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A Preliminary Study on Gamma Radiosensitivity of Tomato (*Lycopersicon esculentum*) and Okra (*Abelmoschus esculentus*)

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Abstract: This investigation was carried out to determine the LD₅₀ and effect of gamma ray on germination, plant height, survival percentage and dry weight of seedlings derived from irradiated seeds of tomato (*Lycopersicon esculentum*) and okra (*Abelmoschus esculentus*). Seeds of tomato and okra were treated with 300, 400, 500, 600 and 800 Gy gamma rays at Malaysian Institute of Nuclear Technology (MINT). The treated seeds including control were sown in sand beds in size 4.6×0.7 m² in a greenhouse at Horticulture Unit, UPMKB. Water was applied manually to maintain the soil moisture at field capacity as well as weed was manually controlled. The experiment was designed as 5×6 factorial in Completely Randomized Design (CRD) with three replications. Lethal dose 50% of population (LD₅₀) was assayed. Observation showed that germination percentage, plant height, survival percentage and shoot dry weights of tomato and okra decreased with increasing dose of gamma ray. The 800 Gy gamma ray dose had a profound effect on these variables perhaps due to injury dose may have caused to the seeds of the tomato and okra. This resulted in poor plant growth and development. The LD₅₀ for survival and germination percentage were within acceptable range. In general, higher gamma ray doses particularly 600 and 800 Gy had negative effect on the morphological characteristics of tomato and okra seedlings derived from irradiated seeds.

Key words: Gamma ray, tomato, okra, Malaysia

INTRODUCTION

Mutation breeding is defined as the utilization of induced mutation (physical or artificial mutation) for the purpose of desired crop improvement. According to Broertjes and Van Harten (1978), mutation breeding makes use of the possibility of altering genes by exposing seeds or other plant parts to chemical or physical mutagens. Mutation breeding is a non-conventional line of genetic science that deals with both permanent heritable genotypic and phenotypic changes (traits) intended to bring about new and improved varieties among selected agricultural crops (Jose, 2005). Studies have shown that the process of exposing substances to radiant energy or ionizing radiation such as gamma ray is useful in solving various agricultural problems such as reduction of post-harvest losses through suppressing sprouting and contamination, eradication or control of insect pests, reduction of food-borne diseases and extension of shelf life (Andress *et al.*, 1994; Emovon, 1996).

Tomato (*Lycopersicon esculentum*) is among the most widely cultivated vegetable crops in the tropics. It is grown extensively throughout Sub-Saharan Africa, in parts of Central and Latin America and is of great economic importance in Asia (Vilmorin, 1993). The crop is grown for its fruit, which is cooked as vegetable, eaten raw in salads or used in chutneys. On the other hand, okra (*Abelmoschus esculentus*) is a popular home garden vegetable in the South Africa, belonging to the

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mallow family (Malvaceae). The edible portion of the plant is its immature pods. The pods are used in soups and stews, or as fried or boiled vegetable. Despite the economic significance of tomato and okra, research on the effects of irradiating seeds of tomato and okra on the growth and development of these vegetable crops is modest (Jamic, 2002). With appropriate exposure doses on tomato and okra seeds to ionizing irradiation such as gamma rays which are known for their simple application, good penetration, reproducibility, high mutation frequency and less disposal problems, these crops may undergo desirable mutation that could be of significant benefit to mankind.

The aim of this study was to determine the LD₅₀ and effect of gamma ray on morphological characteristics of tomato and okra seedlings derived from irradiated seeds.

MATERIALS AND METHODS

Tomato (*Lycopersicon esculentum* cv. MT1) and Okra (*Abelmoschus esculentus* cv. MK Be1) seeds were obtained from MARDI (Malaysia Agricultural Research and Development Institute). The varieties were chosen because of their economic value and high germination percentage (90%). The moisture content of the seeds was measured using Moisture Analyzer (AND MX-50) at the Agrotech Laboratory, University Putra Malaysia Bintulu Campus (UPMBK). Seeds of tomato and okra were treated with 300, 400, 500, 600 and 800 Gy gamma rays at Malaysian Institute of Nuclear Technology (MINT). These treatments were used because treatments such as 50, 100, 150, 200 and 250 Gy in our previous trial did not produce good results. For each dose, 90 seeds were treated.

