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Strategy to increase the growth of sweet banana varieties of chili (*Capsicum sp*) using Gamma Ray Radiation

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ABSTRACT

Chili (*Capsicum sp*) is a herbaceous plant from the eggplant family and is thought to originate from Mexico, Central America, and the Andes region in South America. This research was carried out from November 2023 to May 2024. Sweet Banana Variety Chili Seeds were sent to the Isotope Application Center and Radiation (PAIR), National Nuclear Energy Agency (BATAN) Jl. Lebak Bulus Raya No.49 Cilandak-South Jakarta. Irradiated seeds were planted in the Green House of Labuhanbatu University, Labuhanbatu Regency, North Sumatra. The design used was a non-factorial completely randomized design (CRD) with 5 replications. The experiment used a single factor, namely gamma rays, on sweet banana variety chili seeds with 4 treatment levels: Control (0 Gy), 100 Gy, 200 Gy, 300 Gy. In this study, 20 plant units were observed. Based on the results of observations of the growth of sweet banana variety chili seedlings, seedling growth was different in each treatment, and most of the seedlings were only able to survive at an irradiation level of 100 Gy. The results of the analysis of variance showed that the gamma-ray radiation factor was significantly different from the number of leaves (strands) in the 2nd week after planting, but was not significantly different 4 weeks after planting. The results of the analysis of variance showed that the gamma-ray radiation factor was significantly different 2 weeks after planting, a further DMRT test was carried out at a level of 5%.

Keywords: *Gamma-ray Radiation, Mutation, Production, Sweet Banana Chili. Growth*

1. INTRODUCTION

Chili (*Capsicum sp*) is a herbaceous plant from the eggplant family and is thought to originate from Mexico, Central America, and the Andes region in South America. Before being distributed to other parts of the world, chilies first entered Europe via Spain. Known as chili pepper or guinea pepper, twenty species of chili peppers grow mostly in their native country. Indonesians usually only know a few types of chili: paprika, cayenne, curly chili, and red chili. (Ministry of Health, 2020) .

There are many benefits of vegetables, but Indonesian people cannot ignore them in their daily lives, including as a source of protein and vitamins. Vegetables are in almost all Indonesian food. As the most frequently used vegetable in Indonesian cuisine, it shows that Indonesians like chilies (Asmal et al., 2023).

Indonesia's red chili production is still very low, with a potential of 22 tons per year. New production is only around 8.35 tons per year. By modifying planting materials with gamma rays, red chili production can be increased. Additionally, to reduce selection time, cross-analysis should be performed to see the direct and indirect effects of the analysis. This requires observing the close relationship between variables through correlation analysis. (Sa'diyah et al., 2020) . Therefore, to increase the production and quality of chili plants, it is necessary to apply certain cultivation techniques. Increasing the planting area, especially during the rainy season, is a way to meet the demand for chilies. Independently planting chilies in the yard of the house is also another way to provide chilies to the community when prices are high (Chindy Maelani Devi & Sandi Nasrudin Wibowo, 2022).

One of the vegetables and fruit that has good business opportunities is chili. Chili is a promising commodity because of the large domestic and international demand. The spice, food, and pharmaceutical industries can benefit from increased demand for chilies. It is not surprising that chilies are the horticultural commodity with the highest level of price fluctuation in Indonesia (Sholihah et al., 2020).

Types of varieties, nutrients, pests and diseases, and planting patterns adapted to weather and climate are some of the important factors that influence crop production. Types of varieties, nutrients, and pests can be overcome by selecting superior varieties, fertilizing and eradicating pests, while weather and climate conditions are limiting factors that cannot be overcome in real terms, but have an impact on the types of varieties, nutrients, pests and diseases. Planting patterns adapted to weather and climate are some of the important factors that influence crop production. Types of varieties, nutrients pests, and diseases can be overcome by selecting superior varieties, fertilizing and eradicating pests, while weather and climate conditions are limiting factors that cannot be overcome in real terms, but have a real effect on plant production or health (Syawaluddin, SP et al., 2022).

Growing conditions are the ideal conditions that plants need to grow, develop, and produce good results. Growth consists of three factors, where two (two) are natural factors and one (one) is a social factor. Natural factors are climate, soil, and surrounding environmental conditions. Social factors are socio-economic conditions (Lagiman & Supriyanta, 2021). Chili plants produce conditions that meet these three criteria. Although technological advances have made it possible to manipulate soil and climate it is usually very expensive. Therefore, instead of carrying out land engineering, chili planting is attempted in land conditions that are suitable for chili cultivation.

