Biological Forum – An International Journal **14(4a): 418-422(2022)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Gamma Radiation's Effect on the Germination and Survival of Sesame in M_1 Generation

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(Received 10 September 2022, Accepted 16 November, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: The seeds of the two genotypes, AKT-64 and N-8, were exposed to four doses of gamma radiation at BARC, Trombay, Mumbai, to study the impact of mutagenesis on germination and growth. About 100 seeds from each dose and a control were placed in a lab for germination. The percent germination, root length (cm), and shoot length were measured (cm). Correspondingly, treated seeds per dose were grown at the Instructional Farm of Department of Agricultural Botany, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, in a randomised block design with five replications. The observations regarding plant survival, percent germination, and reduction in plant survival compared to control were observed. The seed germination and plant survival parameters for all the doses differed significantly, indicating that there was enough variation for these parameters, according to the analysis of variance in both genotypes. In laboratory condition, in both genotypes observed a progressive decrease in germination percentage, shoot length, and root length with increasing gamma ray doses. Under field conditions, in both the genotypes the maximum reduction in germination percentage was found at 700Gy (35.78% in AKT-64 and 28.44% in N-8). The LD_{50} was observed at 600Gy dose for AKT-64 genotype and at 500Gy dose for N-8 genotype. The highest reduction in plant survival in M_1 generation was found at 700Gy dose (32.79% in AKT-64 and 26.45% in N-8) compared to both the controls. In general, a dose-dependent relationship between biological damage (%) and the type of mutagen used was observed. All biological parameters were significantly reduced by higher gamma radiation doses.

Keywords: Gamma rays, Sesame, Mutagenesis, germination percentage, LD_{50}.

INTRODUCTION

Sesame (*Sesamum indicum* L.) is one of the oldest and economically important oilseed crops known to man and is widely cultivated in tropical and subtropical parts of the world (Ashri, 1998). There have been many contradictions regarding the origin and domestication of sesame, Africa and Indian subcontinent where the two alternative centers proposed for the same. Most of the wild sesame was endemic to Africa. This supported the African origin of sesame whereas some accept sesame was first domesticated in India as evidenced by morphological and cytological affinities that exist between the domesticated sesame and the south Indian species *Sesamum malabaricum* (Bedigian, 2003a, 2003b). Sesame is variously known as til, gingelly, simsim, gergelim and is one of the nine major oilseed crops in India. It is described as the "Queen of Oil Seeds" due to its excellent oil quality and it is mostly grown for its seeds and the oil extracted from seed (Bedigian and Harlan 1986).

Sesame is an important source of high quality oil and protein, the chemical composition of sesame shows that the seed is an important source of oil (44–58%), protein (18–25%), carbohydrate (13.5%) and ash (5%) (Ellench *et al.*, 2007), roughly half of the seed's weight is its oil, which has excellent stability due to the presence of natural antioxidants such as sesamolin, sesamol and sesamin (Brar and Ahuja 1979).

Sesame is one of the earliest domesticated plants in India, grown next to groundnut, rapeseed and mustard. It is predominantly grown in Uttar Pradesh, Rajasthan, Orissa, Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka, West Bengal, Bihar and Assam India ranks first both in production and acreage of sesame in the world. In India area was about 1526 thousand ha with of production 749 thousand kilo tones and productivity of 491 kg/ha (Ministry of Agril. Govt. of India, 2020-21). The area of sesame in 2020-21 in Maharashtra was 200.62 hundred ha, production 36.15 hundred tons and productivity 223.4 kg/ha (Department of Agriculture, GoM) Anonymous (2020). However, in 2018 the productivity of sesame is low in India (431 kg/ha) as compared to the world's average (512 kg/ha) and it is far below as compared to China (1393 kg/ha) being the highest (FOASTAT, 2020). This evidently indicates the potentiality of the crop for improvement in yield.

