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Evaluation of Mutagenic effects of Gamma Rays and EMS on Seed Germination and Plant Survival in M1 Generation of Tomato (*Solanum lycopersicum* L.)

Ravinsh Kumar Maurya[1]*, Anand Kumar Singh[2], Binod Kumar Singh[2], Akhilesh Kumar Pal[2] and Rohit Kumar Singh[3]

[1]Ph.D. Scholar, Department of Horticulture,
Institute of Agricultural Sciences, BHU, Varanasi (Uttar Pradesh), India.
[2]Professor, Department of Horticulture,
Institute of Agricultural Sciences, BHU, Varanasi (Uttar Pradesh), India.
[3]Assistant professor, Department of Horticulture,
Agriculture College Garhwa, BAU (Jharkhand), India.

(Corresponding author: Ravinsh Kumar Maurya)*
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ABSTRACT: Induced mutagenesis is one of the most effective ways for trait improvement that does not affect the cultivars' well-optimized genetic background. The study had been focuses on evaluating the effects of gamma rays and EMS (Ethyl methane sulfonate) on tomato var. Kashi Adarsh, Kashi Aman and Kashi Anupam in M_1 generation. The experiment was conducted at the Agricultural Research Farm, Institute of Agricultural Sciences at Banaras Hindu University in Varanasi, India, during the Ravi season of 201-19. The experimental design was used as randomized block design, which was replicated three times. The treatments applied in the experiment was control (no treatment), four doses of gamma rays (5kR, 10 kR, 15kR and 20 kR) and four doses of EMS (0.06%, 0.12%, 0.18% and 0.24%). The study was found that both gamma rays and EMS had a negative impact on various aspects of tomato var. Kashi Adarsh, Kashi Aman and Kashi Anupam including seed germination and plant survival. Induced mutations can rapidly create variability in quantitatively and qualitatively inherited traits in crops. EMS was observed to be more effective as a mutagen compared to gamma rays. Tomato is genetically distant from other model plants, making it unique in terms of genetic makeup. Additionally, its sequence information doesn't show significant similarity to other plant species, which complicates the use of tools and knowledge from other model plants. These findings highlight the potential risks associated with mutagenic treatments and provide insights into the sensitivity of tomato plants to these mutagens. Precise identification of accidental mutations is required for understanding trait development and its application in breeding programs.

Keywords: Gamma rays, EMS (Ethyl methane sulfonate), Kashi Adarsh, Kashi Aman, Kashi Anupam, treatments etc.

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) belongs to the nightshade family, botanically known as Solanaceae. It is native to Central and South America from where it has spread to other parts of the world in sixteenth century. It was introduced in India by the Portuguese during 1700 (Kale and Kale 1994). It is the second most important vegetable crop after potato (FAO Stat, 2015). Tomatoes are widely grown for their edible fruits, which are commonly consumed by humans as a vegetable for culinary and nutritional purposes. They are an excellent source of vitamin C, lycopene (powerful antioxidant) and has been associated with various health benefits. They are commonly enjoyed raw in salads, where their juicy and flavourful nature adds freshness to dishes. Tomatoes can also be cooked and used as a vegetable in various recipes, such as sauces, stews, soups, and casseroles. A significant portion of the global tomato crop is processed to create a range of product includes: canned, juice, ketchup, puree, paste and sun-dried are an integral part of global cuisine and offer a rich array of culinary possibilities.

Induced mutation serves as a valuable tool for crop breeders to introduce genetic diversity and create novel variations in existing cultivars. This diversity can lead to the development of plants with improved traits, such as increased yield, better pest resistance or enhanced nutritional content (Tiwari *et al.*, 2018). Mutation is the ultimate source of all genetic variation and provides the raw material for evolution (Saba and Mirza 2002).

Gamma rays are a type of ionizing radiation. They have sufficient energy to remove tightly bound electrons from atoms, resulting in the formation of ions and free radicals. Gamma rays interact with atoms and molecules within cells, leading to the generation of free radicals. These free radicals can cause various types of damage to cellular components, including DNA. Gamma rays induce cytological (cellular), genetical (genetic), biochemical, physiological, and morphogenetic changes in plant cells and tissues. These changes can lead to genetic variations that may result in altered traits. EMS is a chemical mutagen that induces mutations by modifying DNA. It specifically causes nucleotide substitutions, where one DNA base is replaced with another. Similar to gamma rays, EMS induces a wide range of changes in plant cells and tissues, affecting cytology, genetics, biochemistry, physiology and morphogenesis. These changes contribute to the creation of genetic diversity. Both gamma rays and EMS are mutagenic agents that influence plant growth and development by introducing genetic variations. These variations can lead to changes in traits, which may have implications for crop improvement, adaptation to environmental conditions, and overall plant health.

