Radio-Sensitivity Test Of Acute Gamma Irradiation Of Two Variety Of Chili Pepper Chili Bangi 3 And Chili Bangi 5

Aisha, A.H, Rafii, M.Y, Rahim H.A, Juraimi A.S, Misran, A, Oladosu Yusuff

Abstract: Induced mutation is a powerful method to generate heritable variation by exposing plant materials such as seeds, seedlings or other plant parts to physical or chemical mutagens. Mutagenesis remarkably enhanced the agronomical and physiological characters such as pest and diseases resistance, improve yield and yield related traits in crops. Gamma radiation is the most extensively use mutagen to induce mutation in plant breeding because of cost effectiveness, high mutation frequency, and reproducibility. Based on this background, this study was conducted on two chili varieties namely, Bangi3 and Bangi5 by exposing them to different dose of gamma ray 100, 200, 300, 400, 500, 600, 700, 800, 900 and 1000 Gy to determine LD50 and the morph-physiological responses. The irradiated seeds along with the control seeds were sown in nursery bed in the greenhouse in field 16 at Faculty of Agriculture, Universiti Putra Malaysia. Lethal dose LD50 of two chili varieties was determined. The effect of gamma- ray on shoot length, length of root, fresh and dry weight of shoot and root, survival plants were assayed. The result revealed that the low gamma irradiation doses enhanced some of the growth parameters, however high doses severely affect these traits. Therefore, mutagenic dose of 310 and 447 Gy were estimated as the LD50 for Bangi3 and Bangi5 variety, respectively.

Keywords: Chili; gamma ray; growth parameters; Lethal Dose; mutation breeding.

1 Introduction

Chili (Capsicum spp.) is one of the most cultivated vegetable spice crops in tropical and subtropical climates. It belongs to the family Solanaceae that includes other economically important crops such as tomato, potato, and tobacco. Mutation induction is a great potential tool for plant improvement through creating new genetic variation. Induced mutation is powerful method to generate heritable variation by exposing plant materials such as seeds, seedlings or other plant parts to physical or chemical mutagens [1]. Mutagenesis remarkably enhanced the agronomical and physiological characters such as pest and diseases resistance, improve yield and yield component traits in crops [2-4]. In Capsicum, several agronomical characters have been improved using chemical and physical agents [5]. Gamma radiation is the most widely physical mutagen for inducing mutation in plant breeding because of its easy application, good penetration, reproducibility, high mutation frequency and less disposal problem [6].

- *Aisha, A.H: Department of Crop Science, Faculty of Agriculture, Universiti Putra Malaysia (UPM), 43400 Serdang, Selangor, Malaysia & 2Department of Horticulture, Faculty of Agriculture, University of Khartoum, 43400 Khartoum North, Sambat, Sudan. aishaawadalla82@gmail.com*
- *M.Y. Rafii: PhD, Institute of Tropical Agriculture and Food Security, Universiti Putra Malaysia (UPM), 43400 Serdang, Selangor, Malaysia, mrafii@upm.edu.my*
- *Rahim H.A: PhD, Agrotechnology and Bioscience Division, Malaysian Nuclear Agency, Bangi, 43000 Kajang, Selangor Email*******
- *Juraimi A.S: PhD, Department of Crop Science, Faculty of Agriculture, Universiti Putra Malaysia (UPM), 43400 Serdang, Selangor, Malaysia Email*******
- *Misran, A: PhD, Department of Crop Science, Faculty of Agriculture, Universiti Putra Malaysia (UPM), 43400 Serdang, Selangor, Malaysia Email*******
- *Yusuff Oladosu: PhD, Institute of Tropical Agriculture and Food Security, Universiti Putra Malaysia (UPM), 43400 Serdang, Selangor, Malaysia. oladosuy@gmail.com*
- *Corresponding author: aishaawadalla82@gmail.com*

The application of gamma irradiation on the seeds of Capsicum is very beneficial for enhancing heritable variation for breeding and for creating research materials for improving or producing new varieties with high yielding and good quality. Many mutants of pepper have been achieved through induced mutation by both physical and chemical mutagens. There is a significant improvement in quantitative and qualitative traits of pepper such as shoot architecture, β-carotene [3, 7]. In Malaysia, chili is high demand crop and important vegetables on basis of commercial value. Local varieties are genetically heterogeneous, sustainable to pest and diseases, virus diseases and root rot is severe problem which leads to decrease yield production and genetic variation. Therefore, the objectives of this research is to determine of LD50 and the impact of gamma radiation on growth characters of chili seedlings produced from chili seeds irradiated with different gamma-ray doses.

