

## Effectiveness and Efficiency of Physical and Chemical Mutagens in Fennel

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**Abstract:** In the present study, mutagenic effectiveness and efficiency of gamma rays, sodium azide, ethyl methane sulphonate (EMS) and their combinations were estimated in fennel cv. RF-101. A steady reduction in germination, subsequent survival and pollen fertility was observed with the increasing doses of the mutagens. The efficiency of mutagenic treatment increased with the dose of the mutagen. Azide at 3 mM had maximum efficiency (0.976), followed by EMS at 0.50% (0.760). Magnitude of effectiveness also increased with increase in the dose of the mutagen. Sodium azide was found to be the most effective, being 24-fold as effective as EMS and 310 times as gamma rays.

**Key words:** Mutagens, effectiveness, efficiency, biological damage.

Fennel (*Foeniculum vulgare* Mill), belonging to family Umbelliferae, is an important seed spice crop of arid and semi-arid regions of Rajasthan. The success of any breeding methodology for improving quantitative characters in fennel, as in other crops, depends primarily on the magnitude of genetic variability available and its efficient utilization. Therefore, while existence of genetic variability is essential for crop improvement, if not present, then its creation and management becomes central to crop breeding (Chopra, 1989). The induced mutations have been found quite effective in generating useful variation for polygenically controlled traits.

The usefulness of a mutagen in plant breeding depends both on its effectiveness and efficiency. Mutagenic effectiveness is the number of mutations induced by a unit dose of the mutagen, i.e., the ratio factor mutations/dose, while mutagenic effectiveness is the frequency in relation

to undesirable changes, i.e., the ratio factor mutations/biological damage, such as lethality, seedling injury, pollen sterility and chromosomal aberrations at mitosis and meiosis (Konzak *et al.*, 1965). Besides, effectiveness and efficiency are two different properties of mutagens. A highly effective mutagen may not necessarily show high efficiency, and vice-versa. There are several biological, environmental and chemical factors which modify and influence the response of cells in higher plants to physical and chemical mutagens and consequently, mutagenic effectiveness and efficiency are also modified (Blixt, 1972). The purpose of the present study was to determine the effectiveness and efficiency of gamma rays, sodium azide, ethyl methane sulphonate (EMS) and combination of gamma rays with sodium azide and EMS.

### Materials and Methods

Healthy and uniform seeds of fennel cv. RF-101 were exposed to gamma rays

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(5, 10, 15 kR at IARI, New Delhi), ethyl methane sulphonate (0.25% and 0.50%), sodium azide (1 mM and 3 mM) and combination of 5 kR gamma rays + 1 mM azide and 5 kR gamma rays + 0.25% EMS. The chemical treatments were given in 0.1 M phosphate buffer adjusted at pH 3.0 (for sodium azide) and pH 7.0 (for EMS). For chemical treatments, the seeds were pre-soaked in distilled water for 6 h and then immersed in mutagen solution for 6 h (with periodic shaking), followed by post-treatment washing in gentle flow of tap water. The seed samples were surface-dried on a blotting paper before sowing. The LD<sub>50</sub> in respect of the mutagens were observed as 10 kR gamma rays, 1 mM sodium azide and 0.25% EMS. The seeds (approximately 480 seeds/treatment/replication) were sown in RBD with three replications in 4.0 x 2.7 m beds with 45 cm distance between the rows during the rabi season (1998-99). In the second year 270 M<sub>2</sub> progenies were evaluated. Thirty progenies were taken from each mutagenic treatment. Each M<sub>2</sub> progeny was corresponded to single M<sub>1</sub> (selfed) plant. The M<sub>2</sub> progenies were sown in plots consisting of two, 2 m long rows spaced 45 cm apart. Observations were recorded on germination, plant survival and pollen sterility in M<sub>1</sub> and chlorophyll-deficient mutants, along with plants showing gross morphological changes in M<sub>2</sub> generation. Both mutagenic effectiveness and efficiency were determined using the formulae of Konzak *et al.* (1965).

## Results and Discussion

The immediate effects of mutagenic treatments were recorded in terms of reduction in germination, plant survival and

pollen sterility as compared in M<sub>1</sub> generation (Table 1). With the increasing doses of the mutagens a steady decrease in germination, pollen fertility and plant survival were recorded. At LD<sub>50</sub> the mutagens gamma rays (10 kR), sodium azide (91 mM) and EMS (0.25%) showed comparable reduction in germination and plant survival, but not pollen fertility, indicating that higher mutagen doses had greater adverse effect on the biological parameters studied. EMS caused maximum biological damage, closely followed by sodium azide (Table 1). Maximum reduction in germination (74.38%), pollen fertility (39.50%) and plant survival (77.34%) were observed at EMS 0.50%, followed by sodium azide (3 mM) treatment, which reduced the germination, pollen fertility and plant survival by 73.47, 34.30 and 76.19%, respectively.

The combination treatments showed intermediate lethality and pollen sterility effects to those caused by the chemical (EMS and sodium azide) and physical (gamma rays) mutagens. The order in which mutagenic treatment caused biological damage in terms of pollen sterility were EMS>sodium azide>combination and gamma rays.

### *Mutagenic effectiveness and efficiency*

In this study both mutagenic effectiveness and efficiency increased with increase in dose/concentration of the mutagen. This might be due to the recovery of higher frequency of chlorophyll mutations at higher doses/concentrations and consequent increase in per cent M<sub>2</sub> families segregating for the mutants (Table 2). Sodium azide was found to be the most effective (231.62). It was 24-fold as effective as EMS (9.73) and 310 times as gamma rays (0.748). In combination treatment azide