Kashi Adarsh, Kashi Aman and Kashi Anupam are high yielding varieties of tomato. The present investigation was carried out to assess the effect of gamma rays and EMS on tomato var. Kashi Adarsh, Kashi Aman and Kashi Anupam.

MATERIALS AND METHODS

The present investigation was carried out during 2018-19. Uniform and healthy seeds of tomato var. Kashi Adarsh, Kashi Aman and Kashi Anupam were selected for mutagenic treatment. 300 seeds of variety Kashi Adarsh, Kashi Aman and Kashi Anupam per treatment were irradiated with four different dosses of gamma rays *viz*., 5kR, 10kR, 15kR and 20kR at NBRI, Lucknow. For treatment with EMS, soaked in ethyl methane sulphonate (EMS) solution at four different concentrations *i.e.*, 0.06%, 0.12%, 0.18%, and 0.24% in for 06 hours and then washed thoroughly in running tap water over night to eliminate the residual effect of the chemical. A small portion of treated seeds along with control were used for observation on germination test in the laboratory, whereas the major portion of seeds were sown in nursery bed and further transplanted to main experimental blocks in *Rabi* season to raise M_1 generation. The experimental design was randomized block design and replicated thrice at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The row to row and plant to plant distance was maintained at 45 cm and 45 cm, respectively. Recommended agronomical practices were employed for the preparation of field, sowing and subsequent management of M_1 generation.

Germination data were recorded every alternate day up-to 30 days after sowing, till the maximum germination was attained. The germination percentage based on number of seeds sown and germinated, was calculated by the following formula:

$$\text{Germination percentage (\%)} = \frac{\text{No. of seeds germinated}}{\text{Total no. of seed tested}} \times 100$$

Data on plant survival was collected from the field experiment at the time of maturity by counting the total number of surviving plants out of the total germinating seedlings in each treatment as well as control. The following formulae were used to calculate the survival percentage and percent lethality:

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

$$\text{Lethality (\%)} = \frac{\text{Control} - \text{Treated}}{\text{Control}} \times 100$$

RESULTS AND DISCUSSION

All the parameters of M_1 generation var. Kashi Adarsh, Kashi Aman and Kashi Anupam were recorded in Table 1 which were significantly affected by both the mutagens.

Seed germination: Seed germination as per cent of control (untreated population) for the tomato genotypes Kashi Adarsh, Kashi Aman and Kashi Anupam were displayed in Table 1.

The preceding data on seed germination and plant survival in the M_1 generation show that EMS had a greater impact on both than gamma rays. The negative effect on seed germination was more noticeable at higher mutagen dosages, namely 15 and 20 kR gamma rays and 0.18 and 0.24% EMS in Kashi Adarsh. This finding was also supported by Zafar *et al*. (2022); Aruna *et al.* (2010), who investigated the effects of physical (gamma rays) and chemical mutagens (Ethyl Methane Sulphonate (EMS) and Diethyl Sulphate (DES) and concluded that gamma rays were more effective than chemical mutagens in seedling characteristics such as germination percentage, root and shoot length. This conclusion agreed with the research findings of Baghery *et al.* (2016). Similar finding was also reported by Minisi *et al.* (2013), where higher doses of gamma radiation reduced germination percentage and survival in *Moluccella laevis*. The percent of seed germination was decreased with increasing doses/concentration of gamma rays and EMS in chick pea reported by Umavathi and Mullainathan (2014).

In the treated population, increasing the mutagenic dose resulted in a higher drop in seed germination. In the case of Kashi Adarsh, seed germination ranged from 74.73% to 93.41% in gamma rays and 72.53% to 89.01% in EMS treatments. Seed germination ranged from 67.67 to 94.42% and 64.31 to 88.85% in Kashi Aman and from 69.48 to 92.64% and 69.48 to 87.13% in Kashi Anupam under gamma rays and EMS treatments, respectively.