A day before planting the seeds, sand beds were prepared. The sand beds were watered to field capacity to ensure they were moist and loose enough for planting. The treated seeds were sown in the sand beds in size 4.6×0.7 m² in a greenhouse at Horticulture Unit, UPMKB. The row and the distance of seedlings were represented as in Fig. 1. Water was applied manually to maintain the soil moisture at field capacity as well as weed was manually controlled. Pesticides, herbicides and fertilizers were not applied in order to avoid any interference during the study.

The planted seeds were observed daily starting from 1st day of germination. Germination data was taken every 2 days. The criteria for germination were that the radical should be normal and should exceed the seed length (El-Lakany and Sziklai, 1970). Plant height was measured weekly using a meter rule. Each measurement was carried out four times and the mean height recorded. Measurement of plant height was carried out only when the first leaf had stopped growing.

Survived plants were counted at harvest i.e., forty-five Days After Planting (DAP). Survived plants are defined as those plants which produced at least one spike (inflorescences), regardless of seed



Fig. 1: Okra and tomato seeds sown in sand beds at a planting distance of 2 cm between seeds and 5 cm between rows

production. For shoot dry weight, harvested plant shoots were taken to the Agrotechnology Laboratory, UPMKB and oven dried until constant weight was achieved and a digital balance was used to determine the dry of the shoot.

The experiment was designed as 5×6 factorial in Completely Randomized Design (CRD) with three replications. Means in each treatment were compared by Tukey's Test using Statistical Analysis System Version 9.1 (SAS). Lethal dose 50% of population (LD₅₀) was assayed.

RESULTS

The moisture contents of okra and tomato seeds were 10.55 and 9.37%, respectively. These values were not consistent with the range of 12 to 14% reported by Chahal and Gosal (2002). The effect of treating tomato seeds with 0, 300, 400, 500, 600 and 800 Gy gamma rays after planting for 2, 4, and 6 days on germination percentage is presented in Table 1. There was no interaction between gamma dosage and time. The absence of interaction between time and dose suggests that the 2 factors were not interdependent. Time as a factor was also not significant. The doses affected germination percentage but the control and 800 Gy had the lowest and highest effects, respectively on this variable. Generally, the higher the dose, the lower was germination percentage. Similar observation was made for okra (Table 2). LD₅₀ for tomato and okra were obtained at 790 and 770 Gy, respectively.

Table 3 shows that there was significant interaction between dose and time. At 7 and 14 DAP, only 800 Gy was statistically different from the control. At 21 and 28 DAP, 600 and 800 Gy significantly reduced tomato height compared to control while 300, 400 and 500 had no significant effect. At 35 DAP, except for 300 Gy, 400, 500, 600 and 800 Gy significantly reduced tomato height (compared to control), indicating that these doses had profound effect on tomato height with time. In

Table 1: Germination percentage of irradiated tomato seeds with 0, 300, 400, 500, 600 and 800 Gy gamma rays after planting for 2, 4, and 6 days

Dose rate	Days after planting (DAP)			Dose factor
	2	4	6	
	----- (%) -----			
Control	88.33	90.00	90.33	89.56 ^a
300 Gy	85.67	86.33	87.00	86.33 ^a
400 Gy	74.67	76.67	76.67	76.00 ^b
500 Gy	65.67	66.00	66.33	66.00 ^c
600 Gy	58.33	65.33	65.33	63.00 ^c
800 Gy	39.00	43.67	48.33	43.67 ^d
Time factor	68.61 ^a	71.33 ^a	72.33 ^a	

Mean with different letter(s) in column are statistically different between treatments by the Tukey test (p = 0.05); ^aMean of time factor; ^aMean of dose factor

Table 2: Germination percentage of irradiated okra seeds with 0, 300, 400, 500, 600 and 800 Gy gamma rays after planting for 2, 4 and 6 days

Dose rate	Days after planting (DAP)			Dose factor
	2	4	6	
	----- (%) -----			
Control	90.33	90.67	90.67	90.57 ^a
300 Gy	81.33	83.33	83.67	82.78 ^b
400 Gy	70.67	71.00	71.33	71.00 ^c
500 Gy	61.00	62.00	62.67	61.89 ^d
600 Gy	56.00	57.33	59.00	57.44 ^d
800 Gy	40.67	41.67	44.67	42.33 ^e
Day factor	68.67 ^a	67.67 ^a	66.67 ^a	

Mean with different letter(s) in column are statistically different between treatments by the Tukey test (p = 0.05); ^aMean of time factor; ^aMean of dose factor

the case of okra, there was also significant interaction between dose and time (Table 4). At 7 DAP only 300 and 400 Gy did not have effect on okra height compared to control. From DAP 14 to 35, all the doses had significant effect on okra height. A comparison among doses generally indicated that their effects did not differ statistically.

