JUATIKA
JURNAL AGRONOMI TANAMAN TROPIKA
VOL. 7 NO. 1 January 2025
DOI :https://doi.org/10.36378/juatika.v7i1.4126
eissn 2656-1727
pissn 2684-785X
pages : 289 – 293

RESEARCH ARTICLE Open Access

Response of Total Number of Tillers, Plant Height, and Dry Straw Weight of Jangguik rice Genotypes (*Oryza sativa*) With Gamma Ray Irradiation Treatment

Wahyudi[1,*], Elfi Indrawanis[1]

Abstract

The limited number of tillers and the height of the plant stem result in a lighter straw weight per clump, which diminishes farmers' interest in cultivating the Jangguik rice genotype. Jangguik rice may face extinction in a few years if this trend continues. This study aimed to determine the response of the total number of tillers, plant height, and dry straw weight of Jangguik rice genotypes to gamma-ray irradiation treatment. Field research was conducted in Koto Kari Village, Kuantan Tengah District, Kuantan Senggigi Regency, located at coordinates 0 0 00-1 0 00 LS 101 0 02 – 101 0 55 BT with a temperature range of 23.0 – 33.0 °C, air humidity of 60 – 98%, and an altitude of 300 meters above sea level. Gamma irradiation services were conducted on Babarsari St. at the Deputy for Research and Innovation Infrastructure, Yogyakarta Radiation Laboratory, Depok Sleman, Yogyakarta. The research was conducted over seven months, from June to December 2024. This experiment employed a one-factor Randomized Block Design (RAK) experimental method. It consisted of three treatments, each repeated five times, resulting in 15 experimental plots. The treatments included doses of 0 Gy, 100 Gy, and 200 Gy. The study's results were statistically analyzed using an ANOVA table; if the calculated F-value exceeded the F-table value at the 5% significance level, further analysis was conducted using the Honest Significant Difference (HSD) test. Based on the research findings, it can be concluded that gamma-ray irradiation treatment significantly affected plant height, which measured 110.66 cm but did not influence the total number of tillers or the dry weight of straw.

Keywords: Dry Straw Weight, Gamma, Plant Height, Rice, Total Tillers

1. Introduction

Rice plants (*Oryza sativa* L.) are significant contributors to the production of energy, protein, and fat within the rice and cereal groups. According to data from the Badan Pusat Statistik (2023), rice productivity in Indonesia reached 53.63 million tons of GKG in 2023, representing a decrease of 1.12 million tons of GKG, or 2.05 percent, compared to the 54.75 million tons of GKG produced in 2022. Additionally, Indonesia imported 356,286.2 tons of rice in 2020, 7,741.4 tons in 2021, and 429,207.3 tons in 2022.

One of the causes of low rice productivity in Indonesia is that farmers continue to use local varieties, including those in Kenegerian Kari. The Kuantan Senggigi Regency is home to a community that has established a custom known as the Kenegerian Kari, one of the legends in the Central Kuantan District.

One of the local rice genotypes commonly planted by rice farmers in Kenegerian Kari is Jangguik rice, which is currently threatened with extinction, as it is difficult to find farmers who cultivate this rice. Based on the results of the author's interviews with farmers, Jangguik rice has several advantages, including resistance to pests and diseases, drought resistance, the ability to provide a prolonged feeling of fullness when consuming rice, the ability to last a long time to be stored in the warehouse without changing the taste of the rice consumed. However, from these advantages, Jangguik rice has disadvantages, namely, the number of tillers is relatively small, and the height of the plant is too high, so it is easy to fall over.

*Correspondence: wahyudi.uniks@gmail.com
1) Universitas Islam Kuantan Singingi - Jl. Gatot Subroto KM 7, Kebun Nenas, Teluk Kuantan, Sungai Jering, Kuantan Singingi, Kuantan Singingi Regency, Riau 29566, Indonesia

The small number of tillers and the height of the plant stem cause the straw yield to be less, causing the dry straw weight to be less, causing the Jangguik rice genotype to cause farmers to be less interested in cultivating Jangguik rice. If this is allowed to continue, the existence of Jangguik rice will indeed become extinct in a few years, like kasang rice, which is usually cultivated by the people of Kuantan Singingi Regency when opening rubber plantations in years 1, 2, and 3, which at this time the people only know the name without ever seeing what kasang rice is.

To save the existence of Jangguik rice, which is almost extinct, one of the efforts that can be made is to conduct induced mutations. (Sari et al., 2015) Induced mutations are an effective way to obtain sources of diversity because they are considered the fastest and cheapest.