The basic requirement of any crop for genetic improvement is genetic variation. One feasible and potential way to produce these variations is through induced mutagenesis. In nature, spontaneous mutations occur very low. In order to cause mutations in crop plants, both physical and chemical mutagens can be used, and subsequent improvement can be achieved through selection. Gamma rays are one of the physical mutagens that directly penetrate plant tissue and are partially ionizing. They can affect a plant's morphology, anatomy, biochemistry, and physiology as well as damage or modify normal plant cell components, depending on the radiation level. In sesame natural gene pool, the mutagen is very effective at generating genetic variation. Plant survival, seed germination, and seedling development are some of the commonly used criteria for studying effect of gamma rays on sesame plants.

MATERIAL AND METHODS

Dry, uniform color seeds of two genotypes of sesame, AKT-64 and N-8, were developed by Dr. PDKV, Akola, used in the experiment. To create variability, the seeds of both genotypes were exposed to gamma radiation at the Bhabha Atomic Research Centre in Mumbai in doses of 400Gy, 500Gy, 600Gy, and 700Gy. About 100 seeds of each dose, along with the two controls, were taken for germination in order to study the effect of various doses of gamma rays on germination and seedling growth. Germination percentages were calculated by expressing the number of seedlings in a replicate that emerged 7 days after planting as a percentage of the number of seeds planted according to ISTA (2004) rules and root and shoot length (cm).

Raising M_1 generation. The seeds of each dose along with control were sown in the field followed by Randomize block design with five replications, the row to row and plant to plant distances at 30 cm and 10 cm was plotted respectively. Standard cultural and agronomic practices were followed to raise the crop and maintain good plant growth. At the appropriate stages of crop growth in the M_1 generation, the observations on percentage of germination, plant survival, and reduction in plant survival over control were recorded.

Standard Germination Test. In order to calculate germination percentages by expressing the number of seedlings in a replicate that emerged 7 days after planting as a percentage of the number of seeds planted.

$$\text{Germination (\%)} = \frac{\text{Total no. of seeds germinated}}{\text{Total no. of seeds taken}} \times 100$$

$$\text{Plant Survival (\%)} = \frac{\text{Number of plants at maturity}}{\text{Number of seedlings germinated}} \times 100$$

Seedling length (cm). Ten normal seedlings were randomly selected from the each replication of all the varieties and their length was measured in cm. Average length of these seedlings were calculated.

Seedling Vigour indices. Seedling vigor indices were calculated by using the formula suggested by Abdul-Baki and Anderson (1973) and expressed as whole number.

Seedling vigour index = Standard germination (%) × seedling length (cm)

RESULTS AND DISCUSSION

The experimental results are presented under the following two headings: laboratory observations and field observations:

A. Laboratory observations

Gamma rays effect on different parameters of plant growth, including germination percentage, root and shoot length, seedling injury, and seed vigour index in sesame showed in Table 1.

B. Germination percentage

The germination percentage of each dose was lower in both genotypes than the control, From Table no.1, significant maximum reduction in germination percentage was observed in AKT-64 at 700Gy (41.25%) over control (93.25%), similarly in N-8, maximum reduction was recorded at 700Gy (34.75%) over control (92.75%). It can be seen that higher gamma radiation doses primarily had a higher effect on germination. Both Raut *et al.* (2021); Emrani *et al.*

(2011) noted a significant effect of gamma doses on seed germination.

(i) Root length (cm). In both genotypes of sesame, there are significant differences between the root length of gamma-irradiated plants and control plants. According to Table 1, the dose of 500Gy (5.12 cm) showed highest root length in genotype AKT-64 when compared to other doses. Similar results were recorded in the N-8 genotype (3.5cm). In both genotypes, the 700Gy dose recorded shortest root length (2.48cm in AKT-64 and 2.42cm in N-8). The maximum root length was obtained in both of the controls as compared to treated seeds. Kumari *et al.* (2016) reported similar outcomes of shorter roots in sesame plants treated with gamma rays.

(ii) Shoot length (cm). As the gamma radiation doses increased, the shoot length was decrease in both genotypes. Higher shoot length was found in lower gamma rays doses. Maximum shoot length was observed in the genotype, AKT-64 at 500Gy dose (5.72cm) followed by 400Gy (5.22cm), 600Gy (3.6cm) and 700Gy (1.8cm). Similar results have also been recorded in genotype N-8 dose 500Gy (5.12cm) followed by 400Gy (4.22cm), 600Gy (3.8 cm) and 700Gy (2.06cm). Both Boranayaka *et al*. (2010); Kumari *et al*. (2016) reported similar findings.