Plant survival: Plant survival as a percent of control (untreated population) of tomato genotypes Kashi Adarsh, Kashi Aman and Kashi Anupam in M_1 generation were showed in Table 2.

Plant survival was lower in the EMS-treated population than in the gamma-ray-treated group. In general, increase in the dose of the mutagens lower the plant survival as a percent of control also reported by Bhala and Verma (2018). When treated with EMS 0.24%, Kashi Anupam had the lowest plant survival (56.80%), followed by Kashi Aman (58.02%) and Kashi Adarsh (58.30%). Several physical and chemical mutagens have been shown to impair plant survival in vegetable crops (Banu *et al.*, 2004; Kumar and Mishra 2004; Bhosale *et al.*, 2013).

Table 1: Seed germination (as percent of control) of tomato genotypes treated with gamma rays and EMS in M1 Generation.

		Kashi Adarsh			Kashi Aman			Kashi Anupam		
Mutagenic treatment	**No. of seeds studied**	**No. of seed germinated**	**% Seed germination**	**Germination as % of control**	**No. of seed germinated**	**% Seed germination**	**Germination as % of control**	**No. of seed germinated**	**% Seed germination**	**Germination as % of control**
T_0: Control	300.00	273.00	91.00	100.00	269.01	89.67	100.00	272.01	90.67	100.00
T_1: 5 kR Gamma rays	300.00	255.00	85.00	93.41	254.01	84.67	94.42	252.00	84.00	92.64
T_2: 10 kR Gamma rays	300.00	240.00	80.00	87.91	222.00	74.00	82.52	221.01	73.67	81.25
T_3: 15 kR Gamma rays	300.00	228.00	76.00	83.52	201.00	67.00	74.72	204.00	68.00	75.00
T_4: 20 kR Gamma rays	300.00	204.00	68.00	74.73	182.00	60.67	67.66	189.00	63.00	69.48
T_5: 0.06 % EMS	300.00	243.00	81.00	89.01	239.01	79.67	88.85	237.00	79.00	87.13
T_6: 0.12 % EMS	300.00	228.00	76.00	83.52	218.01	72.67	81.04	222.00	74.00	81.61
T_7: 0.18% EMS	300.00	210.00	70.00	76.92	195.99	65.33	72.86	204.00	68.00	75.00
T_8: 0.24 % EMS	300.00	198.00	66.00	72.53	173.00	57.67	64.31	184.00	61.33	67.64

Table 2: Plant survival (as percent of control) of tomato genotypes treated with gamma rays and EMS in M_1 Generation.

		Kashi Adarsh			Kashi Aman			Kashi Anupam		
Mutagenic treatment	**No. of seeds studied**	**No. of plant at maturity**	**% survival**	**survival as % of control**	**No. of plant at maturity**	**% survival**	**survival as % of control**	**No. of plant at maturity**	**% survival**	**survival as % of control**
T_0: Control	300.00	247.00	82.33	100.00	243.00	81.00	100.00	243.00	81.00	100.00
T_1: 5 kR Gamma rays	300.00	217.00	72.33	87.85	219.00	73.00	90.12	216.00	72.00	88.89
T_2: 10 kR Gamma rays	300.00	203.00	67.67	82.19	216.00	72.00	88.89	195.00	65.00	80.25
T_3: 15 kR Gamma rays	300.00	193.00	64.33	87.14	186.00	62.00	76.54	177.00	59.00	72.84
T_4: 20 kR Gamma rays	300.00	169.00	56.33	68.42	150.00	50.00	61.73	150.00	50.00	61.73
T_5: 0.06 % EMS	300.00	214.00	71.33	86.64	222.00	74.00	91.36	216.00	72.00	88.89
T_6: 0.12 % EMS	300.00	189.00	63.00	76.52	189.00	63.00	77.79	183.00	61.00	75.31
T_7: 0.18% EMS	300.00	159.00	53.00	64.37	174.00	58.00	71.60	162.00	54.00	66.67
T_8: 0.24 % EMS	300.00	144.00	48.00	58.30	141.00	47.00	58.02	138.00	46.00	56.80

CONCLUSIONS

The study revealed that there was substantial reduction in seed germination seedling height and plant survival with an increase in doses of gamma rays and EMS. The EMS was more deleterious than gamma rays.

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Conflicts of Interest. None.

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