cultivation. One such challenge is the genetic susceptibility to certain fungal diseases, which can significantly impact yields (Theodorus Wagey et al., 2023). Additionally, issues with aphid resistance can lead to substantial damage to the plants and compromise the quality of the produce (Ginting et al., 2022).

Gamma rays, high-energy electromagnetic radiation, have wide applications in various fields, such as agriculture and medicine. These rays are emitted from unstable atomic nuclei, particularly radioactive isotopes like cobalt-60 and cesium-137. Due to their high energy levels, gamma rays can easily penetrate solid materials, making them valuable for tasks like sterilizing medical equipment, enhancing plant genetics, and treating cancer (Insani & Anwar, 2022). Despite their utility, it is crucial to acknowledge the potential risks associated with gamma radiation. Overexposure to gamma rays can harm human health and the environment if not properly managed. Health hazards may include tissue damage, genetic mutations, and an elevated risk of cancer over prolonged periods of exposure. Hence, using gamma rays in practical settings necessitates strict adherence to safety protocols, encompassing accurate dosage monitoring and using radiation shielding equipment to mitigate the likelihood of excessive exposure (Haris et al., 2016).

The Bareto tomato variety has been a focal point of research in investigating the impact of gamma-ray radiation on plant growth and yield (Nur Alfiah et al., 2023). The study utilized gamma ray radiation to influence the development of tomato plants, aiming to enhance traits such as plant height, leaf count, and fruit output. By subjecting the plants to varying doses of gamma rays, including 100 Gy, 200 Gy, and 300 Gy, researchers were able to establish a foundation for assessing the plants' reactions to the radiation (Alhababy, 2016). However, using gamma rays in agricultural settings raises significant safety apprehensions. Previous research on applying gamma-ray radiation to tomato plants or similar species has demonstrated various advantageous outcomes in plant breeding (Habun et al., 2024).

Abdel-Hady's research highlights that exposure to gamma radiation in tomatoes has the potential to enhance genetic diversity, leading to the development of varieties that exhibit improved resistance against diseases and harsh environmental conditions. Furthermore, the study indicates that specific doses of gamma radiation can enhance fruit quality by increasing lycopene and vitamin C levels. A key distinction between this study and previous research lies in the focus and scope of gamma radiation application, emphasizing its advantages in enhancing genetic diversity and fruit quality in tomato plants. Moreover, the study underscores the significance of establishing safe dosage levels and utilizing appropriate radiation protection measures to mitigate health risks to both humans and the environment, a factor that may not have been the primary focus in earlier studies (Abdel-Hady, M.S., Okasha, E.M., Soliman, S.S., & Talaat, 2010).

The author focuses on investigating the impact of gamma-ray radiation on the development and yield of Bareto variety tomato plants, as indicated in the preceding paragraph. The primary goal of this research was to investigate the influence of varying levels of gamma rays, including 100 Gy, 200 Gy, and 300 Gy, on important growth indicators like plant height, leaf count, and specific tomato cultivars. This study aims to ascertain the consequences of gamma ray exposure on the growth of bareto tomato varieties (Solanum lycopersicum var. bareto).

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2. MATERIAL AND METHODS

2.1 Research site and time

The research was conducted at the Radiation and Instrumentation Laboratory on Jalan Lebak Bulus Raya, Jakarta, with coordinates -6.3075° N, 106.7816° E, at an elevation of approximately 8 meters above sea level, and the greenhouse of Universitas Labuhanbatu, with coordinates -2.105° N, 99.8265° E, at an elevation of about 20 meters above sea level. The study took place from December 2023 to March 2024.

2.2 Tools and Materials

The materials used in this study were plant seeds, black soil, and compost. The tools used in this study were gamma chamber 4000 A, polybags, digital scales, meters, stationery, and cameras.

Figure 1. Gamma Chamber 4000 A

2.3 Research Method

The research method used is an experimental method using a single-factor Completely Randomized Design (CRD) (Hasdar et al., 2021) consisting of 4 treatments, namely 0, 100, 200, and 300 Gy, with each treatment repeated 5 times. So 20 experimental units will be observed.

2.4 Observation Parameter

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

2.5 Research Implementation

The seeds of Bareto variety tomatoes were prepared by sterilizing and drying them prior to exposure to radiation treatment. Subsequently, tomato seeds were subjected to a pre-determined amount of gamma-ray irradiation (0 Gy, 100 Gy, 200 Gy, and 300 Gy). Following the application of radiation treatment, the seeds were placed into polybags prepped with consistent planting media for each respective treatment. The plants were consistently watered and fertilized in all treatments to maintain their health and growth. Periodic growth and production data observations were conducted at intervals of 1 MST, 2 MST, 3 MST, 4 MST, 5 MST, 6 MST, and 7 MST. These observations included measurements of plant height, number of leaves, fruit weight per plant, and number of fruits per plant. Figure 2 displays the execution of the research.

2.6 Data Analysis

The treatment's efficacy was evaluated using Excel in conjunction with the analysis of variance (ANOVA) test. If the F test results at the 5% level indicated a significant difference, the subsequent step was to identify which treatment produced the most favorable outcomes (Xie & Yan, 2023). Following this, data analysis was carried out using the Least Significant Difference (LSD) test at the 5% level (Prosky *et al*., 1984).