According to (Megasari and Asmuliani, 2023), Mutation induction aims to increase the genetic performance of plants by replacing one or some essential characteristics that benefit the plant while maintaining most of its original characteristics. Mutation techniques with radiation radiation aim to obtain new plant variants through high mutation frequencies.

According to findings from a study conducted by Mardiyah et al. (2020), it was concluded that the performance and production of local Aceh rice could be affected by gamma-ray irradiation. The research indicated that plant height may decrease. At the same time, production can increase when exposed to irradiation doses ranging from 100 Gy to 300 Gy, with the highest increase observed at a dose of 300 Gy. Conversely, a decrease in production was observed at a radiation dose of 400 Gy.

This research aimed to analyze the impact of gamma-ray irradiation treatment on the total number of tillers, plant height, and dry straw weight of Jangguik rice genotypes.

2. Material and Methods

Field research was conducted in Koto Kari Village, Kuantan Tengah District, Kuantan Senggigi Regency, with coordinates 0 0 00-1 0 00 LS 101 0 02 - 101 0 55 BT, with a temperature of 23.0 - 33.0 ° C, air humidity 60 - 98% and an altitude of 300 m above sea level. At the same time, the Gamma Irradiation Service was carried out at the Deputy for Research and Innovation infrastructure, Yogyakarta Radiation Laboratory. Jl. Babarsari, Depok Sleman Yogyakarta. The research was carried out for 7 months, from June to December 2024.

The tools and materials used are: Hoe, machete, sickle, kep solo, digital scales, pH meter, tape measure, planting container, gamma camber 4000 A facility, stationery, Jangguik rice seeds, paddy soil, cobalt 60 gamma rays, goat manure fertilizer, dolomite, urea, SP-36, KCL, chemical pesticides, burlap sacks, PE plastic, fence wood, fence netting, nails, barbed wire, and Rapiah rope.

This experiment used an experimental method with a one-factor RAK (Randomized Block Design) experimental design. This experiment consisted of 3 treatments repeated 5 times so that the total number was 15 experimental plots. The treatments tried were as follows: dose 0 Gy, dose 100 Gy, and dose 200 Gy.

The research results were tested statistically using Microsoft Excel version 2010 to see the average value and variance analysis. In the ANOVA table. If the calculated F is greater than the F table of 5%, then continue with the BNJ (Honest Significant Difference) test at the 5% level. The data analysis model is as follows:

$$\mathbf{Yij = \mu + Ti + \varepsilon ij}$$

Where:
Yij : Observation value on experimental units in factor group i up to j
μ : Median value
Ti : Effect of treatment up to i
εij : Effect of error (residual) on the ith treatment of the jth replication

2.1. Implementation of research

Before sowing, the seeds are soaked for 12 hours. Then, the seeds are sown in a nursery tub using a nursery medium consisting of soil, sand, and goat manure with a ratio of 1:1:1. After the seedlings are 21 days old, the seedlings are planted in the field. The planting medium and container used are rice fields put into a 20-litre bucket. Plant maintenance is carried out according to rice cultivation procedures, including irrigation, weeding, and fertilization with a dose of 300 kg urea/ha, 100 kg SP36/ha, and 100 kg KCl/ha. Meanwhile, pest control is carried out by installing nets at the research location and spraying using Decis pesticides with a dose of 2 cc/liter of water. Control is carried out after the plants enter the generative phase until the plants have entered the ripening phase. The flow diagram of this research is as follows:

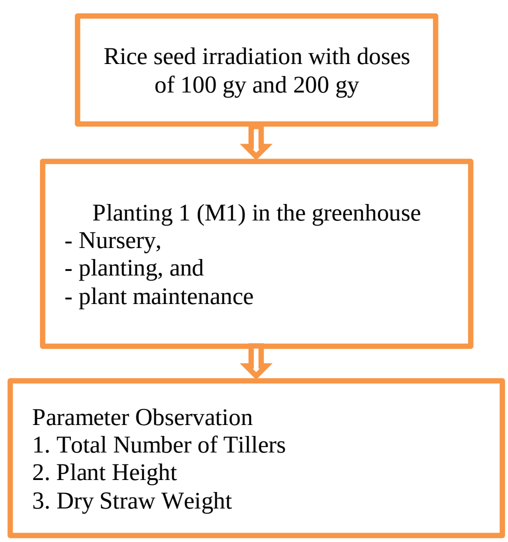

Figure 1. Flowchart of the research on the response of total tiller number, plant height, and dry straw weight of Jangguik rice genotypes with gamma ray irradiation treatment.