2 Materials and Methods

2.1 Plant material

The study was conducted using two varieties of Chili pepper (Capsicum annum L.) chili Bangi3 and chili Bangi5. The seed of two varieties were obtained from Chili Bangi Seeds Company.

2.2. Gamma irradiation

Irradiation of chili seeds was accomplished using Caesium-137 source at a dosage rate of 4.640kGY/hr at the Malaysia Nuclear Agency. Chili seeds were treated with 100, 200, 300, 400, 500, 600, 700, 800, 900 and 1000 Gy gamma rays at Malaysia Nuclear Agency, Bangi, Selangor, Malaysia. The non-treated seeds of chili were considered as control.

2.3. Radio-sensitivity Test

Thirty seed form each treatment with three replications was sowed in nursery bed in the greenhouse at field 16, Faculty of Agriculture, Universiti Putra Malaysia. Data for germination percentage were taken every 3 days for a period of 3 weeks. Data for shoot length were collected weekly after two weeks from sowing up to seven weeks of planting. Data for shoot fresh and dry weight, root length, root fresh and dry weight was collected at week seven.

2.4. Statistical analysis

An analysis of variance (ANOVA) of all traits was calculated using SAS program version 9.3 to determine the variation among the Gamma-ray doses and between the two varieties. Additionally, the mean, range and standard deviation were calculated for each trait. Mean comparisons were performed using LSD.

3 RESULTS

3.1. Germination percentage (%)

The result indicated that there were highly significant differences for germination percentage between the two varieties and among doses of gamma radiation. The interaction between varieties and doses, were also highly significant for this parameter. The Bangi3 variety expressed higher germination percent than Bangi5 variety at all the period of time (3weeks). In general seed germination was delay and decrease with increasing of doses of gamma ray (Table 1).

3.2. Shoot length (cm)

The analysis of variance of shoot length was highly significant between the varieties and among doses of gamma radiation. The interaction between varieties and doses was also significantly different. The Bangi5 variety obtained higher shoot length than Bangi3 Variety for most of gamma-ray doses. Among the doses, the lowest dose of 100Gy had no significant difference compared to control for the two varieties, contrarily, high doses severely affected shoot length. In general, shoot length decreased with increasing of doses of gamma ray (Table 2).

3.3. Shoot fresh and dry weight (g)

The analyses of variance were significantly different between the two varieties and among doses of gamma radiation for shoot fresh weight. The Bangi5 variety achieved higher shoot fresh weight than Bangi3 variety under all doses of the gamma ray. For the interactions, there were no significant differences for this parameter (Figure 1). However, there were significant differences between varieties and doses of gamma radiation for shoot dry weight. The expression of the varieties to different doses of gamma irradiation for shoot dry weight was the same with their response for shoot fresh weight (Figure 2).

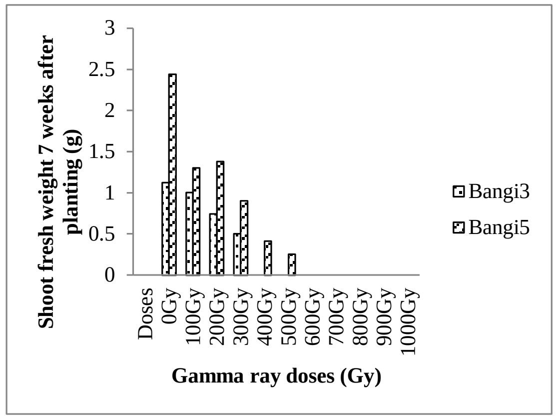

Figure 1. *Shoot fresh weight (g) of irradiated chili seeds with 0, 100, 200, 300, 400, 500, 600, 700, 800, 900 and 1000 Gy gamma ray 42 days after planting.*

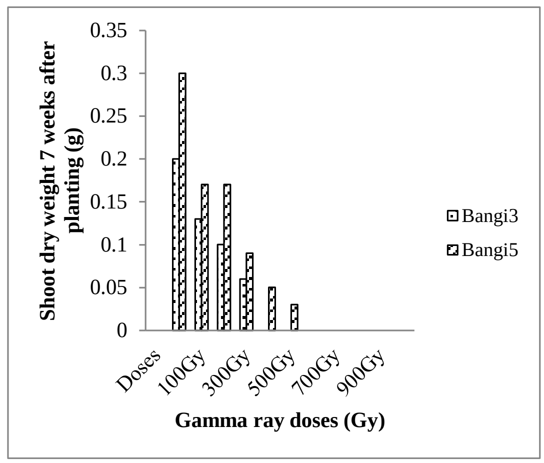

Figure 2. *Shoot dry weight of chili seeds irradiated with 0, 100, 200, 300, 400, 500, 600, 700, 800, 900 and 1000 Gy gamma ray 42 days after planting.*

