

Response of Several Doses of Gamma Rays on the Growth of Sugar Palm Plant (*Arenga pinnata* Merr)

Andi Apriany Fatmawaty ^{*1}, Nurmayulis ², Susiyanti ², Abdul Hasyim Sodiq ²
¹ *Postgraduate Student of Doctoral Program in Agricultural Science, Sultan Ageng Tirtayasa University*

² *Agroecotechnology, Faculty of Agriculture, Sultan Ageng Tirtayasa University*

*Corresponding author: apriany@untirta.ac.id

Abstract

Sugar palm (*Arenga pinnata* Merr) is a plantation crop that has great potential in improving the economy of a region because every part of the sugar palm plant can be utilized. The main problem with sugar palm crop is that many still grow wild in the forest. Therefore, one solution that can overcome this problem is to produce quality sugar palm seeds with the help of technology such as gamma rays and polyethylene glycol (PEG) to produce quality sugar palm mutants. The method of this research was carried out by carrying out two stages, namely 1) selection of sugar palm seed mutants with drought-resistant characters and 2) selection of sugar palm seed mutants with early maturity characters. In this stage 1 research, a factorial randomized block design (RAK) was used consisting of two factors, namely the dose of gamma ray radiation and sugar palm varieties. The first factor is the dose of gamma ray radiation consisting of 6 levels, namely 0 Gy (b0), 4 Gy (b1), 6 Gy (b2), 8 Gy (b3), 10 Gy (b4), and 12 Gy (b5). The second factor is the aren variety, consisting of 2 levels, namely parasite (v1) and local lebak (v2). In stage 2 using DNA. the study showed The results of that gamma ray radiation with a dose of 6 Gy (B2) gave the best effect on the parameters of plant height, leaf width, number of leaves. There was no interaction between the gamma ray radiation dose treatment factor and the aren variety.

Keywords: Sugar palm plant; Gamma rays; Polyethylene glycol (PEG)

Introduction

The sugar palm plant is one of the plants with quite large potential to be developed in Indonesia, because this plant is a natural resource known in the tropics (Charis et al., 2022). The economic value of the products produced by the sugar palm plant is greatly needed by the international market so that it can increase the export value which has an impact on increasing the national economy. The production of sugar palm plants in Indonesia has problems, because most of the sugar palm plants grow in forest areas, so that their growth is not maintained optimally resulting in less than optimal production results (Sebayang, 2016). The large number of sugar palm plants that grow wild results in the quality of the sap having high diversity, so it is necessary to have a standard for the quality of sugar palm seeds for farmers who will cultivate sugar palm professionally. BPS data 2020 - 2022 noted that the area of sugar palm plantations decreased in 2020, the area of national sugar palm plantations reached 64,025 hectares, decreased in 2021 to 63,077 hectares and in 2022 to 63,244 hectares (Badan Pusat Statistik, 2022)

To produce sugar palm plants with high diversity, it can be done by administering a dose of gamma ray radiation to the plant, the effective dose range if radiation is

carried out on seeds compared to other parts of the plant. The radiation carried out will certainly result in genetic changes which will later be reflected in the roots from the physical changes displayed (Warman et al., 2016). The results of research by Zanzibar and Sudarajat (2016), showed that low-dose irradiation treatment (10 Gy) can be used to increase germination, storage capacity, and growth of *Magnolia champaca* L. seedlings. In addition to the use of gamma ray radiation, one type of treatment to obtain superior mutants is drought stress selection which can be carried out in vitro, namely by adding polyethylene glycol (PEG) to the media. PEG is a polymer that is often used as a solvent in the chemical and pharmaceutical industries (Pertiwi et al., 2021). PEG is also used as a plant selection agent against drought stress because it can reduce the water potential in the media (Zuyasna et al., 2016)

The purpose of this study was to determine the effect of gamma ray radiation doses and two aren varieties on the best germination growth rate of aren (*Arenga pinnata* Merr.)

Research Method

This research is an experimental research. The research will be conducted at the Center for Isotope and Radiation Applications (PAIR), National Nuclear Energy Agency (BATAN), Pasar Jumat, South Jakarta. Soil and Agroclimate and Agroecology Laboratory, Faculty of Agriculture, Sultan Ageng Tirtayasa University (Untirta), and located in the greenhouse of the experimental garden (6°12'07"S 106°07'31"E) Department of Agroecotechnology, Faculty of Agriculture, Sultan Ageng Tirtayasa University From September 2024 to December 2024.