(iii) Seedling Injury over control. In both genotypes, the maximum seedling injury over control was noted at a dose of 700Gy (59.02% in AKT-64 and 59.34% in N-8), while the minimum seedling injury was noted at a dose of 500Gy (10.25% in AKT-64 and 20.86% in N-8).

(iv) Seed vigour Index. The genotype AKT-64 maximum seed vigour index was recorded at 500Gy (773.97) dose among other doses, and the genotype N-8, maximum seed vigour index was also found at 500Gy (589.60) dose. The minimum seed vigour index was found at 700Gy dose in both genotypes (159.21 in AKT-64 and 154.11 in N-8). Singh *et al.* (2018); Raut *et al.* (2021) found similar findings.

C. Field Observations

The effects of gamma rays mutagens on various parameters of plant growth such as germination percentage, percent survival, reduction in survival on sesame are presented in Table 2 and Fig. 1 and 2.

Germination. The seed germination decreased as gamma doses increased, as shown in Fig. 1 and 2. When compared to controls, germination was lowest in 700Gy for both genotypes (35.78% in AKT-64 and 28.44% in N-8). The LD_{50} was found to occur at a dose of 600Gy for the AKT-64 genotype and 500Gy for the N-8 genotype. Reduced seed germination in seeds exposed to gamma rays may be caused by a delay in or inhibition of biological and physiological processes essential to seed germination. Above results in accordance with various earlier researchers as follows; Kumari *et al.* (2016) reported LD_{50} at 450-600Gy dose for LKT-4 variety of sesame; Layrisse *et al.* (1992) recorded LD_{50} at 630Gy dose in Venezuelan sesame cultivars whereas Rajaramadoss *et al.* (2014) reported a similar result of reduced germination with increased doses of gamma rays.

Plant survival. In the M_1 generation, the maximum decreased in plant survival was noted at 700Gy dose (32.79% in AKT-64 and 26.45% in N-8) followed by 600Gy dose (48.58% in AKT-64 and 35.26% in N-8), 500Gy dose (53.69% in AKT-64 and 45.49% in N-8) and 400Gy dose (60.96% in AKT-64 and 50.54% in N-8) as compared to both the controls (91.49% in AKT-64 and 87.80% in N-8). The plant survival percent decreased with the increase in doses of gamma rays showed in Fig. 1 and 2. Similar result were recorded by the earlier researchers, Anbarasan *et al.* (2013); Kumari *et al*. (2016); Uttarde *et al.* (2020); Raut *et al*. (2021).

In both the genotypes the highest reduction survival over control was recorded at 700Gy (85.90% in AKT-64 and 90.23% in N-8), while lowest reduction survival over control was recorded at 400Gy (47.52% in AKT-64 and 60.54% in N-8). Similar studies on the effect of mutagens on M_1 parameters have revealed similar results in a variety of crops, including soybean, sesame, and pigeon pea. Because of the genetic abnormalities brought on by higher mutagen doses, treated seeds and M_1 plants have lower survival rates. However, it is possible to successfully increase the genetic variability in sesame by using the lower doses of mutagens used in the current study.

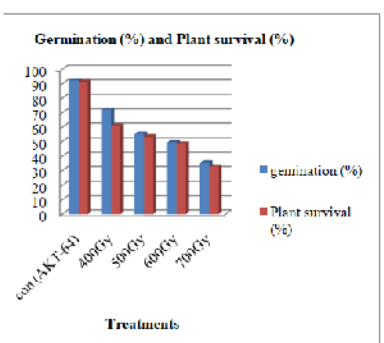

Fig. 1. Germination percent and plant survival percent in field condition (AKT-64).