2.2. Observation parameters.

Observation parameters consist of the following:

1. Plant Height. Observed at the end of the study using a meter starting from the root neck to the tip of the highest panicle.
2. Total Number of Offshoots. Calculate when the plant has borne fruit by counting each offshoot and whether it produces fruit.
3. Dry Straw Weight. Weighed using a 10 kg scale when the straw is dried in the field for 2 weeks.

3. Results and Discussion

3.1. Total Number of Offspring (Stems)

After analysis of variance, the observation data of the total number of Jangguik rice tillers showed that gamma-ray irradiation treatment had no significant effect. The average observation results can be seen in Table 1.

Table 1. Total Number of Tillers of Jangguik rice Irradiated with Gamma Rays (bar).

Treatment	Total Number of Offspring (stems)
0 Gy	20.66 ± 1.02
100 Gy	18.66 ± 1.04
200 Gy	23.33 ± 1.03
KK = 21.07%	

Note: The numbers in the columns followed by the same lowercase letter do not differ according to the F test.

Based on the data from Table 1, it can be seen that the gamma-ray irradiation treatment did not have a significant effect on the total number of tillers of Jangguik rice plants, where the highest number of total tillers was found at 200 Gy, namely 23.33 stems, 0 Gy, namely 20.66 stems and 100 Gy, namely 18.66 stems.

It can be seen in Table 1 that the doses of 0 Gy and 100 Gy have the fewest offspring compared to those given 200 Gy irradiation. Even when compared with the 0 Gy treatment, it produces more offspring than the 100 Gy treatment, and this is the result of plants irradiated with gamma rays whose character cannot be predicted.

According to Siallagan et al. (2023), the effects of gamma-ray irradiation will cause genetic changes in rice plants, and the provision of each treatment that is exposed to irradiation produces plants that cannot be predicted in terms of characteristics or properties. The use of gamma-ray irradiation to increase genetic diversity is not expected because the mutagen used does not necessarily hit the desired target.

Furthermore, it is added with the opinion (Karyanti et al., 2015) that changes in chromosome plants due to gamma rays cannot be predicted because physical mutations are random, which can be positive or negative. Even compared to research conducted by (Tumanggor et al., 2022) shows that the number of shoots produced is inversely proportional to this study, where a higher number of shoots was obtained without treatment, namely (26.37 stems). The smallest number of shoots was obtained in the 400 Gy treatment (13.43 shoots).

3.2. Plant Height (cm)

The observation data of the height of Jangguik rice plants after analysis of variance showed that gamma-ray irradiation treatment had a significant effect. The average observation results can be seen in Table 2.

Table 2. Height of Jangguik rice Plants Irradiated with Gamma Rays (cm).

Treatment	Plant Height (cm)
0 Gy	134.66 ± 2.02c
100 Gy	120.00 ± 3.02 b
200 Gy	110.66 ± 1.05 a
KK= 4.2% KK= 8	

Note: The numbers in the columns followed by the same lowercase letter do not differ according to the Honestly Real Difference (HDR) at the 5% level.

Based on the data from Table 2, it can be seen that the gamma-ray irradiation treatment had a significant effect on the height of the Jangguik rice plants, where the lowest plant height was found in the 200 Gy treatment, namely 110.66 cm, different from the 100 Gy treatment, which is 120.00 cm and is different from the 0 Gy treatment which is 134.66 cm.

Pheng et al. (2005) stated that the ideal height of rice plants is around 90 cm to 100 cm. With this height, the potential for lodging will decrease compared to tall plants. Based on the plant height data produced in this study, the higher the dose of gamma rays given, the lower the plant height; although the expected plant height has not been achieved due to the treatment, there have been changes in the phenotype of the height of the Jangguik rice plant. In line with the opinion of Makhziah et al. (2017). Several characteristics, such as plant height, decreased significantly when the dose of gamma rays increased from 100 to 300 Gy.

Mutation induction treatment with gamma rays results in different plant growth. The higher the dose is given, the more disrupted plant growth. This is also in line with Oualkadi's research (2019), conducted on irradiated Mucuna seeds with different growth; the higher the radiation dose level, the more the growth power is disrupted.

The administration of gamma-ray irradiation with a dose of 200 Gy significantly triggered the growth of Jangguik rice genotypes in this study. The decrease in plant height can be triggered by irradiation, which can cause mutations that affect the mutant phenotype. The impact of gamma-ray irradiation on the emergence of plant diversity depends on the dose given. The higher the radiation intensity, the higher the chance of mutations occurring, and it can cause positive effects at specific doses.

