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Mutagenic effectiveness and efficiency of gamma rays and EMS in soybean (*Glycine max* (L.) Merrill)

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Abstract
Mutagenic effectiveness and efficiency of EMS and gamma rays were studied in the two varieties of soybean (MAUS-71 and JS-335). Both mutagens produced high frequency as well as wide spectrum in mutation. The frequency of mutation was high at lower concentration % / dose of mutagen. The mutagenic effectiveness and efficiency was calculated based on biological damage. Mutagenic effectiveness and efficiency reduced with the increase in concentration / dose of mutagen. In present investigation EMS proved to be effective in two varieties and gamma rays proved to be more efficient.

Keywords: Soybean, EMS, Gamma rays, lethality, pollen sterility, chlorophyll mutants

INTRODUCTION

Soybean [*Glycine max* (L.) Merill, family papilionaceae (Fabaceae)], is a crop of great world importance due to widespread applicability of its products and their economical value in the national and international market. Soybean is the world's most important source of edible oil. The productivity of soybean in India is much low in comparison with world average. Due to small, fragile flowers hybridization is very difficult, tedious and costly. Hence classical breeding methods have got limited application in soybean improvement. Alternatively induced mutagenesis is the best method to enlarge genetic variability within short time. Creation of genetic variability by induced mutagenesis proved best for strengthening crop improvement programmers and represents a more efficient source of genetic variability than the gene pool conserve by nature [1].

The induction of physical and chemical mutation is the quickest way to produce the variations to develop new varieties. The effective and efficient mutagens could be providing a large number of variable plants. In the present contexts, the attempts were made to find out the effective and efficient mutagen.

MATERIALS AND METHODS

Dry seeds (9-12% moisture) of two cultivars MAUS-71 and JS-335 of soybean were treated with ethyl methane sulphonate (EMS) (0.05%, 0.10% and 0.15% concentration) and Gamma rays (10, 20, 30Kr) at Government Institute of Science, Aurangabad, Maharashtra, India. About 300 seeds of each treatment were sown in the experiment field along with control (untreated) following randomized block design in three replicates to rise M_1 generation during Kharif season of 2008. All the treatments including control were raised adopting a spacing of 45cm between two lines and 30cm in between plants.

Mutagenic effectiveness is a measure of the frequency of mutations induced by a unite dose of mutagen (Kr or Concentration X time). The mutagenic efficiency despite the proportion of mutation in relation to biological damage induced. The formulae proposed by Konzak (1965) [2] were followed for the calculations of mutagenic effectiveness and efficiency by incorporating the mutation frequency values recorded for each mutagenic treatment

$$\text{Mutagenic effectiveness} = \frac{\text{Mutation frequency (MF)}}{\text{Dose or (Concentration X time)}}$$

$$\text{Mutagenic efficiency} = \frac{\text{Mutation frequency (MF)}}{\text{Biological damage}}$$

i.e. MF/L, MF/I, MF/S

Where T= duration of treatment with mutagen, C= dose or concentration of mutagen,I= Injury, S= pollen sterility MF= percentage of plants segregating for chlorophyll mutations.

Mutation rate

Mutation rate (MR) was calculated by the following formula

$$MR = \frac{\text{Sum of values of efficiency or effectiveness of particular mutagen}}{\text{Number of treatments of a particular mutagen}}$$

This gives the knowledge of mutations induced by a particular mutagen irrespective of dose.

RESULTS AND DISCUSSION

It was observed that the effectiveness reduced drastically as the concentration of mutagen increased (Table1). The lower concentration of EMS (0.05%) demonstrated more effectiveness than the higher concentration (0.15%). The values of effectiveness for EMS treatment 0.05% were 7.43 and 7.36 in variety MAUS-71

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and JS-335, respectively. Whereas the values of effectiveness for the higher concentration (0.15%) was found to be 3.84 and 3.38 in variety MAUS-71 and JS-335 respectively.

The lower dose of gamma rays (10Kr) was more effective with effectiveness 0.264 in variety MAUS-71 and 0.23 in variety JS-335, than the higher dose of gamma rays (30Kr) were found to be 0.138 and 0.12 in variety MAUS-71 and JS-335 respectively.

As far as EMS is concerned, the EMS treatment (0.05%) was most efficient in regard to lethality and EMS treatment (0.10%) was most efficient in regard to pollen sterility in variety MAUS-71.

However the gamma rays (20Kr) was found least efficient as far as lethality and pollen sterility were concerned.

