Mutagenic effectiveness and efficiency of Gamma rays and Ethyl Methane Sulphonate in pearl millet (*Pennisetum typhoides* (Burn.F.) Stapf. and C.E.Hubb.) Var.CO (cu)-9

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ABSTRACT

Pearl millet is a drought tolerant cereal crop grown primarily as a food grain in India. The present investigation was carried out to find out the seedling injury, lethality and pollen sterility of gamma rays and EMS treated progeny. The seeds of *Pennisetum typhoides* were treated with 10, 20, 30, 40, 50 and 60 kR of gamma rays and 10, 20, 30, 40 and 50 mM of EMS along with control. Mutagenic effectiveness and efficiency was calculated based on biological damage in M1 and chlorophyll mutations in M2. The results indicated that, mutagenic effectiveness and efficiency decreased with increase in mutagenic treatments. The seedling injury and pollen sterility increased with an increase in concentration of mutagenic treatments of both EMS and gamma rays in pearl millet.

Key words: *Pennisetum typhoides*, seedling injury, pollen sterility, mutagenic effectiveness, mutagenic efficiency.

INTRODUCTION

Pearl millet (*Pennisetum typhoides*) locally known as “Bajra” is a nutritious grain cereal. Globally, it is grown on an area of 34.6 million hectare with annual production of 28.8 million tons (FAO, 2005). Pearl millet is grown as food and fodder in arid and semi-arid tropical environments. It is an indispensable source of fodder in many countries of the world (Bhatnagar et al., 1998). It has a high nutritional value as feed for poultry and livestock. Its cultivation in crop rotation has been shown to reduce nematode problems in wheat, soybean and potato. This increases its relevance in biological approaches to pest management. Alternative uses of pearl millet grains show its potential for health foods, bakery products and poultry feed and brewing.

Mutation induction offers the possibility of inducing desired attributes that either cannot be found in nature or have been lost during evaluation. Treatment with mutagens alters genes or breaks chromosomes. Gene mutations occur naturally as errors in DNA replication. Most of these errors are repaired, but some may pass to the next cell division to become established in the plant offspring as spontaneous mutations. Gene mutations without phenotypic expressions are usually not recognized. Consequently, genetic variation appears rather limited and breeders have to resort to mutation induction.

Muller (1927) on artificial transmutation of gene hoped that practical breeders need no longer lie on the mercy of the existing limited genetic variability. He found that X-rays considerably enhance mutation rate in Drosophila. Success with X-rays was achieved by stadler (1928) in barley. Mutation breeding makes extensive use of deviations from the norms to improve the characteristics of important crops. However, an efficient genetic improvement of a cultivar depends on the knowledge of mode of gene action, genetic variability, and the interrelationship among important plant characters.

Induced mutagenesis is a significant tool to break through the limitations of variability and to create variability in a short period of time (Akgun and Tosun, 2004; Yaqoob and Rashid, 2001).

Induced mutation breeding, which has been recognized as a valuable supplement to conventional breeding in crop
improvement has been applied in cereals. This study was undertaken in Pearl millet (*P. typhoides*) variety CO (cu) to assess the effectiveness and efficiency of chemical mutagens, ethyl methane sulphonate (EMS), physical mutagen and gamma rays.

**MATERIALS AND METHODS**

*Pennisetum typhoides* Var. CO (Cu) was selected to induce mutagenesis. The seeds of CO (cu) varieties collected from Tamilnadu Agricultural University, Coimbatore was used for the present study. The seeds irradiated with different doses (10, 20, 30, 40, 50 and 60 kR) of gamma rays from ⁶⁰⁹CO from The Sugar cane breeding Institute, Coimbatore. For EMS treatment, 20 g healthy seeds were treated with different concentrations of (10, 20, 30, 40 and 50 mM) respectively. The seeds were soaked at room temperature for 4 h. The treated seeds were carefully removed from the solution. They were thoroughly washed in tap water for two to three times and untreated dry seeds presoaked in distilled water for four hours and used as control.

For raising M₁ generation, the seeds were treated with different doses/concentrations of gamma rays and EMS were sown along with controls at the Botanical garden of Botany Department, Annamalai University, Annamalai nagar in a Randomized Block Design (RBD). The spacing was maintained at 15 cm (Plant to plant in a row) and 30 cm (between the rows) in the field. All the surviving individual plants were harvested in each treatment in M₁ generation. M₁ plants having sufficient seeds in different treatments were grown to raise M₂ generation with three replications. Screening was done for chlorophyll and viable mutation. Chlorophyll mutations were classified in accordance with the system of Gustaffson (1940) and Blixt and Gottschalk (1975). Frequency of viable mutations was calculated in M₁ plants and M₂ seedling basis. Data on biological abnormalities such as injury and lethality in M₁ generation and chlorophyll mutation frequency in M₁ generation and M₂ generation were used to determine the mutagenic efficiency and effectiveness according to the formula suggested by Konzak et al. (1965) expressed as:

1) Mutagenic effectiveness and mutagenic efficiency

\[
\text{Mutagenic effectiveness} = \frac{\text{Mutation Frequency (MF)}}{\text{Dose or (Time} \times \text{Conc.)}} = \frac{MF}{TC} \text{ or } \frac{MF}{kR}
\]

Where,
MF= Percentage of chlorophyll mutations in M₂ generation
T= Period of treatment with chemical mutagens
C= Concentration of chemical mutagens
kR= Gamma rays, Unit of gamma radiation

Mutagenic efficiency= Mutation frequency (MF)

2) Seedling injury and lethality

Data on seedling injury and lethality was expressed in percentage.