3.4. Root length (cm)

In case of root length, there was highly significant difference between varieties and doses and the interaction between varieties and doses. In comparison of two varieties, the highest value of root length was achieved by Bangi5 than Bangi3 variety. Generally, Root length increase with a decrease in doses of gamma rays (Figure 3).

***Table 1**. Germination percentage of chili seeds treated with 100, 200, 300, 400, 500, 600, 700, 800, 900 and 1000 Gy of gamma ray at 3, 6, 9, 12, 15 and 18 days after planting.*

	3 DAP		6 DAP		9 DAP		12 DAP		15 DAP		18 DAP	
Doses	Bangi3	Bangi5	Bangi3	Bangi5	Bangi3	Bangi5	Bangi3	Bangi5	Bangi3	Bangi5	Bangi3	Bangi5
0Gy	18a	0a	100a	32.7a	100a	89.0a	100a	100a	100a	100a	100a	100a
100Gy	0b	0a	50.3b	31.0a	93.7b	86.3a	100a	100a	100a	100a	100a	100a
200Gy	0b	0a	42.7c	28.0b	81.0c	76.0b	96.7a	92.3b	100a	100a	100a	100a
300Gy	0b	0a	32.0d	28.0b	74.0d	73.7b	86.7b	85.3c	100a	100a	100a	100a
400Gy	0b	0a	11.8e	11.8c	53.0e	53.0c	74.0c	74.0d	89.0b	89.0b	100a	98.3a
500Gy	0b	0a	3.33f	3.33d	32.7f	32.7d	54.7d	54.3e	75.7c	75.6c	100a	93.0b
600Gy	0b	0a	0g	0f	11.0g	11.0e	45.0e	45.0f	66.0d	65.0d	100a	88.7c
700Gy	0b	0a	0g	0f	10.0g	10.0e	42.7e	42.7f	65.0d	65.0d	100a	88.3cd
800Gy	0b	0a	0g	0f	10.0g	10.0e	42.7e	42.7f	56.0e	56.0e	100a	85.0cde
900Gy	0b	0a	0g	0f	10.0g	10.0e	42.7e	42.7f	54.0e	53.0e	100a	84.3de
Mean	1.63	0.0	21.83	12.62	44.03	41.88	65.66	65.12	78.82	78.82	100.00	92.70
LSD (p=0.05)	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001

Mean values that significantly different gave different letters and statistically obtained by LSD test (at 5% level); DAP= Day after planting

***Table 2.** Shoot length of treated chili seeds with 0, 100, 200, 300, 400, 500, 600, 700, 800, 900 and 1000 Gy, 14, 21, 28, 35 and 42 day after planting.*

	14 Day after planting		21 Day after planting		28 Day after planting		35 Day after planting		42 Day after planting	
Doses	Bangi3	Bangi5	Bangi3	Bangi5	Bangi3	Bangi5	Bangi3	Bangi5	Bangi3	Bangi5
0Gy	1.73a	1.8a	2.37a	2.63a	2.91a	4.13a	3.6a	5.57a	9a	10a
100Gy	1.56a	1.83a	2.1ab	2.73a	2.7b	4.1a	3.33b	5.23a	8.8a	9.7a
200Gy	1.04b	1.75a	1.7b	2.7a	2.23c	3.6ab	2.73c	4.63a	8.1c	9.3a
300Gy	1.13b	1.27b	2ab	1.7b	2.3c	2.8bc	2.2d	2.96b	6.7d	8.7b
400Gy	0c	1c	0.33c	1.3c	0d	1.93cd	0e	2.1bc	0e	5.6c
500Gy	0c	0.7d	0.33c	1.1d	0d	1.63d	0e	1.7c	0e	4.3c
600Gy	0c	0e	0c	0.33c	0d	0.67d	0e	0e	0e	0d
700Gy	0c	0e	0c	0d	0d	0e	0e	0e	0e	0d
800Gy	0c	0e	0c	0d	0d	0e	0e	0e	0e	0d
900Gy	0c	0e	0c	0d	0d	0e	0e	0e	0e	0d
Mean	0.49	0.76	0.83	1.1	0.92	1.71	1.1	2.0	2.95	5.3
LDS (P=0.05)	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001

Mean values that significantly different gave different letters and statistically obtained by LSD test (at 5% level).

