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Induction of mutagnesis on morphological characteristics of tomato (*Solanum lycopersicum L.*) by gamma rays and EMS

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Abstract
The cultivated tomato (*Solanum lycopersicum L.*) is one of the globally important crops for fresh market and food processing industry. It is the second most consumed vegetable after potato and contributes greatly to agro-based industry in the world. Induction of mutation by gamma rays, ethyl methane sulfonate (EMS) and their combined treatments was studied in genotypes of Tomato (*Solanum lycopersicum* L.). Chemical mutagens like ethyl methansulphonate (EMS) which brings about single nucleotide changes, are widely used for developing mutant populations. The present study the characteristic of gamma rays on seed germination percentage, plant survival percentage, number of leaves, number of branches and plant height of tomato (*Solanum lycopersicum L.*). Based on LC50 value, five doses 5, 10, 15, 20 and 25KR were selected for laboratory and field study. The Tomato seeds (*Solanum lycopersicum*) were obtained from the Tamil Nadu Agricultural University (TNAU), Coimbatore, TamilNadu. The genotype seeds were selected to study the effect of physical and chemical mutagens. Combination of gamma radiation and EMS caused more damage followed by EMS treatment and gamma radiation alone in M1 generation. Genotype and mutagen both influenced the production of mutants.

Keywords: ethyl methane suphonate (EMS), Mutants, *Solanum lycopersicum* L. and gamma rays

Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most widely grown vegetable in the world. It is cultivated worldwide in all climates like sub-tropical and tropical. It is native of Peru Ecuador Bolivian region (Rick, 1969) [21]. Tomato was introduced in India during British period in the year 1828 by the Royal agri horticultural society, Calcutta. In India, it has become a very popular vegetable. The tomatoes are available in the market almost round the year in India. It is one of the most popular and widely cultivated vegetable crops in the world (Srinivasan, 2010) [25] and its fruit as a vegetable in trade is also considered to be prominent protective food (Alam *et al.,* 2007) [2]. Tomato is rich source of several essential and beneficial nutrients in the human diet, such as antioxidants (Spencer *et al.,* 2005) [24], Vitamins A and C mineral such as iron, phosphorus (Kalloo, 1991) [14] as well as Carbohydrates and phenolic compound such as flavonoids, polyphenols (Campbell *et al.,* 2004) [7] and organic acid such as naringenin and chloragenic acid (Knekt *et al.,* 2002) [15]. Some other compounds with antioxidant and beta-Carotene (Hobson and Grierson, 1993, Beecher, 1998) [12, 5], including chlorogenic acid, plastoquinones, rutin, tocopherol and xanthophylls are also available in tomato (Leonardi *et al*., 2000) [16]. Tomato is grown worldwide for local use or as an export crop. In 2014, the global area cultivated with tomato was 5 million hectares with a production of 171 million tonnes the major tomato producing countries being the Peoples Republic of China and India (FAOSTAT, 2017) [10]. Tomatoes are the richest source of the dietary antioxidant lycopene, which protects cells from oxidation that have been linked to cancer (Agarwal and Rao, 2000) [1]. Tomato plays an important role in the economy of the farmers of our country. The diversity in cultivated tomato germplasm provides a great resource for development of hybrids. The cultivated tomato is morphologically more diverse than their wild relatives from which the crop was first domesticated. Despite the extensive morphological diversity, genetic diversity among the cultivated types is quite low (Van, *et al.,* 2013) [26]. In tomato, crop improvement work on quality and nutrients is very much limited in India. Hybrids are preferred over pure lines varieties in tomato on account of their superiority in marketable fruit yield and fruit quality. Fruit shape in tomato is one of the most important components of fruit firmness, which represents the basis for studying this trait. The degree of fruit firmness has been used as an indication of fruit quality. Storability of tomato is of prime concern in terms of consumer preference and breeders choice. Therefore, pericarp thickness is considered to be a very important attribute among breeder for selecting cultivars as it is much related to storage capacity of tomato. The success of hybridization depends upon the selection of suitable parental genotypes and superior performance of their cross combinations. Combining ability studies furnish useful information regarding selection of suitable genotypes for hybridization and at the same time elucidate the nature and magnitude of different types of gene action involved. Tomato (*Solanum lycopersicum* L.) most of the crop improvement programmes for increased yield, high oil content and quality are being attempted through conventional breeding methods by exploiting only the naturally available variability in the germplasm. Nevertheless, adequate genetic variability is not available in the existing germplasm for changing the plant type. Under these circumstances, induced mutagenesis can be a profitable proposition to increase the genotypic variations in the morphological, physiological and biochemical characters besides inducing new variants in Tomato. At the same time, the exposure of seeds either to high radiation levels or to higher concentration of chemical mutagens may lead to deleterious effects like a severe reduction in generation and survival, stunted growth etc. The present investigation was undertaken to induce mutation in Tomato variety (*Solanum lycopersicum* L.) by using Gamma rays and Ethyl Methane Sulphonate (EMS). The use of mutagens in crop improvement helps to understand the mechanism of mutation induction and to quantify the frequency as well as the pattern of changes in different selected plants by mutagens. Mutation breeding generates a knowledge base that guides future users of mutation technology for crop improvement. Therefore, the intension of this effort is to test the mutagens as a means of generating variations and useful traits in tomatoes.