The tools used in this study were soil sieve, 35 cm x 35 cm polybag, SPAD-502 Plus chlorophyll meter, upgraded Co-60 Gamma Cell 220 irradiator for irradiation treatment, desiccator, caliper. While the materials to be used are Parasi variety and local Lebak palm seeds, polyethylene glycol (PEG) 6000), soil (top soil), rice husk charcoal and cow dung fertilizer with a ratio of 1: 1: 1.

The treatment design used a factorial randomized block design (RAK) with two factors, namely the dose of gamma ray radiation (B) and the variety of aren (V). The first factor is the dose of gamma ray radiation (B) consisting of 6 levels, namely: B0 = 0 gy (No radiation) B1 = 4 gy, B2 = 6 gy, B3 = 8 gy, B4 = 10 gy, B5 = 12 gy. The second factor is the variety of aren (V) consisting of 2 levels, namely: V1 = Parasi V2 = Local Lebak. Each combination of treatments was repeated three times, so that a total of 36 experimental units were obtained. Each experimental unit consisted of two polybags and each polybag contained 1 plant seed, so that the number of aren seeds used was 72 aren seeds.

Table 1. Combination of gamma ray radiation dose treatment and palm sugar varieties.

Gamma Radiation Levels	Palm Variety	
	V1	V2
B0	B0V1	B0V2
B1	B1V1	B1V2
B2	B2V1	B2V2
B3	B3V1	B3V2
B4	B4V1	B4V2
B5	B5V1	B5V2

To determine the influence given in this study, an F test was conducted at the

5% level. If the results of the analysis of variance show a real or very real effect, further testing is carried out. In the study, a further Duncan Multiple Range Test (DMRT) test will be conducted at the 5% level. The plant components to be observed are plant height (cm), leaf width (cm), number of leaves (Shell)

Results and Discussion

This research was conducted at the Experimental Garden of the Faculty of Agriculture, Sultan Ageng Tirtayasa University, Kp. Cikuya Karang Kitri, Sindangsari Village, Pabuaran District, Serang Regency, Banten Province. The microclimate conditions at the research site had an average temperature of 25.1°C – 33°C

PEG concentration was applied after planting. This was done to provide acclimatization to the aren sprouts for initial growth before drought treatment, with a concentration of 10% (100 g L⁻¹). After the PEG solution was diluted according to the treatment level, the solution was poured once into the planting medium as much as 100 ml/polybag

The results of the recapitulation of the analysis of the application of gamma ray dosage on the growth of sugar palm plants (*Arenga pinnata* Merr.) are presented in Table 2. The results show the values that affect each observation of gamma ray dosage except in the 2nd week, 3rd week and 4th week on the plant height parameter, while for varieties and interactions did not show any effect. Table 2. Recapitulation of the results of the analysis of the application of gamma ray dosage on the growth of sugar palm plants (*Arenga pinnata* Merr.).

Table 2. Recapitulation of the results of the analysis of the application of gamma ray doses on the growth of sugar palm plants (*Arenga pinnata* Merr.)

No	Observation Parameters	Plant Age (WAP)	Gamma Radiation Levels	Palm Variety	Interaction	coefficient of diversity
1	Plant Height (cm)	2	tn	tn	tn	16,76% ^a
		3	tn	tn	tn	12,36% ^b
		4	tn	tn	tn	14,06% ^b
		5	*	tn	tn	14,62% ^b
		6	**	tn	tn	16,74% ^b
		7	**	tn	tn	18,09% ^b
		8	**	tn	tn	21,54% ^b
		9	**	tn	tn	23,39% ^b
		10	**	tn	tn	25,47% ^b
		2	Leaf Width (cm)	2	**	tn
3	**			tn	tn	18,66% ^b
4	**			tn	tn	18,87% ^b
5	**			tn	tn	19,35% ^b
6	**			tn	tn	19,38% ^b
7	**			tn	tn	19,40% ^b
8	**			tn	tn	19,60% ^b
9	**			tn	tn	19,82% ^b
10	**			tn	tn	19,83% ^b
3	Number of Leaves (strands)			2	**	tn
		3	**	tn	tn	23,24% ^a
		4	**	tn	tn	23,24% ^a
		5	**	tn	tn	24,99% ^a
		6	**	tn	tn	26,85% ^a
		7	**	tn	tn	27,22% ^a

