

## Ethyl Methanesulphonate (Ems), A Potent Chemical Mutagen: A Review



Science

**KEYWORDS:** EMS, MMS, SA, quantitative characters.

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### ABSTRACT

*World food insecurity is posing a great threat to the human civilization now-a-days. Scientists are busy worldwide to find out workable solutions for combating food insecurity. Different methods are applied worldwide to improve the yield of plants. Out of these, mutation breeding plays an important role to improve the yield and to ameliorate food insecurity which is spreading worldwide. In mutation breeding, both physical and chemical mutagens are applied. The main chemical mutagens are methyl methanesulphonate (MMS), ethyl methanesulphonate (EMS), diethyl sulphate (DES) and sodium azide (SA). EMS is ranked after MMS as a potent chemical mutagen to induce the genetic variability to improve the useful characters in plants. EMS has been used from past to improve the yield characters in plants. In future, it is an important tool and hope to reduce the food insecurity of world's growing population.*

(Million tonnes)

### SUMMARY

EMS has been used by scientists throughout the world to induce mutational variability in plants for increasing the yield of plants. As per the research, the lower concentrations of EMS has been used to induce desirable variability in plants while as the higher concentrations has negative effects on plants. So, it is better in future to use lower concentrations of EMS on plants to increase the yield and its attributing traits in plants to reduce the hunger problem. Moreover, this variability can be achieved in short duration of time minimizing the time consumption.

### INTRODUCTION

World food insecurity is a major problem and a major concern of discussion in the world now-a-days. According to the most recent updates of FAO (2013) that at least 842 million people in the world i.e., 12% of world population were unable to meet their energy requirements in 2011-2013 from 868 million people reported earlier in 2010-2012. Thus around one in eight people are likely to have suffered from chronic hunger. Most of the people among the above (827 million) are from developing countries. This food insecurity has become a major threat worldwide. The major causes of world food insecurity in world are the limited land and low yield of plants. The major focus among the plants is the pulse crops. The reason behind this is the ability of pulse crops to fix atmospheric nitrogen and the appreciable percentage of proteins in their seeds. As already mentioned above the limited land and low yield is the major concern.

The environment is changing constantly throughout world. As per 2nd Advance Estimates, the crop production of 2012-2013 declined by about 6.59 million tonnes compared to 2011-2012. This decline in production has been observed due to the late monsoon and insufficient rains. World population is increasing continuously. Therefore, the immediate need of increased crop production is necessary. The variability in plants for increasing their yield is the solution and the major focus of scientists these days. Different mutagens are applied on pulses to increase their yield. Among them EMS is a potent chemical mutagen to induce the mutational variability in plants. It is an alkylating agent and possibly carcinogenic organic compound. It typically produces only point mutations. Scientists have used EMS to induce mutational variability in plants to increase the yield and ameliorate the hunger problem in the world.

PRODUCTION ESTIMATES OF MAJOR CROPS FOR 2012-2013 AS COMPARED TO PREVIOUS THREE YEARS ARE AS FOLLOWS:

CROP	2009-10	2010-11	2011-2012	2012-13
RICE	89.09	95.98	105.31	101.80
WHEAT	80.80	86.87	94.88	92.30
JOWAR	6.70	7.00	6.01	5.26
BAJRA	6.51	10.37	10.28	8.15
MAIZE	16.72	21.73	21.76	21.06
COARSE CEREALS	33.55	43.40	42.04	38.47
TUR	2.46	2.86	2.65	2.75
GRAM	7.48	8.22	7.70	8.57
URAD	1.24	1.76	1.77	1.74
MOONG	0.69	1.80	1.63	1.27
TOTAL PULSES	14.66	18.24	17.09	17.58
TOTAL FOOD GRAINS	218.11	244.49	259.32	250.14