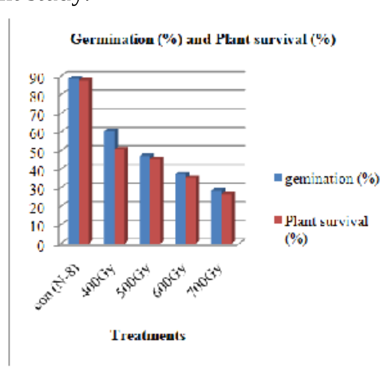

Fig. 2. Germination percent and plant survival percent in field condition (N-8).

Table 1: Effect of mutagens on different parameters in M1 seeds (Laboratory).

Genotypes	Doses of Gamma rays	Germination (%)	Root length (Cm)	Shoot length (Cm)	seedling height (cm)	Seedling Injury (%)	Seed vigour index
AKT-64	Control	93.25	5.34	6.64	11.98	-	1018.3
	400	75.25	4.52	5.22	9.74	17.71	730.5
	500	56.50	5.12	5.72	10.84	10.25	773.97
	600	51.75	3.98	3.6	7.58	36.34	391.12
	700	41.25	2.48	1.8	4.28	59.02	159.21
	Mean	63.60	4.29	4.60	8.88	30.83	588.30
	SE(m)	2.64	0.30	0.31	0.94	2.57	28.46
	CD@5%	8.14	0.90	0.93	2.82	7.91	85.32
N-8	Control	92.75	5.24	5.88	11.12	-	905.16
	400	65.50	3.20	4.22	7.42	33.23	538.69
	500	51.75	3.50	5.12	8.62	20.86	589.60
	600	45.25	3.18	3.8	6.98	37.42	332.24
	700	34.75	2.42	2.06	4.48	59.34	154.11
	Mean	58.00	3.55	4.22	7.72	30.17	447.57
	SE(m)	3.58	0.18	0.23	0.72	2.38	30.06
	CD@5%	11.02	0.54	0.70	2.15	7.13	90.13

Table 2: Effect of mutagenic treatments on various parameters in M_1 generation (Field condition).

Genotypes	Doses of Gamma rays	Germination (%)	Plant survival (%)	Reduction in survival over control
AKT-64	Control	92.44	91.49	-
	400	72.22	60.96	47.52
	500	55.56	53.69	65.49
	600	49.56	48.58	71.29
	700	35.78	32.79	85.90
	Mean	61.11	57.50	67.55
	SE(m)	2.75	3.88	3.40
	CD@5%	8.24	11.62	10.46
N-8	Control	88.67	87.80	-
	400	60.44	50.54	60.54
	500	47.11	45.49	72.28
	600	37.33	35.26	83.14
	700	28.44	26.45	90.23
	Mean	52.40	49.13	76.55
	SE(m)	2.64	2.65	2.87
	CD@5%	7.93	7.96	8.87

CONCLUSION

In the current study, it was found that increasing doses of gamma rays inhibited the seed germination and shoot and root lengths. However, the lower doses of mutagens used in this study can be effectively used to increase genetic variability. The root length showed a greater retardation than the shoot length, these showed that root system seems to be comparatively more sensitive to gamma-ray. In laboratory conditions, gamma ray doses were showed reduced seed germination percentage, seedling height (root and shoot length), and seed vigour index. On the field condition, higher doses than smaller doses had more effect on germination percentage, plant survival, and plant survival over control. The majority of the characteristics of the sesame crop plant were therefore shown to be very susceptible to gamma ray doses.

Acknowledgment. This research was a part of Ph.D. thesis and we are extremely grateful to Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola and Research field of Agricultural Botany, Dr. PDKV, Akola for providing field and STRU for providing laboratory facilities for conducting this trial.
Conflict of Interest. None.

REFERENCES

Abdul-Baki, A. A. and Anderson. J. D. (1973). In: Physiological and biochemical deterioration of seeds. Kozlowski, T.T. (ed.). *Seed biology*, *2*, 283-315. Academic Press, New York.

Anbarasan, K., Sivalingam, D., Rajendran, R., Anbazhagan, M. and Chidambaram, A. (2013). Studies on the mutagenic effect of EMS on seed germination and seedling characters of Sesame (*Sesamum indicum* L.) Var. TMV3. *Int. J. Res. Biol. Sci.*, *3*(1), 68-70.