Radiation is the emission and propagation of energy through matter or space in the form of electromagnetic

waves or particles. Based on its nature, radiation is grouped into 2 types, namely ionizing radiation and non-ionizing radiation. When interacting with matter, ionizing radiation can cause ionization, while non-ionizing radiation does not cause ionization. Examples of ionizing radiation are ultraviolet, alpha, beta, and gamma radiation. For plant breeding purposes gamma radiation is usually used. Gamma radiation is electromagnetic radiation that carries energy in the form of packets called photons. From experiments, it is known that gamma rays have no mass and no charge so they are given the notation 00g. In general, the gamma radiation used is the result of the decay of the Co-60 atomic nucleus. Co-60 is produced from the nuclear reaction between Co-59 and neutrons in the reactor, according to Equation 1 (Made et al., 2020).

The energy during stimulation is also known as gamma-ray radiation (γ). The excited nuclear condition is when the atomic nucleus is disturbed or stimulated from the outside. This occurs during the step of bombarding the atomic nucleus with neutrons. By emitting Gamma radiation, the core can stabilize again. In methods that involve nuclear reactions in atomic reactors or using accelerators, this method is then used to recover Gamma radiation in the excited state of atomic nuclei. In an unstable atomic state, the penetrating power of Gamma radiation is large. Gamma decay is a term used to describe atomic nuclei in an excited state. This occurs when the strength of the atomic nucleus is in poor condition (Nuraeni et al., 2023).

2. MATERIAL AND METHODS

This research was carried out from January 2024 to May 2024. Sweet Banana Variety Chili Seeds were sent to the Isotope and Radiation Application Center (PAIR), National Nuclear Energy Agency (BATAN) Jl. Lebak Bulus Raya No.49 Cilandak-South Jakarta -6.3075° N, 106.7816° E . Irradiated seeds were planted in the Green House, Labuhanbatu University, Labuhanbatu Regency, North Sumatra, -2.105° N, 99.8265° E. The design used was a non-factorial completely randomized design (CRD) with 5 replications. The experiment used a single factor, namely gamma rays, on sweet banana variety chili seeds with 4 treatment levels: Control (0 Gy), 100 Gy, 200 Gy, 300 Gy. In this study, 20 plant units were observed.

The tools and materials used are a 4000 A Gamma chamber, which functions as a source of gamma-ray radiation. The tool used is a digital scale as an accurate measure of soil, compost, dolomite, and NPK. The use of polybags as a container for planting seeds that have been irradiated with gamma rays. The aim of using stationery and cameras is to record observation data and visually document the growth of chili plants that have been irradiated.

Figures 1 . 4000 A gamma chamber device

Observational data was tested statistically using ANOVA *(analysis of variance).* If there are significant differences in the observed characters,

they are further tested using Duncan's Multiple Range Test (DMRT) at the α = 0.05 level. Observations on the growth of sweet banana variety chili plants were carried out on vegetative and generative characters. In vegetative characters, namely the percentage of germination power, and plant height. Meanwhile, the generative characters are flowering age, harvest age, and fruit weight per plant. The calculation of growth capacity is calculated based on the formula according to (Tefa, 2017), namely:

$$\textbf{Percentage of growing power (}\%\textbf{)} = \frac{\sum n}{N} \times 100\%$$