**SOURCE: MP:DS:CP: second advance (8.2.2013) (Release ID: 92103)**

### BIOLOGICAL DAMAGE

EMS is one of the potent alkylating chemical mutagen for chemical mutagenesis. EMS is more effective than physical mutagens (Bhat et al., 2005). Different biological parameters such as seed germination, pollen fertility, and survival have been studied earlier by different authors after the chemical mutagen treatment (Chatuvedi and Singh, 1981; Vandana and Dubey, 1988; Khan 1990; Khan et al 1994; Sharma et al 1995; Khan and Wani, 2005). Gupta and Yashvir (1975) reported a radio protective effect of EMS in *Abelmoschus esculentum*. Dose dependent decrease in seed germination has been reported by Dhole (2003). Decrease in seed germination, growth and survival with increasing concentrations of EMS in *Phaseolus lunatus*. (Kumar et al., 2003). Linearly decrease in seed germination has also been reported by Khan and Wani in mung bean (2004). Decrease in seed germination with increasing concentrations of EMS in chickpea was observed by Parveen (2006). A similar result was observed by Wato et al (2012), after studying the mutagenic variability by EMS in Basmati rice. They observed decrease in seed germination with increasing concentrations of EMS. A linear decrease in seed germination with increasing concentrations of EMS has also been reported by Toker et al in chickpea (2005). Dose dependent decrease in seed germination, pollen fertility has also been reported in chickpea by wani et al (2012). They observed that with the increasing concentrations of EMS, the seed germination and pollen fertility was also reduced in M1 and M2 generation.

Bhosale et al (2013) reported the decrease of seed germination with increasing doses/concentrations of gamma rays and EMS. However, the decrease in seed germination by EMS was found to be more than gamma rays.

#### CYTOLOGICAL ABERRATIONS

The first elaborate report on induction of cytological aberrations was presented by Auerbach and Robson (1942). They reported the induction of mutations and cytological aberrations in *Drosophila* by mustard gas. The occurrence of rod bivalents, ring bivalents and univalents by mutagens was earlier reported by Mansour (1994), Bione et al (2002), and Vinita et al (2004). Bhat et al (2007) observed different cytological abnormalities after EMS treatment of seeds of two varieties of *Vicia faba* L. The different meiotic abnormalities were stickiness, univalents, multivalent, laggards, unorientation, precocious separation of chromosomes at metaphase and bridges. Khan and Tyagi (2009), reported bridges and laggards in soybean after treatment with gamma rays and EMS. Ashutosh et al (2012) reported different cytological abnormalities in root meristem cells in *Catharanthus roseus* L. after treatment with EMS. The chromosomal anomalies observed include condensation, persistent nucleolous, fragmentation, C- metaphase, bridge, laggard, cleft and binucleolated cells. Wani et al (2013) observed various meiotic abnormalities like stickiness, univalents, precocious segregation, laggards, bridges, cytomixis and so on in *Trigonella foenum-graecum* L. after treating it with different doses/concentrations of gamma rays, EMS and SA. They found that gamma rays induced more meiotic abnormalities followed by EMS and SA.

#### MUTAGENIC EFFECTIVENESS AND EFFICIENCY

Effectiveness means the rate of mutation induction as dependent upon mutagenic doses and efficiency refers to the mutation rate in mutation to the various biological effects usually a measure of damage. Different workers have worked on effectiveness and efficiency of mutagens. (Giri and Apparao, 2011; Mahamune and Kothekar, 2012). Khan et al (2005) reported the order of mutagenic effectiveness in chickpea as HZ>SA>EMS. A number of chemical mutagens have been found to be more effective and efficient mutagens. (Basu et al., 2008). Tariq et al (2008) observed that the lower concentrations of EMS are more effective and efficient than higher concentrations in chickpea (*Cicer arietinum* L.). Thilagavathi and Mullainathan (2009) reported EMS as more effective and efficient mutagen than gamma rays in blackgram. Girija et al (2009) observed the decrease in effectiveness with increasing concentrations of EMS in Cowpea (*Vigna unguiculata* L. Walp). EMS was found to be more effective than gamma rays and combined treatment. Wani, A. (2009) observed the decrease in effectiveness with increasing concentrations in EMS treated population in chickpea (*Cicer arietinum* L.). He also observed that lower concentrations of EMS were more efficient than higher concentrations. Wani et al (2011) observed that moderate doses were more effective and efficient in mungbean after treatment with EMS, HZ and SA. They also reported that mutagenic effectiveness decreased at higher concentrations of above three mutagens. They determined the order of mutagenic effectiveness on the basis of mutant progenies as HZ>SA and EMS. These results were in contrary to the previously observed results by Reddy, 1992; Kumar and Dubey, 1998; Waghmare and Mehra, 2001).