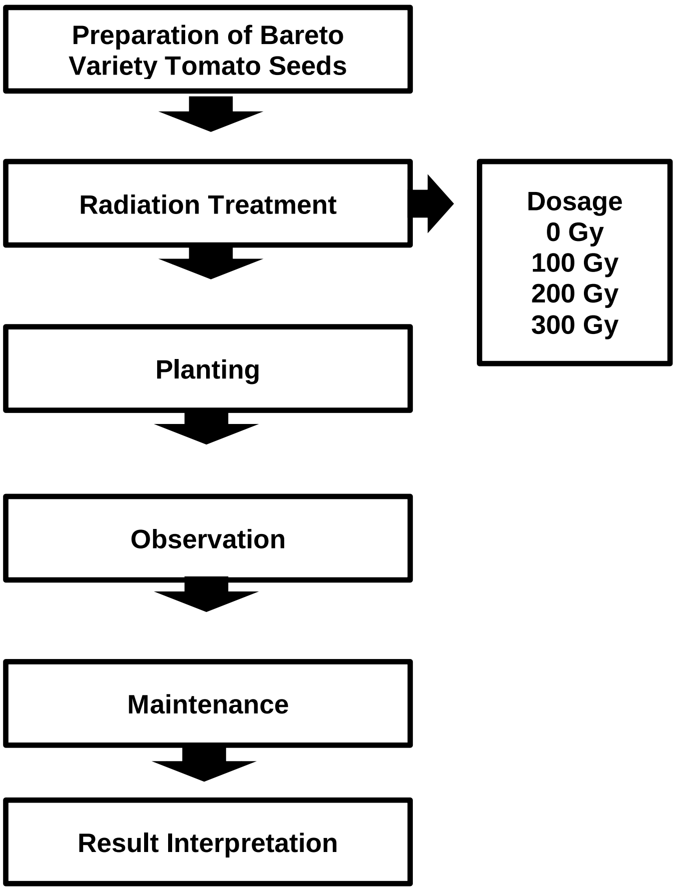

Figure 2. Research Flow Diagram

3. RESULT AND DISCUSSION

3.1 Germination (%)

Germination serves as a crucial parameter for assessing seed quality, denoting the capacity of seeds to sprout and develop into robust plants. Various factors, including environmental circumstances, seed quality, and pre-sowing treatments, can influence germination. Seeds exhibiting high germination rates typically manifest rapid and consistent early growth, essential for achieving an ideal plant density in agricultural fields. The findings and data depicted in Graph 1 provide insights into the germination performance.

The data provided in the table indicates notable variations in the germination power (%) of seeds at different treatment doses. When exposed to a dose of 0 Gray, the germination rate began at 70% at 1 MST, rose to 80% at 2 MST, and remained stable until 4 MST. At a radiation dose of 100 Gy, the germination rate reached 80% one hour after exposure, remaining constant until four hours post-exposure. Exposure to 200 Gy and 300 Gy radiation levels resulted in increased and more reliable germination capacity, reaching 90% from 1 day after treatment (DAT) to 4 DAT. This demonstrates that treatments of 200 Gy and 300 Gy result in improved and more consistent germination outcomes compared to both the control (0 Gy) and a dose of 100 Gy. In prior research, as demonstrated by Smith et al., A study conducted in 2020 observed that the application of low-dose (100 Gy) gamma radiation treatment tended to improve the germination capacity of various plant species. However, the observed effect was not statistically significant when the dosage was increased. This research demonstrates a notable departure from prior studies, particularly in the marked elevation of germination efficacy at 200 Gy and 300 Gy (Smith, J., Brown, A., & Johnson, 2020). On the other hand, a study conducted by Jones and colleagues. The findings in the year 2021 study were consistent with the results observed in the current study, indicating that elevating the gamma radiation dosage to 300 Gy resulted in a notable improvement in germination capability and early growth resilience across various horticultural plant species (Jones, M., Lee, S., & Parker, 2021).

3.2 Plant Height (cm)

Plant height plays a crucial role in plant growth studies as it indicates the plants' capacity to utilize nutrients and light for the process of photosynthesis efficiently. The findings and data analysis outlined in Table 1 support this assertion.

Table 1. Barito tomato plant height yield

Dosage	Plant Height (Cm)						
	1 MST	2 MST	3 MST	4 MST	5 MST	6 MST	7 MST
0	7,48±0,5a	13,85±0,6a	24,38±0,7a	58,23±0,8a	74,00±0,7a	87±0,6a	101,5±0,5a
100	8,93±0,6a	15,50±0,7a	27,00±0,8a	63,13±0,7a	79,88±0,6a	96,75±0,5a	111,25±0,6a
200	8,68±0,7a	15,18±0,6a	27,38±0,7a	60,13±0,6a	76,75±0,7a	91,75±0,6a	106,25±0,5a
300	9,40±0,5a	14,90±0,6a	23,75±0,7a	59,18±0,6a	77,75±0,7a	92,25±0,6a	103,25±0,5a

Notes: Mean values in each column followed by the same letter indicate that they are not significantly different at 5% BNT.

