

GROWTH RESPONSE OF TWO SOYBEAN (*Glycine max* (L.) Merr) VARIETIES DENNA 1 AND RAJABASA SUBJECTED TO RADIATION MUTATION TECHNIQUE

Lilik Harsanti¹, Sasanti Widiarsih¹, Tarmizi¹ and Khafidhotur Rizal²

1. Research Center for Radiation Process Technology, Research Organisation of Power, Nasional Research and Innovation Agency. Jl. Lebak Bulus Raya No. 49, Jakarta 12440, Indonesia

2. National Development University "Veteran" Surabaya.
liliksaleh5@gmail.com

ABSTRACT

GROWTH RESPONSE OF TWO SOYBEAN (*Glycine max* (L.) Merr) VARIETIES DENNA 1 AND RAJABASA SUBJECTED TO RADIATION MUTATION TECHNIQUE.

The soybean production is one of the national programs to reduce dependence on soybean imports and to achieve soybean self-sufficiency by 2022. Soybean seeds of Denna 1 and Rajabasa varieties are irradiated with gamma ray. The treatments used were ranged from 0 -1000 Gy. The treated seeds were planted in aluminum trays in Pasarjumat, Jakarta. The germination rate was the highest on Denna 1 at 0 Gy (88.35%), while the lowest was in Rajabasa at 900 and 1000 Gy, which was both 40%. The highest plant height was in Denna 1 at 0 Gy (34.53 cm), while the lowest was at 800 Gy (1.30 cm). The highest number of leaves was in Denna 1 at 200 Gy (6.40 cm) and the lowest was Rajabasa at 400 Gy (0.50). The longest flowering age at M3 generation was found in Rajabasa-2 at 400 Gy (44,33 days) and the lowest Denna-1.3 at 300 Gy (41,67 days). For weight of filled pods, the highest was indicated in Rajabasa mutant line 200 Gy (55,33 g) and the lowest was in Rajabasa-1 at 300 Gy (33 g). The conclusion of this dosage orientation experiment may help determining the optimum dose on post-irradiated plants.

Keywords: irradiation, dose, soybean, greenhouse, varieties

1. Introduction

Soybean is one of the most important food commodities after rice and corn. One of the government's programs to increase domestic soybean production to reduce dependence on imports needs to be continuously supported by all elements in Indonesia. The role of soybean as a secondary food commodity which is rich in vegetable protein content which in its utilization has various uses, especially as a raw material for the food industry (tempe, tofu, tauco, soy milk, edible oil and soybean flour) and raw material for the animal feed industry. while, the two processing industries are growing in line with business developments. This condition causes the demand for soybeans to continue to increase from year to year, but domestic soybean production cannot keep up with it, so to meet it, it must be imported [1].

Soybean production is currently decreasing every year, one of which is influenced by land area. The land available in Indonesia is mostly used by farmers to cultivate crops that have the potential to meet their economic needs, so very few farmers use their land for soybeans [2].

Cultivation of soybeans as intercroops under plantation stands, industrial forest plantations or intercropping with other seasonal food crops is a strategy to increase national soybean production. However, soybean cultivation as intercropping or intercropping faces various obstacles, one of which is lack of light due to shade [3]. Cultivation of soybeans as intercroops

under plantation stands, industrial forest plantations, or intercropping with other seasonal food crops is a strategy to increase national soybean production. However, soybean cultivation as intercropping or intercropping faces various obstacles, one of which is lack of light due to shade [3]. The effect of 50 % shade intensity gives effect on plants (4)

Soybean production, including by expanding the planted area and increasing production per unit area. Expansion of the planting area by utilizing unproductive land, sub-optimal land and shaded land [5]. In line with these problems, planting shade-tolerant soybeans as intercrops is considered as one of the efforts that can be taken to increase land productivity which is now decreasing [6]. while, increasing the production of broad units, including by using high-yielding varieties assembled through plant breeding programs.

Soybean breeding aims to obtain superior soybean varieties that are able to adapt to various environmental conditions. Plant breeding using crosses is still the main method of improving plant varieties in Indonesia. However, the limited genetic resources used as parents in crosses can be an obstacle for this method. To expand genetic diversity in a population, one way that can be used is the mutation method [7].