3) Pollen sterility

Pollen sterility was determined from 20 randomly selected plants belonging to each treatment. Aceto-carmine test was used to determine the pollen sterility. The pollen grains from freshly dehisced anthers were stained with 1% acetocarmine. Pollen grains that stained fully were considered as fertile, while the empty, partially stained shivelled ones were considered as sterile.

**RESULTS AND DISCUSSION**

**Mutation frequency**

Chlorophyll and viable mutations was calculated in M₂ seedlings and plant basis. High mutation frequency was observed in 20 kR of gamma rays and 30 mM of EMS (Ambli and Mullainathan, 2015) in Pearl millet. Mutagenic effectiveness reflects rate of mutation in relation to mutagen dose, whereas, mutagenic efficiency is the mutation rate in relation to lethality or biological injury. There were differences in mutagenic effectiveness and efficiency (M/L) in relation to EMS and irradiation dose. Lethality or biological injury based on germination increased with increasing doses of gamma rays and EMS. Mutagenesis 40 mM of EMS produced the highest (47.75) lethality and 30 kR of gamma rays produced (49.0) lethality (Table 1). Similar results were earlier reported in Urdbean (Bhosale et al., 2013).

**Mutagenic effectiveness**

High mutagenic effectiveness was observed in 10 kR of gamma rays and low mutagenic effectiveness observed in 40 mM of EMS. The mutagenic effectiveness decreased with increase in dose of both the mutagens. Similar results were reported earlier in Lentil (Sharma, 1990; Solanki et al., 2004), Green gram (Velu et al., 2008), Cowpea (Dhanavel et al., 2008) Chilli (Sri devi and Mullainathan, 2011) and Chickpea (Kharkwal, 1998).

**Mutagenic efficiency**

The mutagenic efficiency increased dose of both gamma
rays and EMS treatments. The mutagenic efficiency varies on different dose or concentration of mutagen. The highest mutagenic efficiency was observed in 20 kR of gamma rays and 20 mM of EMS. Singh (2007) reported mutagenic effectiveness, efficiency of gamma rays and ethyl methane sulphonate in Mungbean and treatments of the mutagens suggesting the direct relationship with the dose dependent increase.

### Pollen sterility

Pollen sterility revealed that both the mutagens employed in the present investigation, EMS and Gamma rays are effective in inducing pollen sterility in M₂ generation. The rate of pollen sterility increased with increase in the concentration or dose of mutagens. These results are in agreement with those of earlier researchers like Khan et al. (2000) in Green gram, Khan and Wani (2006) in Mungbean, Sharma et al. (2005) in Urdbean, Barshile et al. (2006) in Chickpea, Satpute (2009) in Lentil, Rubina et al. (2012) in *Vicia faba* and Sangle and Kothekar (2013) in Pigeon pea.

### Conclusion

The seedling injury, lethality and pollen sterility increased with an increase in concentration or dose of mutagenic treatments of both EMS and Gamma rays. Mutagenic effectiveness and efficiency varies on different dose or concentration of mutagen. In the present study, it was concluded that chemical mutagens are more effective including maximum mutation frequency as observed in Pearl millet.

### ACKNOWLEDGEMENT

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### REFERENCES


### Table 1. Mutagenic effectiveness and efficiency of chlorophyll and viable mutation in *Pennisetum typhoides* Var. CO (cu)-9.

<table>
<thead>
<tr>
<th>Mutagens conc./doses</th>
<th>Total number of plant studied</th>
<th>Total number of plant mutant</th>
<th>Mutation frequency % (M)</th>
<th>Lethality % (L)</th>
<th>Injury % (I)</th>
<th>Pollen sterility</th>
<th>Effectiveness M/C x T</th>
<th>Efficiency</th>
<th>L=M/L</th>
<th>I=M/I</th>
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<tbody>
<tr>
<td>10 kR</td>
<td>780</td>
<td>44</td>
<td>5.64</td>
<td>19.5</td>
<td>11.94</td>
<td>0.05</td>
<td>0.56</td>
<td>0.28</td>
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<td>20 kR</td>
<td>724</td>
<td>63</td>
<td>8.70</td>
<td>45.25</td>
<td>15.75</td>
<td>0.15</td>
<td>0.43</td>
<td>0.19</td>
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<tr>
<td>30 kR</td>
<td>708</td>
<td>39</td>
<td>5.50</td>
<td>49.00</td>
<td>18.43</td>
<td>0.20</td>
<td>0.18</td>
<td>0.11</td>
<td>0.29</td>
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<tr>
<td>20 mM</td>
<td>756</td>
<td>60</td>
<td>7.93</td>
<td>25.25</td>
<td>9.67</td>
<td>0.10</td>
<td>0.39</td>
<td>0.31</td>
<td>0.82</td>
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<tr>
<td>30 mM</td>
<td>684</td>
<td>68</td>
<td>9.94</td>
<td>40.5</td>
<td>16.91</td>
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<td>40 mM</td>
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<td>55</td>
<td>8.18</td>
<td>47.75</td>
<td>18.75</td>
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