		8	**	tn	tn	26,40% ^a
		9	**	tn	tn	29,15% ^a
		10	**	tn	tn	11,38% ^b

Description:

- * : Significantly Influenced at $\alpha = 5\%$
- ** : Very Significantly Influenced at $\alpha = 1\%$
- tn : No Significant Effect
- KK : Coefficient of Diversity
- WAP : Weeks After Planting
- a : 1 time data transformation
- b : 2 times data transformation
- c : 3 times data transformation

Plant height is an indicator in assessing the vegetative growth of plants. This growth is generally influenced by several factors such as plant physiology, plant genetics and also the surrounding environment. The average results of plant height can be seen in table 3.

Table 3. Average height of sugar palm plants in gamma ray dose treatment with sugar palm varieties

Plant Age (WAP)	Gamma Radiation Levels (B)	Palm Variety (V)		Average
		V1	V2	
2	B0	1.48	1.70	1.59
	B1	1.61	1.66	1.63
	B2	2.06	1.76	1.91
	B3	1.50	1.63	1.56
	B4	2.00	1.72	1.86
	B5	1.52	1.47	1.49
	Average	1.69	1.66	1.67
3	B0	1.19	1.19	1.19
	B1	1.21	1.35	1.28
	B2	1.40	1.31	1.35
	B3	1.10	1.23	1.16
	B4	1.21	1.10	1.16
	B5	1.10	1.10	1.10
	Average	1.20	1.21	1.21
4	B0	1.32	1.36	1.34ab
	B1	1.40	1.49	1.45a
	B2	1.50	1.38	1.44a
	B3	1.22	1.21	1.22ab
	B4	1.39	1.10	1.25ab
	B5	1.10	1.10	1.10b
	Average	1.32	1.27	1.30
5	B0	1.42	1.49	1.45ab
	B1	1.54	1.54	1.54a
	B2	1.67	1.53	1.60a
	B3	1.23	1.26	1.24ab
	B4	1.42	1.17	1.30ab
	B5	1.10	1.10	1.10b
	Average	1.40	1.35	1.37

6	B0	1.48	1.60	1.54abc
	B1	1.76	1.59	1.68ab
	B2	1.84	1.62	1.73a
	B3	1.23	1.30	1.27bc
	B4	1.47	1.24	1.35abc
	B5	1.10	1.10	1.10c
	Average	1.48	1.41	1.44
7	B0	1.54	1.72	1.63ab
	B1	1.86	1.66	1.76a
	B2	1.97	1.76	1.87a
	B3	1.29	1.36	1.33ab
	B4	1.54	1.27	1.41ab
	B5	1.10	1.10	1.10b
	Average	1.55	1.48	1.51
8	B0	1.58	1.83	1.71ab
	B1	2.11	1.70	1.91a
	B2	2.13	1.88	2.01a
	B3	1.35	1.40	1.38ab
	B4	1.69	1.33	1.51ab
	B5	1.10	1.10	1.10b
	Average	1.66	1.54	1.60
9	B0	1.63	1.92	1.77ab
	B1	2.23	1.75	1.99a
	B2	2.23	1.97	2.10a
	B3	1.40	1.43	1.41ab
	B4	1.79	1.40	1.59ab
	B5	1.10	1.10	1.10b
	Average	1.73	1.60	1.66
10	B0	1.65	1.98	1.81ab
	B1	2.33	1.82	2.07a
	B2	2.30	2.09	2.20a
	B3	1.44	1.47	1.45ab
	B4	1.90	1.47	1.68ab
	B5	1.10	1.10	1.10b
	Average	1.79	1.65	1.72

Description: Numbers followed by the same letter in the same column or row indicate significant differences based on the 5% DMRT test.

Based on the data presented in Table 3, it is known that the treatment of the type of planting media has a significant effect on the parameters of plant height at the beginning of growth, namely at 2,3 and 4 MST. Based on research by Effendi (2010), the air temperature needed for the growth of sugar palm plants is at least an average of 25°C, so that the temperature data at the research site is not a problem in the growth process or production of sugar palm plants. The altitude at the research site is 117.34 meters above sea level, land conditions that are suitable for sugar palm plants are land that has a moderate to wet climate with fairly high rainfall ranging from 1,200-3,500 mm/year.