Utilization of genetic resources through breeding programs to obtain early maturing soybean varieties and high yielding productivity is carried out by various approaches, such as increasing plant genetic diversity through crossbreeding, somaclonal variation, and mutation techniques [8].

Plant breeding using radiation mutation techniques has developed quite rapidly in Indonesia, especially at the National Nuclear Energy Agency to obtain new superior varieties. Currently, various superior varieties of rice, soybeans, sorghum, green beans, wheat and cotton have been released. Various superior varieties with radiation mutation techniques have contributed to increasing the production of agricultural commodities in Indonesia. One of the agricultural commodities that have been produced using this radiation mutation technique is soybean [9,10]. Currently, PRTPR ORTN BRIN has released 15 superior soybean varieties through

Mutation is a process in which genes under changes or all kinds of changes in hereditary material that cause changes in phenotypes that are passed on from one generation to the next. By using mutagens or materials that cause mutations, new diversity can be created in an effort to obtain superior varieties according to the purpose of breeding [11].

Plant breeding with induced mutations is an effective way to enrich the existing germplasm and at the same time to improve varieties [8]. The advantages of mutation techniques include that one of the characteristics of a variety can be improved without changing other traits, causing new traits that are not owned by the parent, being able to separate gene links and this method is complementary to other techniques so that these techniques can be used simultaneously. with other techniques such as hybridization and biotechnology [12].

The results research has been carried out on shade-tolerant soybeans at the Research Center for Radiation Process Technology, Research Organization of Power, Nasional Research and Innovation Agency, to obtain doses to look for shade-tolerant soybean lines. RAJABASA is the superior variety. then carried out with radiation mutation technique on soybean varieties Denna 1 and varieties Rajabasa. The use of high-quality varieties, in this case high production and disease resistance, is one of the criteria to make soybeans a superior commodity for shade-resistant soybeans [13].

2. Material and Methods

a. Preparation

Aluminum tubs are filled with homogeneous soil mixed with biological fertilizers for planting soybean seeds at the Green house. The materials used were 500 seeds of shade-resistant soybean varieties Denna 1 (Variety Ministry of Agriculture) and Rajabasa (PRTPR ORTN BRIN) varieties that had been irradiated with ^{60}Co (dose rate of 1.527 Gy/second) with doses of 0, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000 Gy.

b. Planting

Soybean seeds of Denna 1 and Rajabasa varieties that had been irradiated were planted in 8 aluminum tubs as replicates, each aluminum tub was labeled with a row of 0 Gy, 100 Gy, 200 Gy, 300 Gy, 400 Gy, 500 Gy, 600 Gy, 700 Gy, 800 Gy, 900 Gy and 1000 Gy. On the third day the amount of growth was observed as well as on the 7th, 14th and 21st days.

Observations made by shade-tolerant soybeans on the Denna 1 and Rajabasa varieties included:

1. The ability of viable soybean seeds to germinate.
2. Soybean Plant Height
3. Number of leaves of soybean plant
4. Soybean Leaf Width
5. Soybean Root Length

3. Results and discussion

Soybean plants are plants that require full sun to grow normally, but can still grow at a certain level of shade. The development of soybean plants as intercropping or intercropping is an alternative to increase soybean production [14]. Observations of soybean plants were carried out on the ability of viable soybean seeds to germinate.

Observations in Table 1. show that the percentage of germination growth was the largest or highest in the Denna 1 variety, which was a dose of 100 Gy, which was 90 percent of the Rajabasa variety at a dose of 200 Gy, which was 71.65, while the lowest was in the Denna 1 variety at a dose of 200 Gy, namely 70% and Rajabasa varieties with doses of 900 and 1000 Gy respectively 40 percent.



Figure 1. The process of observing soybean germination

The higher the radiation dose or the lower the ability to survive on soybean seeds, it can be seen in Figure 1 on the growth of germination, it can be seen that further growth observations can be seen.