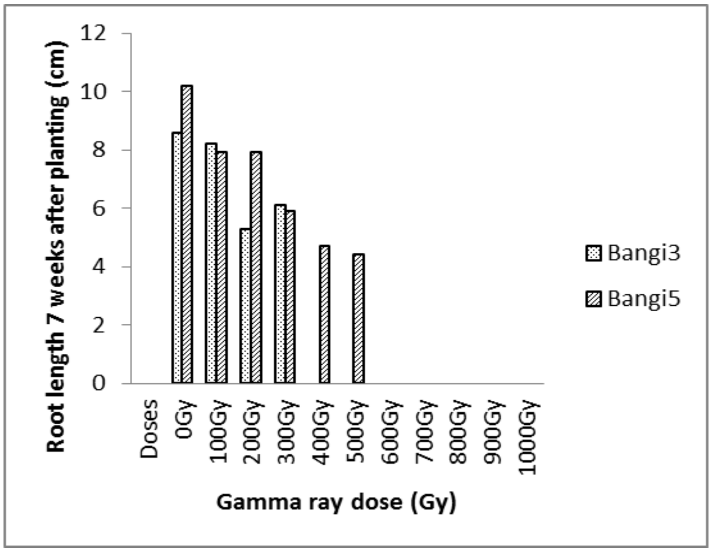

Figure 3. *Root length (cm) of chili seeds irradiated with 0, 100, 200, 300, 400, 500, 600, 700, 800, 900 and 1000 Gy gamma ray 42 days after planting.*

3.5. Root fresh and dry weight

Observations of root fresh and root dry weight showed significant differences among doses of gamma radiation, however, no significant difference was observed between the two varieties (Figure 4 and 5). These two parameters were inhibited with increasing the doses of gamma rays.

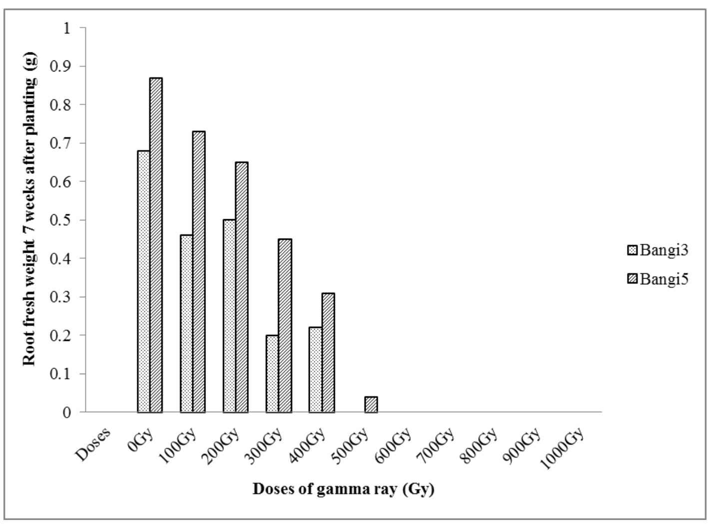

Figure 4. *Root fresh weight of chili seeds irradiated with 0, 100, 200, 300, 400, 500, 600, 700, 800, 900 and 1000 Gy gamma ray 42 days after planting.*

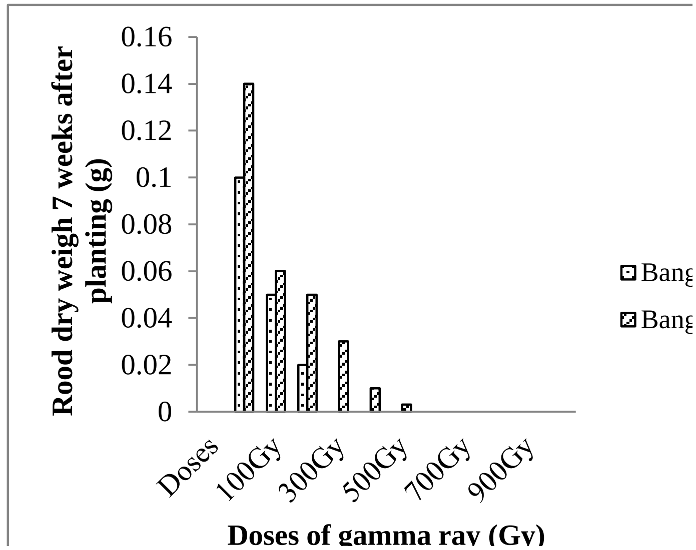

Figure 5. *Root dry weight of chili seeds exposed to 0, 100, 200, 300, 400, 500, 600, 700, 800, 900 and 1000 Gy gamma ray 42 days after planting.*

