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Effect of gamma rays and EMS on mutation frequency, mutagenic efficiency and effectiveness in M_2 generation of chilli

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Abstract
Comprised effectiveness and efficiency of gamma rays and EMS for inducing mutation in chilli seeds were treated with gamma rays and EMS. The number of variants and mutation frequency was observed in each treatment in M_2 generation. Mutation frequency as the frequency at which a specific kind of mutation was found in the population of cells or individuals. The frequency and saturation of mutations can be regulated by varying the mutagen dose and mutagenic agents can induce different extensions of genomic lesions, ranging from base mutations to larger fragment insertions or deletions. Mutagenic effectiveness reflects rate of mutation in relation to mutation dose, whereas mutagenic efficiency is the mutation rate in relation to lethality or biological injury. Lethality or biological injury based on germination, increased with increasing doses of irradiation and EMS. The maximum mutagenic efficiency and effectiveness was recorded in the lower doses of mutagenic treatments 0.2% EMS and 100 Gy gamma rays.

Keywords: Gamma rays, EMS, mutation frequency, mutagenic efficiency and effectiveness, chilli

Introduction
Chilli is a spice cum vegetable crop of commercial importance, characterized by tempting colour and biting pungency. No dish will fulfil without this spice in India. India is blessed with a plethora of chilli varieties which are as fresh green fruits, fresh red fruits, and dried red fruits or processed in to chilli paste, chilli powder, oleoresin etc. The fruit quality is determined in terms of nutrient contents of B, P, Fe, Mg, Si, Mn, Al, Ca and Cu. The chilli is an important condiment of high commercial value and also medicinal values containing antioxidant properties, anti-cancerous and many other properties.
Mutation is a sudden heritable change, brought out in a single nucleotide base pair either by addition, deletion or substitution caused by the various factors which leads to a change in the coded information finally expressed in terms of changed phenotypes through alteration in the chain of events like transcription and translation. Mutations are of two types viz., natural or spontaneous mutation and artificial or induced mutation. Frequency of natural mutation is very low, hence artificial mutations are induced and genetic variability is enhanced mostly through the induced mutagenesis with an application of mutagens. Mutations are the tools and being used to study the nature and basis of plant growth and development, thereby producing raw materials for genetic improvement of crops. Induced mutations can rapidly create variability in quantitatively and qualitatively inherited traits in crops.

Material and method
Estimation of mutation frequency, mutagenic efficiency and effectiveness
1. Mutation frequency
The mutation frequency for induced visible mutant was calculated in percentage for each treatment as suggested by Gaul (1958) [4] by using the following formula:

$$\text{Mutation frequency (\%)} = \frac{\text{Number of visible mutants scored}}{\text{Total plant population in treatment}} \times 100$$

2. Mutagenic efficiency and effectiveness

The efficiency and effectiveness of mutagen in the different treatments in M_2 generation was estimated as per the formula given by Konzak *et al.* (1965) [9].

a. Mutagenic efficiency

The mutagenic efficiency was analyzed by mutations per 100 M_2 plants on one side and lethality on the other side as shown below,

Mutagenic efficiency = MP/L

Where,
MP = Mutation per 100 M_2 plants
(Mutation frequency on M_2 plants basis)
L = Percent lethality

b. Mutagenic effectiveness

The mutagenic effectiveness was analyzed for physical and chemical mutagens as given in Table 1.

Table 1: Mutagenic effectiveness

Mutagenic effectiveness	
For physical mutagen	**For chemical mutagen**
MP/ kR	MP/tc

Where,
MP = Mutation per 100 M_2 plants
(Mutation frequency on M_2 plants basis)
kR = Radiation dose in kilo roentgens
t = Duration in hours
c = Concentration of chemical mutagen in millimoles

Result and discussion

Mutation Frequency in M_2 generation

The number of variants and mutation frequency was observed in each treatment in M_2 generation and accordingly the data is presented in table 2.

Table 2: Effect of Gamma rays and EMS on Mutation Frequency in M_2 generation

Treatment	No. of progenies sown	Available M_2 population	Observed mutants	Mutation frequency (%)
T_1 : 100 Gy gamma rays	300	281	09	3.20
T_2 : 200 Gy gamma rays	300	245	12	4.90
T_3 : 300 Gy gamma rays	300	232	04	1.72
T_4 : 400 Gy gamma rays	300	197	09	4.57
T_5 : 0.2 % EMS	300	273	12	4.40
T_6 : 0.3 % EMS	300	267	05	1.87
T_7 : 0.4 % EMS	300	261	08	3.07

The mutation frequency for each treatment was calculated in the percentage based on M_2 population. The maximum percentage of mutation was recorded with the radiated treatment T_2 (4.90 %) followed by the treatments T_4 (4.57 %) and T_5 (4.40 %), while minimum was occurred under T_3 (1.72 %) followed by the treatment T_6 (1.87 %). Mutation frequency as the frequency at which a specific kind of mutation was found in the population of cells or individuals.

Mutagenic Efficiency and Effectiveness in M_2 generation

The mutagenic efficiency and effectiveness was worked out for all the mutagenic treatments and has been presented in table 3.

Table 3: Effect of Gamma rays and EMS on Mutagenic Efficiency and Effectiveness in M_2 generation

Treatment	Lethality (%)	Mutation (Mutation frequency) (%)	Mutagenic efficiency (MP/L)	Mutagenic effectiveness (MP/tc or MP/kR)
T_1 : 100 Gy gamma rays	13.8	3.20	0.23	0.32
T_2 : 200 Gy gamma rays	17.5	4.90	0.28	0.25
T_3 : 300 Gy gamma rays	20.3	1.72	0.09	0.06
T_4 : 400 Gy gamma rays	22.9	4.57	0.20	0.11
T_5 : 0.2 % EMS	14.3	4.40	0.31	0.18
T_6 : 0.3 % EMS	18.1	1.87	0.10	0.05
T_7 : 0.4 % EMS	19.7	3.07	0.16	0.07

Where,
L: Percent lethality
MP: Mutation per 100 plants (mutation freq. %)
kR: Radiation dose on Kilo Roentgen
t: Duration in hours
c: Concentration in millimoles

The maximum mutagenic efficiency was recorded with the treatment 0.2% EMS (T_5) and it was followed by the treatments 200 Gy gamma rays (T_2), 100 Gy gamma rays T_1 and 400 Gy gamma rays (T_4), while it was minimum with the treatment 300 Gy gamma rays (T_3) followed by the treatment 0.3% EMS (T_6) and the treatment 0.4% EMS (T_7). On the other hand, maximum mutagenic effectiveness was recorded in the treatment 100 Gy gamma rays (T_1) followed by the treatments 200 Gy gamma rays (T_2) and 0.2% EMS (T_5), while minimum mutagenic effectiveness was recorded by the treatment 0.3% EMS (T_6) followed by the treatment 300 Gy gamma rays (T_3) and the treatment 0.4% EMS (T_7). Mutagenic effectiveness and efficiency increased with increasing dose of EMS.

Conclusion

Mutagenic effectiveness reflects rate of mutation in relation to mutation dose, whereas mutagenic efficiency is the mutation rate in relation to lethality or biological injury. Lethality or biological injury based on germination, increased with increasing doses of irradiation and EMS. The maximum mutagenic efficiency and effectiveness was recorded in the lower doses of mutagenic treatments 0.2% EMS and 100 Gy gamma rays.

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