Except for 300 Gy whose effect on survival percentage was statistically similar to control, that of 400, 500, 600 and 800 Gy were statistically lower (Table 5). This indicates that the higher the dose of gamma ray, the lower was the survival percentage of tomato. In the case of okra, similar observation was made (Table 5) except that the survival percentages obtained for 300 and 400 Gy were not different from that of the control. The LD₅₀ (survival percentage) for tomato and okra were obtained at 640 and 580 Gy, respectively.

For tomato, 500, 600, and 800 Gy significantly reduced shoot dry weight compared to control. In the case of okra, the reduction was significant starting from 400 to 800 Gy. This indicates that the higher gamma ray doses reduced dry matter production of these plants while the opposite was true for the lower doses (Table 6).

Table 3: Height of irradiated tomato seeds with 0, 300, 400, 500, 600 and 800 Gy gamma rays after planting for 7, 14, 21, 28 and 35 days

	Day after planting (DAP)					
	7	14	21	28	35	
Dose rate	(cm)					Dose factor
Control	1.58 ^a	2.66 ^a	3.95 ^a	5.42 ^a	7.81 ^a	4.28 ^a
300 Gy	1.54 ^{ab}	2.72 ^a	3.80 ^a	5.02 ^{ab}	7.20 ^{ab}	4.05 ^a
400 Gy	1.58 ^a	2.74 ^a	3.48 ^{ab}	3.93 ^{ab}	4.88 ^{bc}	3.32 ^a
500 Gy	1.43 ^{ab}	2.45 ^{ab}	3.29 ^{ab}	3.86 ^{ab}	4.68 ^c	3.14 ^a
600 Gy	1.28 ^{ab}	2.17 ^{ab}	2.71 ^{bc}	3.41 ^{bc}	4.75 ^c	2.86 ^b
800 Gy	1.16 ^b	1.86 ^b	2.17 ^c	2.46 ^c	3.50 ^c	2.23 ^b
Time factor	1.43 ^a	2.43 ^d	3.23 ^c	4.02 ^b	5.47 ^a	

Mean with different letter(s) in column are statistically different between treatments by the Tukey test ($p = 0.05$); ^aMean of time factor; ^bMean of dose factor

Table 4: Height of irradiated okra seeds with 0, 300, 400, 500, 600 and 800 Gy gamma rays after planting for 7, 14, 21, 28 and 35 days

	Day after planting (DAP)					
	7	14	21	28	35	
Dose rate	(cm)					Dose factor
Control	4.70 ^a	7.37 ^a	8.38 ^a	9.61 ^a	11.95 ^a	8.40 ^{a*}
300 Gy	3.72 ^{ab}	5.34 ^b	6.29 ^b	7.30 ^b	10.69 ^{ab}	6.67 ^{b*}
400 Gy	3.61 ^{abc}	5.09 ^{bc}	5.61 ^b	6.64 ^b	8.52 ^{bc}	5.89 ^{c*}
500 Gy	3.25 ^{bc}	4.20 ^{cd}	5.05 ^b	6.28 ^b	6.92 ^c	5.14 ^{d*}
600 Gy	2.91 ^{bc}	4.47 ^{cd}	5.08 ^b	5.91 ^b	6.59 ^c	4.99 ^{d*}
800 Gy	2.55 ^c	3.45 ^d	4.98 ^b	5.88 ^b	6.93 ^c	4.76 ^{d*}
Time factor	3.46 ^{a*}	4.99 ^{d*}	5.89 ^{c*}	6.93 ^{b*}	8.60 ^{a*}	

Mean with different letter(s) in column are statistically different between treatments by the Tukey test ($p = 0.05$); ^aMean of time factor; ^bMean of dose factor

Table 5: Survival percentage of irradiated tomato and okra seeds with 0, 300, 400, 500, 600 and 800 Gy gamma rays after planting for 45 days