Information:
$\sum n$ = Number of seeds growing normally
N = Total seeds planted

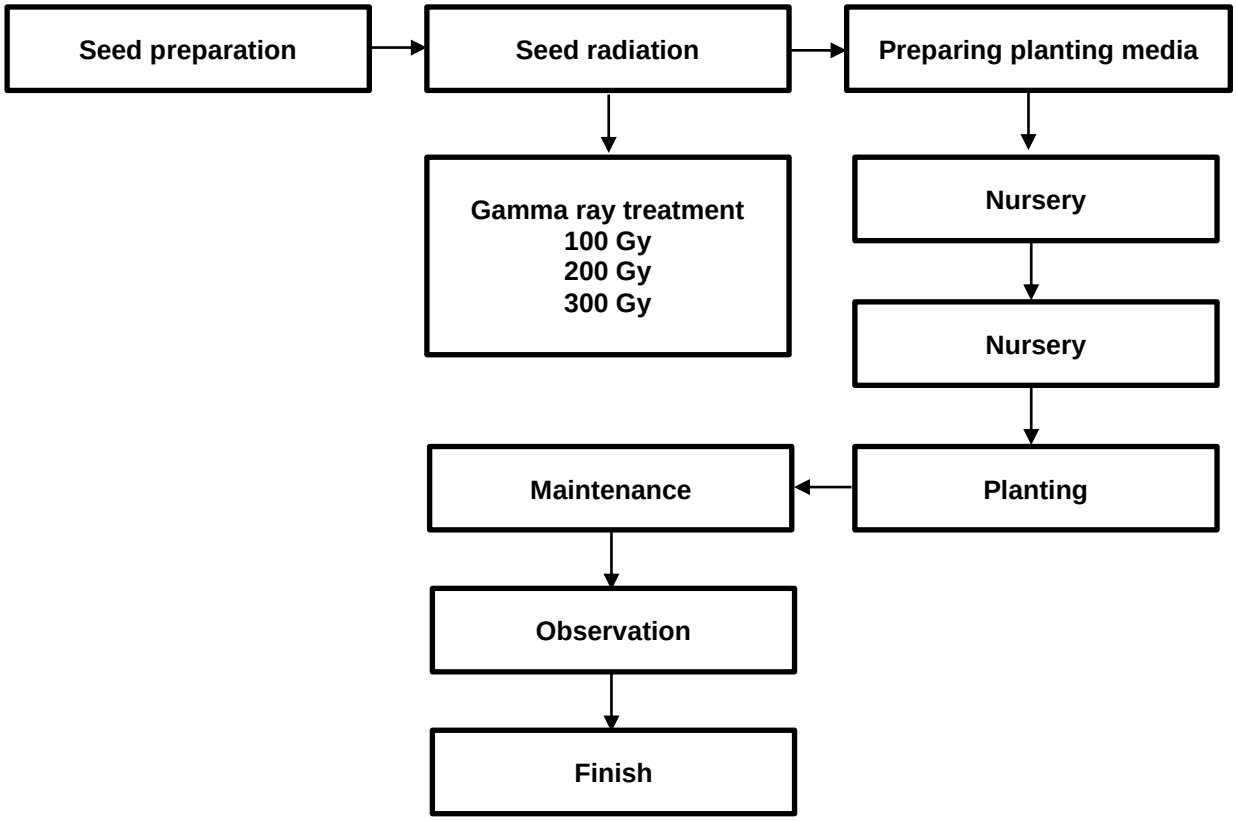

Figure 2. Research flow diagram

3. RESULT AND DISCUSSION

3.1 Germination Percentage (%)

The germination capacity of the Sweet Banana variety of chili plants describes the ability of the seeds to grow and develop into strong plants. This process is greatly influenced by seed quality, environmental conditions, and appropriate crop management practices (Figure 3).

Based on observations of the growth of sweet banana variety chili seedlings, seedling growth was different in each treatment, and most of the seedlings were only able to survive an irradiation level of 100 Gy. Seedling growth at irradiation levels of 200 Gy and 300 Gy, most of the seedlings grew abnormally (stunted) with a brownish color, until the seedlings became dry and died most of the seedlings in the 200 Gy and 300 Gy treatments did not experience growth. So in this study, the seeds of the sweet banana variety chili plants that could be transferred to small polybags were: seeds treated with 100 Gy, one seed treated with 200 Gy, one seed treated with 300 Gy, and seedlings with control plants. However, when the plants were moved to the greenhouse, at

the age of 4 WAP the seedlings in the 300 Gy treatment wilted and even died.