#### CHLOROPHYLL MUTATIONS

The genetic effects of various mutagens can be evaluated by chlorophyll mutations. Rao et al (1975) observed various chlorophyll mutations in blackgram after mutagenic treatment. Different chlorophyll mutations were observed by Khan and Siddique (1993) in two varieties of mungbean (*Vigna radiata* (L.) Wilczek.) after chemical mutagen treatment viz., EMS, MMS and SA. Among these chemical mutagens, EMS produced highest

frequency of mutations ( in terms of effectiveness) followed by MMS and SA. Girija and Dhanavel (2009) observed that more chlorophyll mutations in EMS treated plants than gamma irradiated plants in M2 generation. Similar observations were reported by Solanki (2005) in Lentil.

#### QUANTITATIVE TRAITS

Effect of EMS on quantitative traits has been reported in sunflower by Selvaraj and Jaykumar (2004). Basu et al (2008) observed improvement of different quantitative traits like pod length and number of pods in M3 plants of fenugreek (*Trigonella foenum-graecum* L.) after treating with different concentrations of EMS. Selvaraj et al (2010) studied different quantitative characters like plant height, number of days for first flowering etc after treatment of EMS in *Jatropha curcas* L. They observed that height decreased with increasing concentrations of EMS while the number of days for first flowering considerably reduced at lower concentrations while as the same increased at higher concentrations. Decrease in quantitative traits at higher concentrations of EMS has been reported by Kozgar et al (2010) in *Vigna radiata* and *Vigna mungo*. Wani et al (2012), reported the increase of various quantitative characters like number of pods per plant and 100 seeds weight at lower concentrations of EMS in M3 generation in chickpea (*Cicer arietinum* L.).