Table 1. Germination of Soybeans of Denna 1 and Rajabasa Varieties of Radiation Results

Presentation Germination					
Variety	Dose	Presentation	Variety	Dose	Presentation
Denna 1			Rajabasa	0 gy	

0 gy	88,35			55
100 gy	90		100gy	41,65
200 gy	70		200gy	71,65
300 gy	83,35		300 gy	61,65
400 gy	70,85		400 gy	57,5
500 gy	83,35		500 gy	55,85
600 gy	75		600 gy	39,15
700 gy	83,35		700 gy	52,5
800 gy	84,15		800 gy	55
900 gy	71,65		900 gy	40
1000 gy	84,15		1000 gy	40

Plant breeding using crosses is still the main method of improving plant varieties in Indonesia. However, the limited genetic resources used as parents in crosses can be an obstacle for this method. To expand genetic diversity in a population, one way that can be used is the mutation method [7].

Plant Height

The results of observations 14 days after planting on soybean plant height from dose orientation of the Denna 1 variety showed that at the dose 0 Gy dose treatment the Denna 1 variety showed the maximum height compared to other dose treatments, with an average height of about 34.53 cm and The lowest yield can be seen in the 1000 Gy treatment with an average height of only 1.43 cm in the Denna 1 variety and the lowest result can be seen in the dose 1000 Gy treatment with an average of 1.47. All variations in soybean plant height from various dose treatments were caused by the effects of gamma ray radiation

Gamma ray radiation which has a very strong penetrating power can cause DNA changes in the parent plant so that mutations occur. Mutations that occur can be good or bad. As is the case with the difference in plant height from the results of the dose orientation. This is in accordance with research [2] which showed that gamma ray radiation causes genetic changes in soybean plants. The yield of plant height can be seen in (figure 2).

As was the case with the soybean plant height, it can be seen that the height of the dose-oriented treatment results was very diverse, which from these results could be selected so that better traits or characters could be selected, while good characters in the original plant or variety is retained.

Table 2. Pant Heght Variety Denna 1 and Rajabasa

Variety	Dose Radiation	Average Plant Height (cm)	Variety	Dose Radiation	Average plant Height (cm)
Denna 1	0 Gy	34,53	Rajabasa	0 Gy	30,10
	100 Gy	30,27		100 Gy	25,33
	200 Gy	25,77		200 Gy	25,00
	300 Gy	17,97		300 Gy	12,77
	400 Gy	8,6		400 Gy	5,27

500 Gy	3,77	500 Gy	3,57
600 Gy	2,00	600 Gy	2,60
700 Gy	1,70	700 Gy	2,40
800 Gy	1,30	800 Gy	2,47
900 Gy	1,53	900 Gy	1,80
1000 Gy	1,43	1000 Gy	1,47

The interaction between genotype x environment had a significant effect on plant height, number of filled pods, flowering age, ripening age, seed yield, and weight of 100 seeds [15].