The administration of gamma ray doses that gave the highest results was at a gamma ray dose of 6 gy (B2) which was at 9 MST of 2.10 cm, while when compared to

the overall results of plant height, the administration of gamma ray doses of more than 6 gy resulted in plant height not exceeding the height of plants at a dose of 6 gy. Zanzibar (2011) stated that the use of 5 Gy irradiation doses on seeds that have decreased in quality will significantly increase the potential of seeds to produce normal seedlings. Low-dose irradiation treatment on seeds that have aged or whose viability has decreased will increase seedling growth.

Leaves are important organs in plants because they function as a place for photosynthesis activity, the more leaves there are, the more photosynthesis production will increase and tend to be stronger because of the abundant availability of nutrients (Yama and Kartiko, 2020). Observation of the number of leaves can be one indicator of plant vegetative growth parameters.

Table 4. Average number of leaves of sugar palm plants in gamma ray dose treatment with sugar palm varieties

Plant Age (WAP)	Gamma Radiation Levels (B)	Palm Variety (V)		Average
		V1	V2	
2	B0	1.05	1.05	1.05ab
	B1	1.22	1.17	1.20a
	B2	1.22	1.22	1.22a
	B3	0.88	0.88	0.88ab
	B4	1.22	1.05	1.14ab
	B5	0.71	0.71	0.71b
	Average	1.05	1.01	1.03
3	B0	1.05	1.05	1.05ab
	B1	1.22	1.17	1.20a
	B2	1.22	1.22	1.22a
	B3	0.88	0.88	0.88ab
	B4	1.22	1.05	1.14ab
	B5	0.71	0.71	0.71b
	Average	1.05	1.01	1.03
4	B0	1.05	1.05	1.05ab
	B1	1.22	1.17	1.20a
	B2	1.22	1.22	1.22a
	B3	0.88	0.88	0.88ab
	B4	1.22	1.05	1.14ab
	B5	0.71	0.71	0.71b
	Average	1.05	1.01	1.03
5	B0	1.05	1.17	1.11ab
	B1	1.22	1.17	1.20a
	B2	1.34	1.22	1.28a
	B3	0.88	0.88	0.88ab
	B4	1.22	1.05	1.14ab
	B5	0.71	0.71	0.71b
	Average	1.07	1.03	1.05
6	B0	1.05	1.29	1.17ab
	B1	1.46	1.23	1.35a
	B2	1.46	1.41	1.43a

	B3	0.88	1.05	0.97bc
	B4	1.29	1.17	1.23ab
	B5	0.71	0.71	0.71c
	Average	1.14	1.14	1.14
7	B0	1.17	1.29	1.23ab
	B1	1.46	1.23	1.35a
	B2	1.58	1.46	1.52a
	B3	0.88	1.17	1.03ab
	B4	1.35	1.17	1.26ab
	B5	0.71	0.71	0.71b
	Average	1.19	1.17	1.18
8	B0	1.17	1.29	1.23ab
	B1	1.58	1.23	1.41a
	B2	1.58	1.53	1.55a
	B3	0.88	1.17	1.03ab
	B4	1.41	1.17	1.29a
	B5	0.71	0.71	0.71b
	Average	1.22	1.18	1.20
9	B0	1.17	1.39	1.28ab
	B1	1.77	1.39	1.58a
	B2	1.63	1.53	1.58a
	B3	0.88	1.17	1.03ab
	B4	1.53	1.29	1.41a
	B5	0.71	0.71	0.71b
	Average	1.28	1.24	1.26
10	B0	1.28	1.36	1.32ab
	B1	1.51	1.36	1.43a
	B2	1.46	1.44	1.45a
	B3	1.21	1.28	1.25ab
	B4	1.44	1.33	1.39a
	B5	1.10	1.10	1.10b
	Average	1.33	1.31	1.32

Description: Numbers followed by the same letter in the same column or row indicate significant differences based on the 5% DMRT test.

The results of the analysis showed that the gamma ray dose treatment had a significant effect on the number of leaves. There was no interaction between the gamma ray dose and the variety of sugar palm plants. The best response was shown by plant samples with a gamma ray dose treatment of 6 gy with an average leaf number of 1.55 strands. Gamma ray irradiation can cause chromosome aberration (broken chromosome threads) in plants. This can affect plant growth such as the growth power of leaf buds (Lestari et al. 2018).