Differences in regulating genes indicate differences in the genotype characters of the Jangguik rice produced. Each dose of radiation produces different results. (Nazirah (2015) stated that the diverse appearance of plants due to differences in genetic composition is one of the causes of differences in plant height.

According to (Giono et al. (2014), plant breeding by induction of gamma-ray radiation on plant material can cause changes in the desired morphological, anatomical, and genetic characteristics and help obtain better genotypes according to the expected targets through selection. Exposure to ionizing radiation that hits biological systems activates several chemical and physical reactions from the initial energy absorption until biological damage occurs. Furthermore, according to Esnault et al. (2010), excitation and ionization reactions result from the formation of ionized water molecules and free radicals. These free radicals can damage or modify plant cell components, thus affecting chemical and biological processes that may be vital to the survival of an organism Marcu et al. (2013). This follows the statement of Erlya et al. (2020) that mutation induction through seed irradiation causes physical mutations and can penetrate plant seeds to the chromosome layer, resulting in changes indicated by plant morphology. This has been seen in the height of the plants produced in this study, with the difference in irradiation given will cause differences in the height of the plants produced.

Variations in the impact of radiation may arise due to the ionizing nature of gamma-ray radiation, which generates free radicals and subsequently leads to the alteration or harm of chromosomes in plants and the spontaneous damage of DNA molecules (Asadi, 2016). Exposure to gamma-ray irradiation can potentially influence cell division activity, specifically in the apical meristem. This factor is the driving force behind alterations in traits, such as the height of a plant.

The height of a plant is a significant agronomic trait correlated with biomass, making it a viable marker for selection purposes. According to Lestari and Dewi (2015) ... Hence, the selection process in this research focused on measuring plant height.

3.3. Dry Straw Weight (kg)

The data from observing dry straw weight of Jangguik rice after analysis of variance showed that gamma-ray irradiation treatment had no significant effect. The average observation results can be seen in Table 3.

Table 3. A dry weight of Jangguik rice straw irradiated with gamma rays (cm).

Treatment	Dry Straw Weight (kg)
0 Gy	0.56 ± 0.02
100 Gy	0.56 ± 0.02
200 Gy	0.60 ± 0.04
KK= 25.6%	

Note: Numbers in columns followed by the same lowercase letter do not differ according to the F test.

According to the findings presented in Table 3, it is evident that the application of gamma-ray irradiation treatment did not significantly impact the dry straw weight of Jangguik rice plants. The plants' highest recorded dry straw weight was observed in the 200 Gy treatment, at 0.60 kg, while both the 100 Gy and 0 Gy treatments resulted in a dry straw weight of 0.56 kg.

Figure 2. Results of Weighing Dry Straw in the Field for Each Treatment of 0 Gy, 100 Gy, and 200 Gy.

The average weight of dry straw produced in the 200 Gy treatment is intricately linked to the effects of the preceding two variables: the total number of tillers and the height of the plants. Combining both parameters results in the highest tiller count and shorter plant height, yielding the most abundant straw.

Variations in the weight of straw demonstrate diversity and are anticipated to result in sustainable genetic modifications that can be transmitted to future crop generations. Lestari (2016) argues that quantitative and qualitative plant attributes can distinguish genetic alterations. The study focused on the quantitative aspect of the weight of dry straw. The dry weight of straw can be used to characterize the vegetative portion of the plant and the amount of biomass produced, as it indicates the water content present in the plant cells following the drying process in the field.

4. Conclusion

The research findings indicate that applying a 200 Gy gamma ray irradiation treatment impacted the plant height, resulting in a measurement of 110.66 cm. However, this treatment did not affect the overall number of tillers or the dry weight of straw in the Jangguik rice genotype.

Acknowledgments

We want to extend our sincere appreciation to the Institute for Community Service Research and Islamic Propagation (LPPMDI) of Universitas Islam Kuantan Singingi for their generous support of this research, as well as to the National Research and Innovation Agency (BRIN) Yogyakarta Radiation Laboratory, Babarsari St., located in Depok Sleman Yogyakarta, was utilized to administer gamma irradiation services to Jangguik rice genotype seeds, which were used as research materials.

References

Asadi, A. (2016). Pemuliaan mutasi untuk perbaikan terhadap umur dan produktivitas pada kedelai. *Jurnal AgroBiogen, 9*(3), 135–142. https://doi.org/10.21082/jbio.v9n3.2013.p135-142

Badan Pusat Statistik. (2023). *Luas panen dan produksi padi di Indonesia 2023 (angka sementara)*.

Dalfiansyah, Z., Zuyasna, & Hafsah, S. (2016). Seleksi mutan generasi kedua (M_2) kedelai kipas putih terhadap produksi dan kualitas biji yang tinggi. *Jurnal Agrista, 20*(3), 115–125.