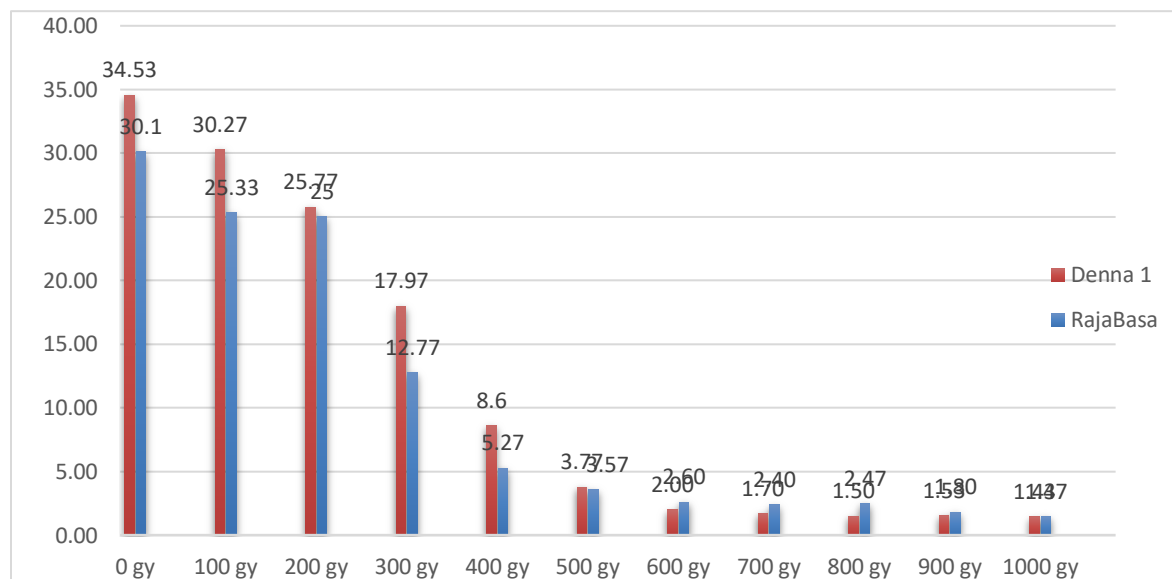


Figure 2. Denna 1 and Rajabasa Plant Height

Number of Leaves

One of the parameters of the observations made is the calculation of the number of leaves. The results for the calculation of the number of leaves at 14 days after planting can be seen in the table.3

the number of leaves it was seen that. Measurement of the number of leaves on the Denna 1 variety showed that the highest number of leaves was at a dose of dose 200 Gy with an average number of leaves of 6.40, while for the Rajabasa variety it could be seen that the dose 100 Gy treatment had the highest number of leaves compared to that of the Rajabasa variety. the other dose orientation treatment, namely the number of leaves an average of 3.47 leaves per plant (figure.3)

Table 3. Number of leaves of Denna 1 and Rajabasa soybean plants

Variety	Dose Radiation	Average leave number	Variety	Dose Radiation	Average leave number
Denna 1	0 Gy	5,00	Rajabasa	0 Gy	3,20
	100 Gy	5,00		100 Gy	3,47
	200 Gy	6,40		200 Gy	3,00
	300 Gy	4,67		300 Gy	1,27

400 Gy	3,20	400 Gy	0,50
500 Gy	0,60	500 Gy	0
600 Gy	0	600 Gy	0
700 Gy	0	700 Gy	0
800 Gy	0	800 Gy	0
900 Gy	0	900 Gy	0
1000 Gy	0	1000 Gy	0

The effect of the dose orientation treatment of gamma rays. It can also be concluded that the higher the radiation dose given, the plant's ability to produce leaves is also very low [6].

As for the 0 Gy or control doses, 200 Gy, 300 Gy, 400 Gy had a lower average number of leaves. Then it can be seen that at a treatment dose of 500 Gy - 1000 Gy the ability of plants to produce leaves is very weak, it can be seen that at that dose treatment no leaves grow on both varieties as shown in Figure 2. There is a comparison between the Denna 1 and Rajabasa varieties.