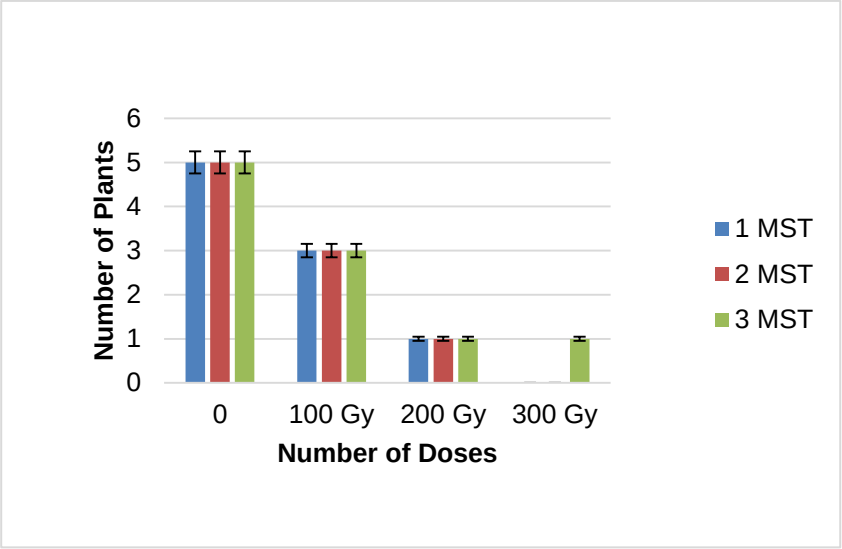

Figure 3. Percentage of germination after Gamma ray radiation

3.2 Plant Height (cm)

Plant height measurements began 4 weeks after planting (WAP), and were carried out every two weeks until the first flowers appeared. Plant height is calculated from the base of the soil to the tip of the tallest leaf. Based on the analysis of variance, it shows that the irradiation dose influences the average height of the sweet banana variety chili plants for each 2-week observation. The results of the analysis of variance showed that the gamma-ray irradiation factor was significantly different at 2 weeks after planting (MST), so a further DMRT *(Duncan Multiple Rane Test) test was carried out* at the 5% level (Table 2). However, 6 weeks after planting (MST) showed that the gamma-ray irradiation factor was not significantly different.

Table 2. Plant height after Gamma ray radiation

Dosage (Gy)	4 WAP	6 WAP
0	23.69 ± 0.01 a	48.02 ± 0.04 a
100	21.38 ± 0.11 b	46.04 ± 0.00 a
200	18.11 ± 0.03 ab	38 ± 0.21 a
300	16.47 ± 0.02 ab	35.6 ± 0.04 a

Note: Numbers followed by different letters in the same column indicate significant differences based on the 5% DMRT test.

The following observations, show that at 4 WAP the tallest plants were those treated with gamma-ray irradiation at a dose of 0 Gy (control) with an average value of 23.69 cm, and the plants with the lowest height were at a dose of 300 Gy, namely 16.47 cm.

3.3 Number of Leaves (Strengths)

Observation of the number of leaves on sweet banana variety chili plants was carried out every 2 weeks by counting the number of leaves on each plant. The results of the analysis of variance showed that the gamma-ray radiation factor was significantly different from the number of leaves (strands) in the 2nd week after planting, but was not significantly different 4 weeks after planting.

At the age of 2 WAP, the highest number of leaves was in plants without 0 Gy treatment (control) with an average of 7 leaves, and the lowest at a dose of 300 Gy with an average of 6.5 leaves. The results of further tests showed that the gamma-ray radiation treatment in observing the number of leaves at the age of 2 WAP showed that there was a difference between the 0 Gy treatment (control) and the 300 Gy treatment. The

number of leaves with HSPT at ages 7, 14, and 21 tended to be higher at a dose of 200 Gy but was not statistically different from other gamma-ray dose treatments. The number of leaves with HSPT at age 28 tended to be higher at a dose of 300 Gy but was not statistically different from other gamma-ray dose treatments. (Vazilla et al., 2023) .

Table 3. Number of leaves after gamma irradiation

Dosage (Gy)	2 WAP	4 WAP
0	7 ± 0.03 a b	10.75 ± 0.06 a
100	6.58 ± 0.07 ab	10.83 ± 0.05 a
200	6.58 ± 0.04 ab	10.17 ± 0.01 a
300	6.5 ± 0.03 b	9.67 ± 0.06 a

Note: Numbers followed by different letters in the same column indicate significant differences based on the 5% DMRT test.

4. CONCLUSION

The germination capacity of the Sweet Banana variety of chili plants describes the ability of the seeds to grow and develop into strong plants. This process is greatly influenced by seed quality, environmental conditions, and appropriate crop management practices. The radiation dose affected the average height of sweet banana variety chili plants for every 2 weeks of observation. The results of the analysis of variance showed that the gamma-ray radiation factor was significantly different 2 weeks after planting, so a further DMRT test was carried out at the 5% level. Giving different doses to sweet banana variety chili plants can affect the growth of sweet banana chili fruit. So further research is needed on the F_2 and $F_{3\ generations}$ to find out how gamma ray radiation affects the physiology and morphology of sweet banana variety chili plants.

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