Anonymous (2020). Department of Agriculture, Government of Maharashtra, http://krishi.maharashtra.gov.in/1238/District-Level.

Ashri, A. (1998). Sesame breeding. Plant Breeding Reviews, *16,* 179-228.

Bedigian, D. (2003a). Evolution of sesame Revisited: Domestication, diversity and prospects. *Genet Resource Crop*, *50*, 799–787.

Bedigian, D. (2003b). Sesame in Africa: Origin and Dispersals. In: Neumann K, Butler A, Kahlheber S, eds. Food, Fuel and Fields: Progress in African Archaeobotany. Cologne: Heinrich Bert Institute, pp. 17–36.

Bedigian, D. and Harlan, J. R. (1986). Evidence for the cultivation of sesame in the ancient world. *Econ. Bot*., *40*, 137-154.

Boranayaka, M. B., Kambegowda, R., Nandini, B., Satish, R. G. and Santoskumar, B. P. (2010). Influence of gamma rays and ethyle methane sulphonate on germination and seedling survival in sesame (*Sesamum indicum* L.). *Int. J. Pl. Sci. 5*, 655–659.

Brar, G. and Ahuja, R. (1979). Sesame: its culture, genetics, breeding and Biochemistry. In Annu. Rev. Plant Sci. Edited by: Malik, C.P. New Delhi, Kalyani Publishers, pp. 285-313.

Ellench, M, Besbes, S., Roiseux, O., Blecker, C. and Attia, H. (2007). Quality characteristics of sesame seeds and by products. *Food Chem*., *103*, 641-650.

Emrani, S. N., Arzani, A. and Saeidi, G. (2011). Seed viability, germination and seedling growth of canola (*Brassica napus* L.) as influenced by chemical mutagens, *African Journal of Biotechnology*, *10*(59), 1260212613.

FAOSTAT (2020). Food and agriculture organization of the United Nations. http://www.fao.org/faostat/en

ISTA (International Seed Testing Association) (2004): International rules for seed testing annexes. International Seed Testing Association (ISTA), Zurich, Switzerland.

Kumari V., Chaudhary, H. K., Prasad, R., Kumar, A., Singh, A., Jambhulkar, S. and Sanju, S. (2016). Effect of Mutagenesis on Germination, Growth and Fertility in Sesame (*Sesamum indicum* L.), *Annual Research & Review in Biology, 10*(6), 1-9.

Layrisse, A; Nava, A. and Monteverde, E. (1992). Selection de las mejores dosis de rayos gamma para inducir mutaciones en ajonjoli (in Spanish), In: IV Congreso Venezolano de Genetica, Caracas. p. 397.

Ministry of Agril. Govt. of India, 2020-21. http://agricoop.nic.in

Rajaramadoss, B, Ganesamurthy, K., Angappan, K. and Gunasekaran, M. (2014). Evaluation of the effect of gamma rays on sesame genotype TTVS 51 and TTVS 19 in M_1 generation, *International Journal of Development Research*, *4*(2), pp. 273-277.

Raut, Y., Vaidya, E. R. and Sasane, P. R. (2021). Effect of gamma rays on germination and plant survival in sesame (*Sesamum indicum* L.). *The Pharma Innovation Journal*, *10*(12), 392-394.

Singh, L., Singh P.P. and Mishra, M. N. (2018). Effect of gamma rays, hydroxylamine and maleic hydrazide on germination, plant survival and pollen viability in sesame (*Sesamum indicum* L.). *J. of Pharmacognosy and Phytochemistry*; *SP2*, 293-296.

Uttarde, R. B., Bolbhat, S. N., Admuthe, N. B., Kumavat, V. S. and Bhor, A. K. (2020). Induced mutations in sesame (*Sesamum indicum* L.). *IJCRT*, *8*(3), 3171.

How to cite this article: Pallavi Sasane, E.R. Vaidya, Y.C. Raut, D.T. Deshmukh, S.S. Gomashe, S.K. Burghate, R.D. Walke and Aditi Rajane (2022). Gamma Radiation's Effect on the Germination and Survival of Sesame in M_1 Generation. *Biological Forum – An International Journal, 14*(4a): 419-422.