Erlya, R. M. R. (2020). Pengujian potensi dosis iradiasi sinar gamma terhadap terjadinya mutan padi beras merah lokal Bahbutong dan Aek Sibundong pada generasi M_1.

Esnault, M. A., Legue, F., & Chenal, C. (2010). Ionizing radiation: Advances in plant response. *Environmental and Experimental Botany, 68*(3), 231–237. https://doi.org/c43v25

Giono, B. R. W., Farid, B. D. R. M., Nur, A., Solle, M. S., & Idrus, I. (2014). Ketahanan genotipe kedelai terhadap kekeringan dan kemasaman, hasil induksi mutasi dengan sinar gamma. *Jurnal Agroteknos, 4*(1), 44–52.

Karyanti, Purwito, A., & Husni, A. (2015). Radiosensitivitas dan seleksi mutan putatif jeruk keprok Garut (*Citrus reticulata* L.) berdasarkan penanda morfologi. *Jurnal Agronomi Indonesia, 43*(2), 126. https://doi.org/10.24831/jai.v43i2.10417

Rahmadani, F., & Jonyanis. (2020). Tradisi perkawinan di Kenegerian Kari Kecamatan Kuantan Tengah Kabupaten Kuantan Singingi. *JOM FISIP, 7*(2), 1–13.

Sari, L., Purwito, A., Soepandi, D., Purnamaningsih, R., & Sudarmanowati, E. (2015). Pengaruh iradiasi sinar gamma pada pertumbuhan kalus dan tunas tanaman gandum (*Triticum aestivum* L.). *Ilmu Pertanian, 18*(1), 44–50.

Siallagan, D. S. E., Marnita, Y., & Iswahyudi. (2023). Evaluasi keragaman dan potensi produksi padi Arias Kuning generasi mutan-2 hasil iradiasi sinar gamma. *Jurnal Produksi Tanaman, 11*(2), 77–85.

Lestari, E., & Dewi, I. (2015). Evaluasi dan seleksi galur mutan sorgum manis varietas numbu hasil mutasi. *Prosiding Seminar Nasional Biologi II, 6 Agustus 2015*, 11–16.

Lestari, E. G. (2016). *Pemuliaan tanaman melalui induksi mutasi dan kultur in vitro*. http://repository.pertanian.go.id/handle/123456789/12094

Makhziah, Sukendah, & Koentjoro, Y. (2017). Pengaruh radiasi sinar gamma Cobalt-60 terhadap sifat morfologi dan agronomi ketiga varietas jagung (*Zea mays* L.). *Jurnal Ilmu Pertanian Indonesia (JIPI), 22*(1), 41–45.

Mardiyah, Y., Marnita, & Syahril, M. (2020). Keragaan dan produksi padi gogo lokal Aceh kultivar Sileso generasi M_1 hasil iradiasi sinar gamma. *Jurnal Ilmiah Aplikasi Isotop dan Radiasi, 17*(1).

Marcu, D., Damian, G., Cosma, C., & Cristea, V. (2013). Gamma radiation effects on seed germination, growth and pigment content, and ESR study of induced free radicals in maize (*Zea mays*). *Journal of Biology and Physics, 39*(4), 625–634. https://doi.org/b538

Megasaria, R., & Asmuliani. (2023). Respon perkecambahan benih padi lokal Siam Kuning hasil iradiasi sinar gamma. *Jurnal Agercolere, 5*(1), 26–30.

Nazirah, L., Purba, E., Hanum, C., & Rauf, A. (2015). Evaluasi toleransi berbagai varietas padi gogo terhadap cekaman kekeringan dengan penggunaan PEG (polyethylene glycol). *Lentera, 15*(16).

Oualkadi, M., Mouhib, & Hajjaj, B. (2019). Study of radio sensitivity of strawberry runners (*cv. Fortuna*) under Moroccan conditions. *American Journal of Plant Science, 10*(10), 1921–1931. https://doi.org/10.4236/ajps.2019.1010135

Peng, S., Khush, G. S., Virk, P., Tang, Q., & Zou, Y. (2008). Progress in ideotype breeding to increase rice yield potential. *Field Crops Research, 108*, 32–38.

Tumanggor, G. E., Iswahyudi, & Mardiyah, A. (2022). Pertumbuhan, produksi, dan karakter genetik padi kultivar Sileso generasi M_2 hasil iradiasi sinar gamma. *Agrosamudra: Jurnal Penelitian, 9*(2), 1-8.