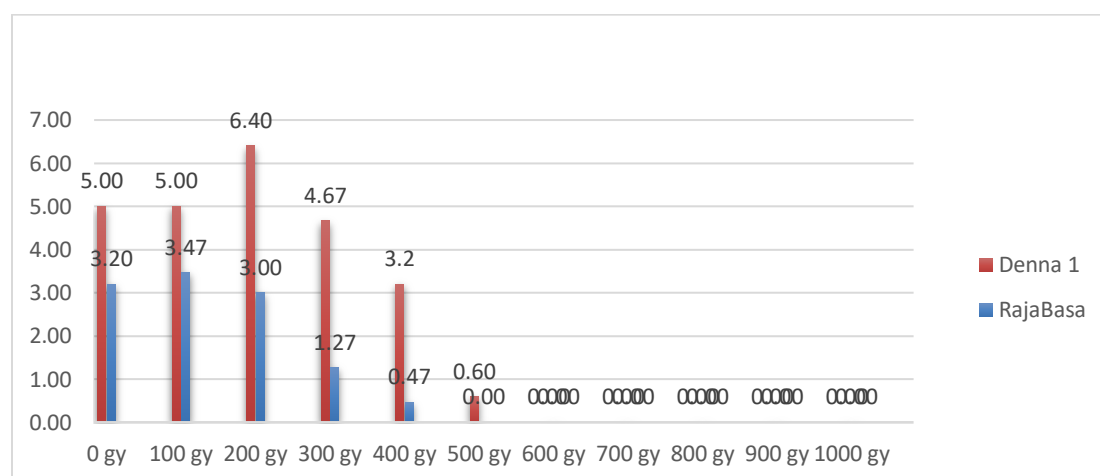


Figure 3. Number of Leaves of Denna 1 and Rajabasa Varieties

leaf width

From the observations in Table 4. for the Denna 1 variety, it can be seen that the measurement of leaf width at 14 days after planting at a dose of 0 Gy or control treatment had the widest leaves compared to other dose orientation treatments, with an average leaf width of 3.43 cm and a difference of 3.43 cm (Figure.4) slightly with a treatment doses of 100 Gy - 400 Gy which only has a difference of 0.3 mm. However, when compared to the treatment at doses of 400 Gy - 500 Gy, the differences were very much, and at this dose treatment the leaves on soybean plants had experienced differences in shape and color to become abnormal.

Then for doses of 600 Gy - 1000 Gy there are no leaves on soybean plants, so that leaf width cannot be measured. Like wise for the Rajabasa variety, the dose of 0 Gy is the dose that has an average leaf width of 3.21 and at a dose of 400 Gy - 500 Gy has the lowest leaf width. This is influenced by the results of gamma ray radiation. The rate of mutation varies according to the dose, the higher the dose of the mutagen, the more frequent mutations will occur and the more frequent chromosomal damage, which means the higher the genetic damage but also the higher the physiological damage (mutated cells die) [16].

Table 4. Leaf Width of Denna 1 and Rajabasa

Variety	Dose Radiation	Average Leaf Width (cm)	Variety	Dose Radiation	Average Leaf Width (cm)
Denna 1	0 Gy	3,43	Rajabasa	0 Gy	3,21
	100 Gy	3,23		100 Gy	2,41
	200 Gy	2,11		200 Gy	2,77
	300 Gy	2,64		300 Gy	1,62
	400 Gy	1,55		400 Gy	0,27
	500 Gy	0,28		500 Gy	0,11
	600 Gy	0		600 Gy	0
	700 Gy	0		700 Gy	0
	800 Gy	0		800 Gy	0
	900 Gy	0		900 Gy	0
	1000 Gy	0		1000 Gy	0

It can also be seen that the higher the radiation dose, the smaller the leaf width on soybeans as well as the number of leaves.

The following is Figure 4. From the final measurement 14 days after planting the width of the soybean leaf from the dose orientation of the Denna 1 and Rajabasa varieties, it can be seen that the difference is getting wider and the leaf growth is getting less leaf due to the high dose of radiation given.