3.6. Survival percentages

The data for shoot length collected at week seven was used to determine the LD50. The regression lines on Figure 6 and 7 were determined the 50% lethal dose (LD50) of the two chili varieties were 310 Gy was estimated for chili Bangi3 and 447 Gy for chili Bangi5 (Figure 6 and 7). At 400Gy (LD100), no plant survive for chili Bangi3, while all chili Bangi5 plants died at 600 Gy (LD100) gamma ray. In case of survival plants, the differences between the varieties and among doses of gamma radiation were highly significant. Chili seeds irradiated with 100, 200, 300, 400 Gy, had no significant differences in comparison with the control and it was 100% for the two varieties (Bangi3 and Bangi5). For Bangi5 variety the survival percentage 50% at 500 and, 20% at 600Gy, while no plant survival for Bangi3 variety. At doses 700, 800, 900 and 1000Gy no plant survived among the two varieties (Figure 8).

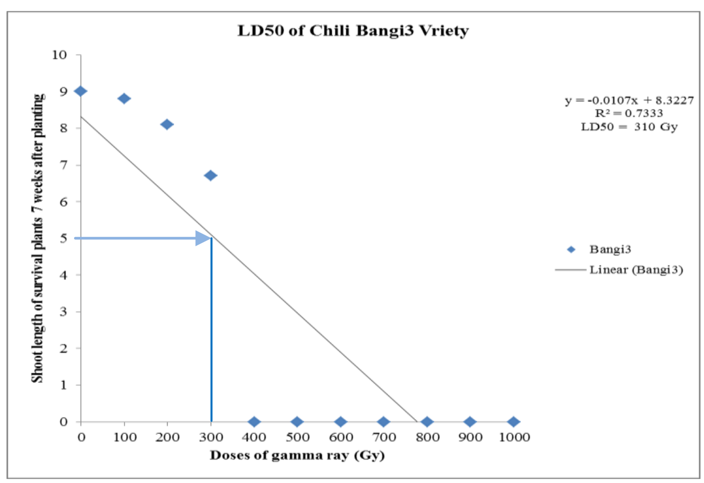

Figure 6. *LD50 (50% survive) of chili Bangi5 seeds irradiated with 0, 100, 200, 300, 400, 500, 600, 700, 800, 900 and 1000 Gy gamma ray 42 days after planting.*

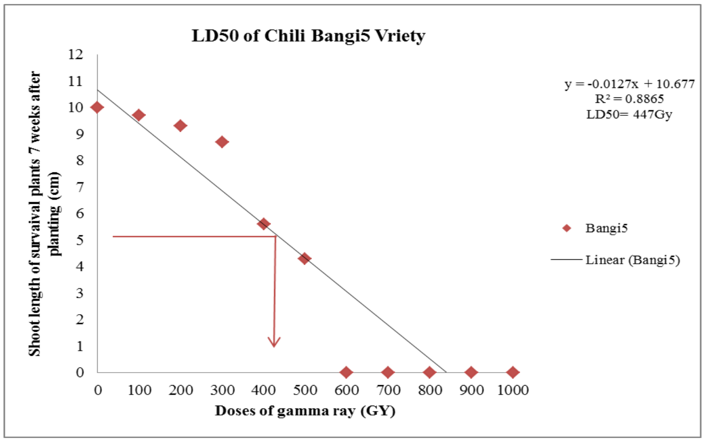

Figure 7. *LD50 (50% survive) of chili Bangi5 seeds irradiated with 0, 100, 200, 300, 400, 500, 600, 700, 800, 900 and 1000 Gy gamma ray 42 days after planting.*