Leaf width also has a correlation with the rate of photosynthesis, the wider the leaf surface, the greater the area available to absorb light, thereby increasing the photosynthesis process. This has an impact on the production of photosynthate, namely carbohydrates and sugars used for plant growth and development (Lewar and Hasan, 2022). The average leaf width results can be seen in table 5.

Table 5. Average leaf width of sugar palm plants in gamma ray dose treatment with sugar palm varieties

Plant Age (WAP)	Gamma Radiation Levels (B)	Palm Variety (V)		Average
		V1	V2	
2	B0	1.36	1.64	1.50ab
	B1	1.86	1.45	1.65a
	B2	1.76	1.56	1.66a
	B3	1.27	1.31	1.29ab
	B4	1.37	1.17	1.27ab
	B5	1.10	1.10	1.10b
	Average	1.45	1.37	1.41
3	B0	1.37	1.64	1.50ab
	B1	1.88	1.50	1.69a
	B2	1.76	1.66	1.71a
	B3	1.28	1.33	1.31ab
	B4	1.47	1.24	1.36ab
	B5	1.10	1.10	1.10b
	Average	1.48	1.41	1.44
4	B0	1.32	1.36	1.34ab
	B1	1.40	1.49	1.45a
	B2	1.50	1.38	1.44a
	B3	1.22	1.21	1.22ab
	B4	1.39	1.10	1.25ab
	B5	1.10	1.10	1.10a
	Average	1.32	1.27	1.30
5	B0	1.37	1.64	1.51ab
	B1	1.91	1.59	1.75a
	B2	1.79	1.68	1.73a
	B3	1.29	1.36	1.33ab
	B4	1.60	1.30	1.45ab
	B5	1.10	1.10	1.10b
	Average	1.51	1.45	1.48
6	B0	1.37	1.64	1.51ab
	B1	1.91	1.59	1.75a
	B2	1.79	1.68	1.73a
	B3	1.29	1.36	1.33ab
	B4	1.60	1.30	1.45ab
	B5	1.10	1.10	1.10b
	Average	1.51	1.45	1.48
7	B0	1.37	1.65	1.51ab
	B1	1.91	1.60	1.75a
	B2	1.80	1.70	1.75a
	B3	1.30	1.41	1.36ab
	B4	1.62	1.30	1.46ab
	B5	1.10	1.10	1.10b
	Average	1.52	1.46	1.49
8	B0	1.37	1.66	1.51ab

	B1	1.91	1.61	1.76a
	B2	1.80	1.70	1.75a
	B3	1.30	1.43	1.37ab
	B4	1.63	1.33	1.48ab
	B5	1.10	1.10	1.10b
	Average	1.52	1.47	1.49
9	B0	1.37	1.66	1.51b
	B1	1.91	1.61	1.76a
	B2	1.83	1.71	1.77a
	B3	1.30	1.44	1.37ab
	B4	1.63	1.33	1.48ab
	B5	1.10	1.10	1.10b
	Average	1.52	1.47	1.50
10	B0	1.37	1.71	1.54ab
	B1	1.93	1.62	1.77a
	B2	1.95	1.77	1.86a
	B3	1.30	1.46	1.38a
	B4	1.71	1.45	1.58ab
	B5	1.10	1.10	1.10b
	Average	1.56	1.52	1.54

Description: Numbers followed by the same letter in the same column or row indicate significant differences based on the 5% DMRT test.

The results of the analysis showed that the gamma ray dose treatment had a significant effect on the number of leaves. There was no interaction between the gamma ray dose and the variety of sugar palm plants. The gamma ray dose treatment could slightly increase the leaf width compared to the control treatment. The best response was shown by plant samples with a gamma ray dose treatment of 6 gy with an average value of 1.86 cm at 10 MST. Changes in plant morphology due to radiation can be caused by the interaction of gamma rays with molecules that can produce free radicals. These free radicals trigger the modification of cell components which results in changes in plant morphology. (Hartati, et al 2022).

Conclusion

Based on the results of the research and discussion, it can be concluded as follows The best use of gamma ray doses on sugar palm plants is 6 Gy and the varieties used do not show any interaction with the use of gamma ray doses.

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