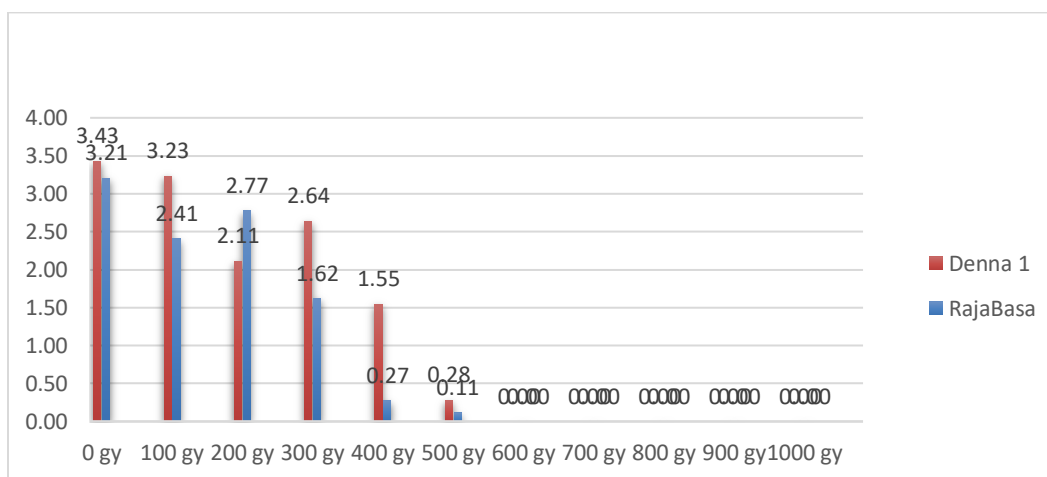


Figure 4. Leaf width of Denna 1 and Rajabasa varieties

Root Length

Root length is also an important thing to be used as a research parameter on the effect of gamma ray irradiation on the growth of the Denna 1 or shade-resistant soybean plant and on the growth of the Rajabasa or acid-resistant soybean plant where this Rajabasa variety serves as a comparison. The results of measurements of root length can be seen in the table. 5 for the Denna 1 and Rajabasa varieties, the highest yield of root length was the Denna 1 variety at a dose of 0 Gy, which was 29.93 cm, while the Rajabasa variety was also at a dose of 0 Gy (20.97 cm). Meanwhile, the lowest root length in the Denna 1 variety with a dose of 800 Gy (13.27 cm), while for the Rajabasa variety the lowest dose of 1000 Gy (8.47 cm). Irradiation on seeds is to

determine the dose on plants after irradiation to get the plants we want, the higher the radiation dose, the soybean plants will be unable to survive or die [10].

Table 5. Root Length of Denna 1 and Rajabasa

Variety	Dose Radiation	Average Root Length (cm)	Variety	Dose Radiation	Average Root Length (cm)
Denna 1	0 Gy	29,93	Rajabasa	0 Gy	20,97
	100 Gy	24,87		100 Gy	12,93
	200 Gy	13,63		200 Gy	16,70
	300 Gy	18,53		300 Gy	10,87
	400 Gy	16,23		400 Gy	10,60
	500Gy	16,87		500 Gy	10,87
	600 Gy	15,83		600 Gy	8,83
	700 Gy	17,00		700 Gy	11,87
	800 Gy	13,27		800 Gy	11,37
	900 Gy	13,77		900 Gy	10,53
	1000 Gy	13,43		1000 Gy	8,47

The following is Figure 5. From the final measurement 14 days after planting, the root length of soybean plants as a result of gamma ray irradiation of the Denna 1 and Rajabasa varieties showed a very large difference in root length, the higher the radiation dose, the shorter the root length.