## REFERENCE

- 2nd Advance Estimates of Crop Production 2014. Press Information Bureau, Government Of India. | Auerbach, C. and Robson, J. M. (1942). Experiments on the action of mustard gas on *Drosophila*. Production of sterility and mutation. Report to Minister of supply 31979. | Basu et al., (2008). Genetic improvement of fenugreek (*Trigonella foenum-graecum* L.) through EMS induced mutation breeding for higher seed yield under western Canada prairie conditions. *Euphytica*. 160, 249–258. | Bhat et al., (2007). Meiotic studies in two varieties of *Vicia faba* L. (Fabaceae) after EMS treatment. *Asian Journal of Plant Sciences*. 6, 51-55. | Bhat, T. A., Khan, A. H. and Parveen, S. (2005). Comparative analysis of meiotic abnormalities induced by gamma rays, EMS and MMS in *Vicia faba* L. *J. Ind. Bot. Soc.* 84, 45-48. | Bhosale et al. (2013). M1 generation studies in urdbean (*Vigna mungo* (L.) Hepper) *Advances in Applied Science Research* 4, 95-97. | FAO (2013). FAO, IFAD and WFP (2013). *The State of Food Insecurity in the World 2013. The multiple dimensions of food security*. Rome, FAO. | Giri, S. P., Apparao, B. J. (2012). Studies on effectiveness and efficiency of EMS in pigeonpea (*Cajanus cajan* L.). *Bioscience Discovery* 2, 29-31. | Girija, M. and Dhanavel, D. (2009). Mutagenic Effectiveness and Efficiency of Gamma Rays, Ethyl Methane Sulphonate and Their Combined Treatments in Cowpea (*Vigna unguiculata* L. Walp). *Global Journal of Molecular Sciences*. 4, 68-75. | Gupta, P. K. and Yashvir. (1975). Induced mutation in foxtail millet (*Setaria italica* Beauv.) I Chlorophyll mutations induced by gamma rays, EMS and DES. *Theor. Appl. Genet.* 45, 242-249. | Khan, M. H. and Tyagi, S. D. (2009). Cytological effects of different mutagens on soybean (*Glycine max* (L.) Merrill). *Front. Agric. China*. 3, 397-401. | Khan, S. and Siddique, B. (1993). Chlorophyll mutation in *Vigna radiata* (L.) Wilczek. II mutagenic effectiveness and efficiency of chemical mutagens. *Pak. J. Bot.* 25, 161-166. | Khan, S. (1990). Studies on chemical mutagenesis in mungbean (*Vigna radiata* (L.) Wilczek). Ph. D. Thesis. Aligarh Muslim University, Aligarh. | Khan, S., Siddiqui, B. A. and Nadeem, M. (1994). Variation in quantitative characters of mungbean after treatment with DES. *Adv. Plant. Sci.* 7: 41-45. | Khan, S., Wani, M. R., Bhat, M. and Parveen, K. (2005). Induced chlorophyll mutations in chickpea (*Cicer arietinum* L.). *International Journal of Agriculture and Biology*. 7, 764–767. | Kozgar, M. I., Goyal, S. and Khan, S. (2010). EMS induced mutational variability in *Vigna radiata* and *Vigna mungo*. *Res. J. Bot.* 6, 31-37. | Kumar, S. and Dubey, D. K. (1998). Mutagenic efficiency and effectiveness of separate and combined treatments with gamma rays, EMS and DES in Khesari (*Lathyrus sativus* L.). *Journal of Indian Botanical Society*. 77, 1–4. | Mahamune, S. E. and Kothekar, V. S. (2012). Induced mutagenic frequency and spectrum of chlorophyll mutants in French bean. *Int. Multidisciplinary Res. J.* 2, 30-32. | Mansour, K. S. (1994). Effect of gamma irradiation on mitosis of *Lens esculenta*, *Trigonella foenum graecum* and *Vicia faba* L. *Egypt. J. Bot.* 34, 81-92. | Rao, A. S., Rao, S. P. and Jana, M. K. (1975). Induction of non-dormant mutants in blackgram. *J. Heredity*. 66, 388-389. | Reddy, V. R. K. (1992). Mutagenic parameters in single and combined treatments of gamma rays, EMS and sodium azide in triticale, barley and wheat. *Advances in Plant Sciences*. 5, 542–553. | Selvaraj et al., (2012). Physical and chemical mutagenesis in *Jatropha curcas* L. to induce variability in seed germination, growth and yield traits. *ROM. J. BIOL. – PLANT BIOL.* 55, 113–125. | Selvaraj, R. and Jayakumar. S. (2004). Effect of gamma rays and ethylmethane sulphonate on qualitative and quantitative traits in sunflower (*Helianthus annuus* L.) Cv. Morden. *Madras Agric J.* 91, 206-210. | Sharma, R., Singh, V. P., Srivastava, A. and Sharma, S. K. (1995). The influence of copper on mutagenic efficiency of EMS in mungbean. *J. Indian. Bot. Soc.* 73, 83-84. | Solanki, I. S. (2005). Isolation of macromutations and mutagenic effectiveness and efficiency in lentil (*Lens culinaris* Medik.). *Indian J. Genet.* 65, 264-268. | State of Indian Agriculture. (2012-2013). Ministry of Agriculture and Cooperation New Delhi. | Thilagavathi, C. and Mullainathan, L. (2009). Isolation of Macro Mutants and Mutagenic Effectiveness, Efficiency in Black Gram (*Vigna mungo* (L.) Hepper). *Global Journal of Molecular Sciences*. 4, 76-79. | Vandana, S. K. and Dubey, D. K. (1996). Meiotic anomalies induced by EMS and DES in *Vicia faba* L. *J. Indian Bot. Soc.* 75, 237-240. | Verma et al., (2012). Cytogenetic effect of EMS on root meristem cells of *Catharanthus roseus* (L.) G. Don var. Nirmal. *International Journal of Pharmacy and Biological Sciences*. 2, 20-24. | Waghmare, V. N. and Mehra, R. B. (2001). Induced chlorophyll mutations, mutagenic effectiveness and efficiency in *Lathyrus sativus* L. *Indian J Genet Plant Breed*, 61, 53–56. | Wani et al., (2012). Induction and assessment of genetic variability for yield and yield contributing traits of chickpea [*Cicer arietinum* L.], *Journal of Plant Genomics*. 2, 28-33. | Wani et al., (2013). Chromosomal damage induced by gamma rays, ethyl methyl sulphonate and sodium azide in *Trigonella foenum-graecum* L. *Chromosome Botany*. 8, 1-6. | Wani et al., (2013). Studies on mutagenic effectiveness and efficiency in fenugreek (*Trigonella foenum-graecum* L.). *African Journal of Biotechnology*. 12, 2437-2440. | Wani, M. R., Khan, S. and Kozgar, M. I. (2011). Induced chlorophyll mutations. I. Mutagenic effectiveness and efficiency of EMS, HZ and SA in mungbean. *Front. Agric. China*. 5, 514–518. | Wattoo et al., (2012). Ethyl methanesulphonate (EMS) induced mutagenic attempts to create genetic variability in Basmati rice. *Journal of Plant Breeding and Crop Science*. 4, 101-105. |