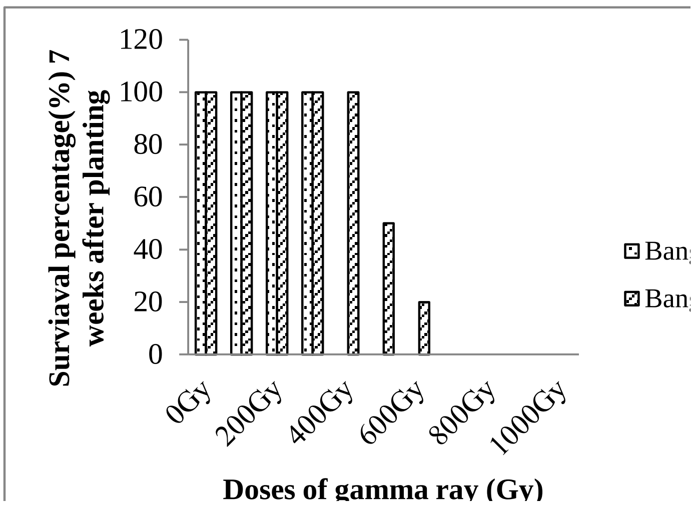

Figure 8. *Survival percentage (%) of chili seeds exposed to 0, 100, 200, 300, 400, 500, 600, 700, 800, 900 and 1000 Gy gamma ray 56 days after planting.*

4 DISCUSSION

Treatments of two varieties of chili pepper with various dose of gamma-ray resulted in the decline of the shoot and root length, shoot fresh and dry weight, root fresh and dry weight and survival percentage by increasing of gamma-ray doses. According to the result, shoot length indicated significant impacts among various dose of gamma-ray. The Bangi5 Variety expressed higher shoot length than Bangi3 variety for all treated doses of radiation at all the seven weeks. The growth performance of seedlings derived from untreated (control) plants and plants derived from treated seeds with low doses (100, 200 and 300 Gy) of gamma-ray obtained highest values in comparison with those exposed with high doses of gamma ray (400, 500 and 600 Gy). This result is in agreement with Omar et al. [8], they reported that this may be attributed to the effect of mutagenic radiations that can directly cause DNA double-strand breaks, and then prevent plant growth or make it slow. The reduction of growth rate with increase in dose of irradiation may interrupt cell division as a result of DNA mutation that DNA synthesizes at the interphase. In case of root length, there was a significant difference between the varieties, doses of gamma radiation, and the interaction between varieties and doses of root length. Root length like the other parameters was responded negatively with increasing of gamma irradiation doses. Low dose of irradiation can stimulate plant growth through their effect on hormone in plant cell or by raising the antioxidative capacity of the cells [9]. For root fresh and dry weight, the higher values were obtained by the seedling derived from untreated seeds and those treated with low dose of irradiation. Reduction of those traits with increasing of gamma-ray dose that may be due to the insufficient water and nutrient uptake as result of severing effect of high irradiation dose of root growth and development. This observation was in agreement with the of previous study on eggplant conducted by Ulukapi [10], who indicated that varieties react to mutation doses differently and differentiation of varieties has a major role in determining the effective dose in mutation studies. In term of survival percentages of seedling derived from chili seeds irradiated with low doses is higher compared to those treated with higher doses. The data of shoot length of survival seedling was used to determine the LD50 and LD100, the 50% (LD50) of chili Bangi3 and chili Bangi5 Varieties plants were 310 Gy and 447 Gy, respectively. At 400Gy (LD100), no plant was survival for chili Bangi3, while all chili Bangi5 plants died at 600 Gy (LD100) gamma ray. This indicated that varieties can respond differently to gamma radiation. This observation is similar with findings Tabasum et al. [11] and Oladosu et al., [12], they revealed that the response of genotypes to various dose of gamma irradiation was different and highest dosage caused reduction in physiological processes. For example, at high dose of gamma ray 600, 700 and 800 seeds were germinated and grew at the beginning of the growth stage but they die a few weeks after sowing. This supported by Gaswanto et al. [13], who evident that LD50 of chili genotypes were ranged between 422- 629 Gy. It also agreed with Kon et al. [14] they reported that the high dose of gamma-ray was negatively affected the survival rate of Snap bean plants. This indicates that high dose of irradiation can cause physiological damage as well as DNA damage of treated materials.

5 CONCLUSIONS

This investigation revealed that low doses of gamma radiation stimulated some of the growth parameters, however, high dose severely affect the evaluated parameters. The two chili varieties responded differently to various doses of gamma ray, hence, 310 and 447 Gy were estimated as the LD50 for Chili Bangi3 and Chili Bangi5 varieties, respectively. At 400Gy (LD100) no plant was survival for chili Bangi3, while all chili Bangi5 plants died at 600 Gy (LD100) gamma ray.

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