Materials and Methods

Genotype

The Tomato seeds (*Solanum lycopersicum*) were obtained from the Tamil Nadu Agricultural University (TNAU), Coimbatore, TamilNadu. The genotype seeds were selected to study the effect of physical and chemical mutagens.

Mutagens

The two mutagens were selected in the mutation study. A physical mutagen Gamma rays was selected for the purpose of irradiation and chemical mutagen of Ethyl Methane Sulphonate (EMS) were used for the chemical mutation.

Gamma irradiation

A physical mutagen, gamma rays was selected fir the purpose of irradiation and a chemical mutagen, Ethyl Methane Sulphonate (EMS) was used for the chemical treatment. Irradiation was done at the gamma chamber at Tamil Nadu Agricultural University (TNAU), Coimbatore, Tamil Nadu. Based on LC50 value, five doses 5, 10, 15, 20 and 25KR were selected for laboratory and field study. The Tomato seeds (*Solanum lycopersicum*) were subjected to the chemical mutagen of Ethyl Methane Sulphonate (EMS). The EMS having the concentrations at 0.5%, 1.0%, 1.5%, 2.0%, 2.5% and 3%. The treated seeds after soaking in EMS, it was thoroughly washed in running tap water for 3 to 5 times and transferred to petriplates containing two layers of moist filter paper to study germination. EMS treated seeds were sown in 10 separate petriplates for study the percentage of germination and seedling variations. Based on the LD_{50} values were four doses 0.5%, 1.0%, 1.5% and 2.0% treated seeds were selected for further M_1 field studies.

Results and Discussion

Tomato (*Solanum lycopersicum* L.) seeds used widely into industrial and nutritional applications and higher levels of which are composed of fat and protein (Shoot, 1995) [23]. It is one of the oldest oil crops in the world. Higher yield and more protein may be due to the activation of several mechanisms, associated with plant growth and metabolism (Bora and Sarma, 2006) [6]. The untreated seeds of Tomato genotype had 100 percent germination. The germination percentage decreased with increase in the dose/conc. of the treatments. Data on the effect of mutagens on germination, expressed as per cent over control and LD_{50} value was observed Gamma rays and EMS of Tomato (*Solanum lycopersicum* L.) is presented in Tables 1.

Table 1: FLD_{50} Value in Gamma Rays and EMS Treatment of Tomato (*Solanum lycopersicum* L.)

	Gamma rays				EMS			
S. No	Treatment doses	Germination %	Percent Control	Per cent reduction over control	Treatment doses	Germination %	Percent Control	Per cent reduction over control
1	Control	95.43	100	-	Control	92.43	100	-
2	5KR	90.32	89.32	-10.68	0.5 mM	75.12	78.57	-21.43
3	10KR	87.02	75.24	-24.76	1.5 mM	63.35	63.15	-36.85
4	15KR	78.03	65.31	-34.69	2.0 mM	57.11	59.18	-40.82
5	20KR	70.03	55.42	-44.58	2.5 mM	45.34	48.22	-51.78
6	25KR	65.21	50.32	-49.68	3 mM	35.33	38.35	-61.65

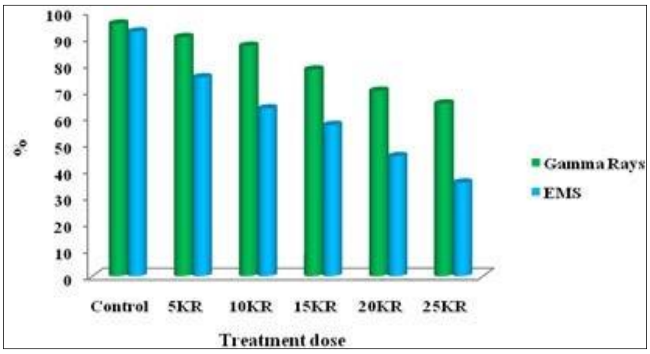

Fig 1: Gamma rays and EMS treatment of M1 generation of tomato (*Solanum lycopersicum L.)*

The percentage of Seed germination was 100%. Germination percentage showed steady reduction from lower to higher doses of Gamma radiations which were 95.43%, 90.32%, 87.02%, 78.03%, 70.03% and 65.21% for control, 5kR, 10kR, 15kR, 20kR and 25kR respectively. Mutation breeding is one of the possible alternatives to conventional breeding for crop improvement. Genetic variability is the pre-requisite for crop improvement which helps in selection, recombination and isolation of superior genotype.