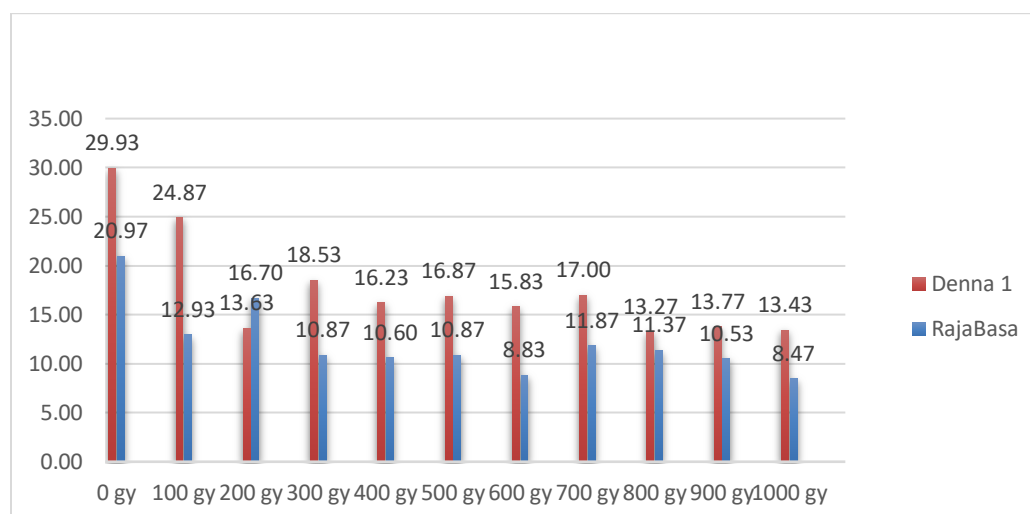


Figure 5. Final Result observation of Root Length of Denna 1 and Rajabasa

The result of observation generation M3 variety at two months of age in the shade-tolerant soybean use net intensitas 50 % experimental garden at Citayam, Bogor, West Java, can be see in table 6 and figure 6 namely at the flowering, while the hight yield Rajabasa 2 dose 400 Gy ($44,33 \pm 1,16$) and the lowest Denna 1.3 dose 300 Gy ($41,67 \pm 1,56$), the hight yield of filled pods in the Rajabasa mutant line dose 200 Gy ($55,33 \pm 8,97$) the lowest Rajabasa 1 dose 300 Gy (33 ± 8). Flowering age and number of pods if the highest yield is the weight production of the plant in shaded condotions [17]

Tabel. 6: Flowering age and number of pods Generation M3 shade-tolerant soybean net intensitas 50%

Location : Experimental Garden Citayam, Bogor West Java

No.	Mutant lines/Variety	Flowering age (day)	number of pods (gram)
1.	Denna 1.2. 200 gy	45,33±0,57	36±0,6
2.	Denna 1.3 300 Gy	41,67±1,56	43,33±1,53
3.	Mutiara A 200 Gy	43±2	42,67±3,79
4.	Rajabasa 1 300 Gy	43,67±2,31	33±8
5.	Rajabasa 400 Gy	43,67±1,16	42,33±2,31
6.	Rajabasa 200 Gy	43,67±1,16	55,33±8,97
7.	Rajabasa 2 400 Gy	44,33±1,16	42±7,55
8.	Rajabasa	44±1	45,33±4,51
9.	Denna 1	42,33±1,16	42,33±2,52



Figure 6. Shade Tolerant Generation M3 Plant Soybean Net Intensitas 50%, at Citayam, Bogor, West Java

4. Conclusion

1. The ability to germinate after irradiation of soybean plants resulted in the largest or highest percentage of germination growth power in the Denna 1 variety, namely a dose of 100 Gy, which was 90 percent of the Rajabasa variety at a dose of 200 Gy, namely 71.65 which grew.
2. Soybean plant height after irradiation on day 14, the highest dose of 0 Gy was 34.53 cm in the Denna 1 variety, while the Rajabasa variety at the 0 Gy dose was 30.10 cm.

3. The results for the highest number of leaves were observed at 14 DAP on soybeans of the Denna 1 variety at a dose of 200 Gy, namely 6.4 while the Rajabasa variety at a dose of 100 Gy with an average number of leaves was 3.47cm.
4. The results of observations for the leaf width of soybean varieties with Denna 1 at a dose of 0 Gy was 3.34 cm, while the Rajabasa variety at a dose of 0 Gy was 3.21 cm.
5. The maximum root length measurement on day 14 showed that the Denna 1 variety soybean at a dose of 0 Gy was 29.93 cm, while the Rajabasa variety at a dose of 0 Gy was 20.97 cm.
6. Dosage orientation is to determine the dose of post-irradiated plants to get the plants we want, the higher the radiation dose, the more soybeans will be unable to survive or die.
7. Flowering age the hight yield Rajabasa 2. 400 Gy ($44,33 \pm 1,16$) and the lowest Denna 1.3 300 Gy ($41,67 \pm 1,56$), and number of pods the hight yield of filled pods in the Rajabasa mutant line 200 Gy ($55,33 \pm 8,97$) the lowest Rajabasa 1 300Gy (33 ± 8). if the highest yield is the weight production of the plant in shaded condotions.

5. Acknowledgments

The author would like to thank Nadi and Parno who have assisted in this research from the beginning until this research is completed and this research will be continued to the next stage for field testing.