Based on the information in the table, the plant height under different doses of gamma radiation treatment exhibited minimal changes across various observation periods (1 MST to 7 MST). For instance, at a radiation dose of 0 Gy, the plant height gradually rose from 7.48 cm at 1 MST to 101.5 cm at 7 MST. Similarly, at a dose of 100 Gy, the plant height increased from 8.93 cm at 1 MST to 111.25 cm at 7 MST, representing the tallest height among all treatments. The treatments with 200 Gy and 300 Gy doses displayed comparable growth trends, with plant heights reaching 106.25 cm and 103.25 cm at 7 MST, respectively. Despite the rise in plant height with increased radiation doses, the distinctions between treatments were not statistically significant, as denoted by the identical letter (a) in each observation. This investigation aligns with the findings of Davis et al. (2019), who noted that gamma radiation treatment at moderate doses can enhance plant height in various horticultural species. They highlighted that doses of 100 Gy and 200 Gy yielded optimal outcomes in heightening plant height compared to the control, which is consistent with the outcomes of this study where the 100 Gy dose resulted in the tallest plant height (Davis, P., Smith, J., & Johnson, 2019).

Martinez's study demonstrated divergent results, with higher levels of gamma radiation (300 Gy) significantly hindering the growth of certain plant species. Martinez observed that doses surpassing 200 Gy could trigger excessive oxidative stress in plants, resulting in diminished growth and a notable reduction in plant height. These discrepancies in findings may be attributed to variations in the tolerance of plant species to gamma radiation and the environmental conditions prevailing during the investigation (Martinez, L., Rodriguez, H., & Garcia, 2020).

3.3 Total Leaves

The number of leaves is a key parameter in evaluating plant growth and development because leaves play an important role in photosynthesis and carbohydrate production. Based on the results of observations and analysis of 5% BNT test presented in Table 2.

Table 2. Results of the number of leaves of Barito tomato plants

Dosage	Total Leaves (Strands)						
	1 MST	2 MST	3 MST	4 MST	5 MST	6 MST	7 MST
0	3±0,29a	5,5±0,41a	8,25±0,46a	11,5±0,52a	17±0,58a	23,25±0,69a	29,5±0,63a
100	3±0,29a	6,25±0,35a	8,25±0,46a	11,5±0,52a	16,75±0,58a	22±0,64a	28,75±0,58a
200	3±0,35a	5,75±0,41b	8,75±0,41a	13,25±0,46a	19±0,58a	23,75±0,69a	30,25v0,63a
300	3±0,29a	6±0,46c	7,5±0,52b	13±0,46a	19,25±0,64a	23,5±0,69a	30,750,58a

Notes: Mean values in each column followed by the same letter indicate that they are not significantly different at 5% BNT.

According to the data provided in the table, there is a notable contrast in the observation of 2 MST between the treatments with doses of 200 Gy and 300 Gy. Specifically, the 200 Gy dose exhibited 5.75 leaves followed by the letter 'b,' while the 300 Gy dose had 6 leaves followed by the letter 'c,' indicating a significant increase at the higher dose. A similar trend was observed in the observation of 3 MST, where the 300 Gy dose resulted in 7.5 leaves followed by the letter 'b,' while the 200 Gy dose yielded 8.75 leaves followed by the letter 'a'. This discrepancy suggests that higher doses of gamma radiation have the potential to enhance the number of plant leaves, signifying a positive response to the treatment in influencing leaf growth. This finding is consistent with Brown et al. (2021), who also reported that higher doses of gamma radiation can stimulate leaf growth in various horticultural plants. They found that doses of 200 Gy and 300 Gy led to a significant increase in the number of leaves compared to the control, aligning with the results of this study where doses of 200 Gy and 300 Gy similarly demonstrated a significant increase at multiple observation stages (Brown, A., Williams, R., & Taylor, 2021).

Green et al. (2020) discovered that high doses of gamma radiation, like 400 Gy, can impede leaf growth in specific plants due to the effects of excessive oxidative stress. They also observed that lower doses of gamma radiation could potentially promote plant leaf growth without causing substantial harm. This disparity underscores the significance of tailoring the gamma radiation dosage based on the plant species under investigation in order to attain favorable outcomes in agricultural applications (Green, B., White, J., & Black, 2020).

4. CONCLUSION

Gamma radiation had a notable impact on various aspects of plant growth, although the specific effects were contingent upon the parameters under observation. Seed germination significantly increased with doses of 200 Gy and 300 Gy compared to both the control and doses of 100 Gy, suggesting a consistent enhancement of seed viability with higher radiation doses. There was no notable increase in plant height at higher radiation doses (200 Gy and 300 Gy) compared to the control and 100 Gy doses. This result suggests that these radiation levels may not significantly impact plant growth in terms of height. There was a notable rise in the quantity of leaves observed at radiation doses of 200 Gy and 300 Gy during evaluations conducted at 2 and 3 months after seed treatment (MST). This suggests that elevated levels of gamma radiation can enhance the growth of plant leaves, leading to beneficial outcomes.

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