The genetic variability available today in plant collection is the result of past evolution involving spontaneous mutation, recombination and exposure to the forces of natural selection (Gottlieb, 1984) [11]. Many reports confirmed that even with single monogenic mutation, a remarkable reconstruction of plant architecture was possible in grains, legumes and in other dicotyledonous plants (Rao *et al.*, 1975, Saha *et al.*, 2017) [20, 22]. The physical and chemical mutagens can be used for inducing mutation in cultivated plants. It can be possible to increase the genetic variability by inducing many mutations in plants (Donini and Sanino, 1998, Maibam *et al.*, 2018) [9, 17]. In the present study was investigated to improve the quantitative traits and selection of economically important mutants by using mutagens of Gamma rays and EMS in Tomato.

Table 2: Effect of mutagen on plant height, number of leaves and number of branches in *Solanum lycopersicum L.*

S. No	Treatment dose	Plant height (cm) mean	Number of leaves / Plant	Number of branches / Plant
1	Control	55.3 ± 0.78	73.2 ± 0.19	12.7 ± 0.18
2	5KR	50.3 ± 0.60	72.1 ± 0.18	12.5 ± 0.16
3	10KR	45.1 ± 0.55	71.5 ± 0.15	12.3 ± 0.14
4	15KR	40.8 ± 0.37	70.9 ± 0.13	12.1 ± 0.12
5	20KR	35.6 ± 0.30	69.7 ± 0.09	11.9 ± 0.05
6	25KR	30.3 ± 0.25	68.4 ± 0.08	11.5 ± 0.03

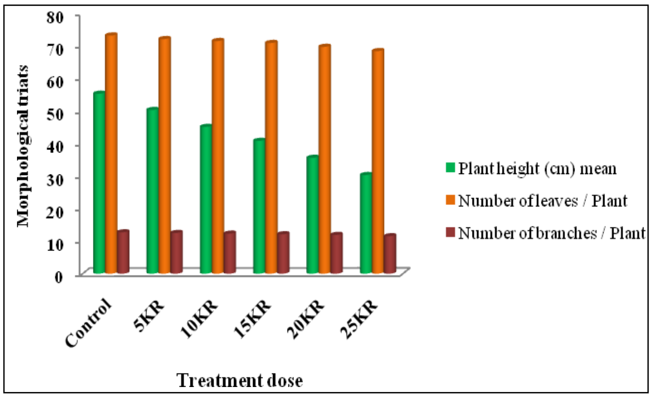

Fig 2: Effect of gamma radiations on various morphological traits in M1 generation of *Solanum lycopersicum L.*

The gamma irradiation on average plant height of *Solanum lycopersicum L.* was measured in the control and irradiated experimental groups (Table 2). It shows the average mean plant heights of the control was 55.3cm and that of plants exposed to 5, 10, 15, 20, 25 and 30 kR gamma irradiation were 50.3, 45.1, 40.8, 35.6 and 30.3 respectively. All the doses showed decrease in the average mean plant height and showed inverse proportionality to the radiation intensity (Fig-2). Irfaq and Nawab, (2001) [13] and Chaudhary, (2002) [8] reported decrease in average plant height in response to gamma radiation. The different doses of gamma rays were observed for number of leaves per plant (Table 2) on *Solanum lycopersicum L.* The mean value of number of leaves in control was observed (73.2) and other irradiated doses, showed the mean value of number of leaves decreased with increasing irradiation doses (Figure 2). In present study, the higher expose of gamma rays affected the total number of leaves per plant. Similar results were reported by (Naheed, 2014) [18, 19]. The different doses of gamma rays were observed for number of branches per plant were measured and compared with the control population (Figure 2). The mean number of branches showed constant decrease with the increasing dose of gamma rays (Ariraman *et al*, 2014). The highest (12.7) mean value of number of branches was measured in control and the lowest (11.5) mean value of number of branches was noticed in 25kR treated plants of gamma radiations (Table 2).

Conclusion

From above investigations it is clear that gamma rays are capable in inducing damage to plants at molecular level and is capable of inducing mutation. Higher the dose of Gamma rays more will be the damage and chances of getting variables may increase. The present investigation clearly demonstrated that induced mutation can be successfully utilized to create genetic variability when it is desired to improve specific traits in plants. It may be concluded that gamma ray mutagenesis can effectively be utilized in the development of desirable economical and quality traits along with some degree of tolerance against biotic stresses in tomato.

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