6. References

- [1]. Irawan. Determining Factors and Farmer Decisions in Choosing Soybean Varieties in Pidie District. J.Agrisep. Vol (14) No. 1 pp.10.2013
- [2]. Noertjahyani, Akbar, C., Komariah, A. & Mulyana, H. Shade Effect On Grouth, Yield, and Shade Tolerance of Three Peanut Cultivars. Jurnal Agro 7(1), 2020
- [3]. Chairudin, Efendi, and Sabaruddin. Impact Shade Against Changes in Agronomic Character and Morpho-Physiology of Leaves in Soybean Plants (*Glycine max* (L) Merrill) Journal of Floratek.10: pp 26 – 35. 2015
- [4]. Noertjahyani Choirul Akbar, Ai Komariah and Hudaya Mulyana. 2020. Shade Effect and Growth, Yield, and Shade Tolerance of Three Peanut Cultivars. Journal Agro 7 (1) p.102
- [5]. Nerty Soverda and Yulia Alia. Morphological Responses of Several Genotypes of Soybean (*Glycine max* (L.) Merril) Results of Crosses of Tolerant and Sensitive Varieties in Shade. Journal of Agrium 15(2), 2018
- [6]. Adwitya Handriawan1, Dyah Weny Respatie, Tohari.. Effect of Shade Intensity on Growth and Yield of Three Soybean Cultivars (*Glycine max* (L.) Merrill) in Bugel Beach Sand Land, Kulon Progo. Vegetalika.5(3): 1-14.2016
- [7]. Harsanti Lilik and Yulidar Growth of Soybean Varieties (*Glycine max* (L.) Merill) In Generation M2 With Mutation Techniques. Journal of Indonesian Nuclear Science and Technology.. Vol.19.No.2 pp. 53-60. 2019
- [8]. Anna P K L, Ying C ung, Sobari H, Abdul R H, Atsusi T and Haseyoshihiro, *Morpohological and Biochemical Responses of Oryza sativaL (kultival MR 219) to ion beam irradiation*, Journal of Zhenjiang University Science.4.(12):pp.53-58. 2013.

- [9]. A. Haitami, Elfi Indrawanis, Chairil Ezward, Wahyudi. The Growth and Production Performance of Several Soybean Varieties (*Glycine Max L.*) In The Palm Oil Palm Oil Compartment. *Journal Agrotekma*, 4 (2) Juni 2020
- [10]. Harsanti Lilik and Yulidar Effect of Gamma Ray Irradiation on Early Growth Soybean Plant *Glycine max(L.) Merrill* Denna variety 2. *Proceedings and Scientific Presentations-Basic Research in Nuclear Science and Technology*. pp.59-63. 2015.
- [11]. Saryoko, Z Yursak, Y Astuti, S Kurniawati, S Kusumawati, and T Mulyaqin. Yield Performance of Shade Tolerant Soybean Cultivars under Shaded Environment at Various Planting Densities. *The 2nd International Conference on Agriculture and Rural Development IOP Conf. Series: Earth and Environmental Science* 715 p. 1. 2021
- [12]. Riefena Rahmanda, Titin Sumarni, Setyo Mudo Tyasmaoro. Two Soy Response (*Glycine max (L.) Merr*) Against Differences in Light Intensity in the System Sengon Agroforestry. *Journal Production Plant..Vo.5. No.9. pp.1561.2017.*
- [13]. Ashadi. Mutation Breeding for Improvement of Age and Productivity in Soya beans. *Journal of Agrobiogen.9.(3): 135 - 142. 2013.*
- [14]. Adwitya Handriawan, Dyah Weny Respatie, Tohari, Dyah Weny Respatie, Effect of Shade Intensity on Growth and Yield of Three Soybean Cultivars (*Glycine max (L.) Merrill*) in Bugel Beach Sand Land, Kulon Progo. *Jounal Vegetalika*. 2016. 5(3): 1-14
- [15]. Titik Sundari, Novita Nugrahaeni, and Gatut Wahyu Anggoro Susanto. Interaction Genotype x Environment and Yield Stability of Shade Tolerant Soybeans. *Journal Agronomy. Indonesia.44 (1) : 16 – 25.2016.*
- [16]. IAEA. *Manual Mutation Breeding*. Second Edition. Join FAO – IAEA, Vienna.2018.
- [17]. Nerty Sorveda and Yulia Alia. Morphological Responses of Several Soybean Genotypes from Crosses of Tolerant and Sensitivities in shade. *Journal Agrium* 15(2) h.66-69. 2018