Treatments	Tomato	Okra
	Survival (%)	
Control	85.67 ^a	87.67 ^a
300 Gy	79.00 ^a	78.00 ^a
400 Gy	64.67 ^b	62.33 ^{ab}
500 Gy	52.33 ^b	49.00 ^{bc}
600 Gy	41.00 ^{bc}	35.67 ^{bc}
800 Gy	30.00 ^d	22.00 ^c

Mean with different letter(s) in column are statistically different between treatments by the Tukey test ($p = 0.05$)

Table 6: Shoot dry weight of irradiated tomato and okra seeds with 0, 300, 400, 500, 600 and 800 Gy gamma rays after planting for 45 days

Treatments	Tomato	Okra
	Shoot dry weight (g)	
Control	0.15 ^a	0.27 ^a
300 Gy	0.13 ^{ab}	0.21 ^{ab}
400 Gy	0.11 ^{abc}	0.14 ^{bc}
500 Gy	0.05 ^{bc}	0.11 ^{bc}
600 Gy	0.04 ^{bc}	0.06 ^c
800 Gy	0.02 ^c	0.04 ^c

Mean with different letter(s) in column are statistically different between treatments by the Tukey test (p = 0.05)

DISCUSSION

Although moisture content of the seeds was not consistent with the standard range of 12 and 14% it did not affect the radiosensitivity of treatments. This was evident in the morphological characteristics studied.

The absence of significant interaction between dose and time (Table 1 and 2) suggests that the 2 factors were acting independently. Germination percentage of tomato and okra decreased with increasing dosage. The lower germination percentage at 800 Gy might have caused injury to the seeds and this may have prevented them from germinating well. The differences in germination due to different treatments was expected as many of the metabolic events that are known to occur during germination differ in their timing, both among the various organs of a particular seed and among seeds of different species (Mayer and Poljakoff-Mayber, 1989; Bewley and Black, 1982; Hegarty, 1978). The LD₅₀ (lethal dose would kill 50% of living plants of tomato) was found to be about 790 Gy. This means that to achieve 50% of tomato germination, the seed should be treated with about 790 Gy, a value that approximates that 800 Gy. The LD₅₀ (germination percentage) for okra was obtained at 770 Gy. Thus, to achieve a germination percentage of 50 in okra, a gamma radiation should be 770 Gy.

The significant reduction in tomato plant height caused particularly by 600 and 800 Gy (Table 3) might be because the plant was quite sensitive to higher dose (Jamie, 2002). Jamie (2002) pointed out that by increasing the amount of exposure of irradiation, and increasing the intensities of gamma rays, tomato will have an increasing mutation rate. Mokobia and Anomoharan (2005) found that the seeds of okra which were irradiated with low gamma radiation were taller than those irradiated with a high dose. This finding is in agreement with the observation made in this study where 500, 600 and 800 Gy were found to reduce okra height significantly.

The higher survival percentage of plants whose seeds were not treated with gamma ray compared to those treated with 600 and 800 Gy could be because of rainfall which occurred during growth phase as this increased the mortality of the plants (Table 5). As reported by Amos (2004), environmental requirements for germination are fewer and simpler than those for whole plant development, so germination is relatively independent of the environment for a considerable period of seedling development. Besides, higher doses also increased the rate of plant mortality. LD₅₀ for tomato survival percentage was obtained at 640 Gy. This value was lower than that obtained for germination. This finding was also true for okra. This observation was so because even heavy doses of ionizing radiation, which caused 100% lethality when counted at the time of harvest, may have little effect upon the onset of germination.

The lower shoot dry weight values of plant exposed to gamma ray than that of control was due to poor growth. Logically, the better the plant growth, the higher will be the dry weight. This is because as plants grow better, their roots absorb water much better from the soil than plants growing poorly. Savaskan and Toker (1991) found significant decrease in shoot weight rye (*Secale cereale* L.) when it was subjected to gamma irradiations.

CONCLUSIONS

Increasing gamma ray dose decreased germination percentage, plant height, survival percentage and shoot dry weight of tomato and okra. The LD₅₀ for germination and survival percentages for tomato were obtained at 790 and 640 Gy, respectively while those of okra plant were approximately 770 and 580 Gy. In general, higher gamma ray doses particularly 600 and 800 Gy had negative effect on the morphological characteristics of tomato and okra seedlings derived from irradiated seeds.

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