In case of variety JS-335, the EMS treatment (0.05%) was found most efficient in case of lethality and pollen sterility. The lowest values of efficiency were observed in treatment of EMS (0.15%) for lethality and gamma rays (20Kr and 30Kr) for pollen sterility.

Mutation rates were more in mutagen EMS than gamma rays. On the basis of effectiveness, the mutation rates in EMS were 5.25 and 5.07 in variety MAUS-71 and JS-335. In case of mutagen gamma rays, mutation rates were 0.180 and 0.163 in variety MAUS-71 and JS-335, respectively.

Table 1.The relative effectiveness and Efficiency of mutagens in M_1 generation of Soybean.

Mutagen	Concentration % Dose	% chlorophyll mutants (MF)		Lethality (L)		Pollen sterility (S)		Effectiveness MF/T x C		Efficiency MF/L		MF/S		Total ME	
		MAUS-71	JS-335	MAUS-71	JS-335	MAUS-71	JS-335	MAUS-71	JS-335	MAUS-71	JS-335	MAUS-71	JS-335	MAUS-71	JS-335
Control	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
EMS	0.05%	2.23	7.36	10.66	7.66	4.46	3.5	7.43	7.36	0.209	0.288	0.5	0.631	0.709	0.919
	0.10%	2.70	4.48	14.33	14.00	11.3	8.93	4.50	4.48	0.188	0.192	0.238	0.301	0.426	0.493
	0.15%	3.46	3.38	22.66	20.66	15.16	14.7	3.84	3.38	0.152	0.147	0.228	0.207	0.38	0.354
Gamma ray	10Kr	2.64	0.23	14.00	10.00	12.43	13.66	0.264	0.23	0.188	0.236	0.212	0.172	0.4	0.408
	20Kr	2.80	0.14	20.00	18.00	14.81	18.23	0.14	0.14	0.14	0.161	0.189	0.159	0.329	0.32
	30Kr	4.14	0.12	21.66	19.00	20.93	23.4	0.138	0.12	0.191	0.196	0.197	0.159	0.388	0.355

Table 2.Mutation rates of the mutagens in the terms of effectiveness and efficiency in M_1 generation of soybean.

Mutagens	Mutation rate in terms of effectiveness		Mutation rates in terms of efficiency			
			Lethality		Pollen sterility	
	MAUS-71	JS-335	MAUS-71	JS-335	MAUS-71	JS-335
EMS	5.256667	5.073333	15.88333	14.10667	10.30667	9.043333
Gamma ray	0.180667	0.163333	18.55333	15.66667	16.05667	18.43

As far as mutation rates in terms of efficiency concerned, mutation rates of lethality and pollen sterility induced by EMS and gamma rays were more in variety MAUS-71 than variety JS-335. The highest mutation rates were observes in regard to lethality.

In the present investigation lower concentrations of EMS and gamma rays showed higher effectiveness values. In other words the effectiveness of the mutagens decreased with increase in concentration of mutagens. Chemical mutagen (EMS) was found to be most effective than physical mutagen (gamma rays). It was also found that the lower concentrations of both chemical and physical mutagens were most effective. Kavithamani et al. (2008) [3] , Mundhe (2008) [4], Tambe (2009) [5], Pavadai et al. (2009) [6] and Khan and Tyagi (2010) [7] reported higher mutagenic effectiveness at lower concentrations / dose of EMS and gamma rays in soybean. The decrease in effectiveness with increasing concentrations/dose of mutagen has been reported by several authors Sassi Kumar et al. (2003) [8] in limabean, Sharma et al. (2006) [9] in urdbean, Badere and Choudhary (2007) [10] in Linseed, Dhanavel et al. (2008) [11] Girija and Dhanvel (2009) [12], Ashok kumar et al. (2009) [13] in cowpea, Bhosle and kothekar (2010)[14] in cluster bean, and Giri and Apparao (2011)[15] in pigeon pea.

Increasing trend in lethality percentage was observed with increasing dose of EMS and gamma rays in soybean. Similar results were also found by Mundhe (2008)[4], Tambe (2009) [5] in soybean and Sagade (2008) [16] in urdbean. Both the mutagens exhibited gradual decrease in mutagenic efficiency with the increasing concentration or doses with respect to pollen sterility and lethality. This was also reported by Solanki and Sharma (1994)[17], Harsulkar (1994) [18], Mehraj–ud-din et al. (1999) [19], Mitra and Bhowmik (1999) [20], and Koli and Ramkrishna (2002)[21]. According to Konzak et al. (1965) [2], higher efficiency at lower concentration of a mutagenic agent is due to the biological damage (like seedling injury, lethality and sterility) which increases with increase in dose at faster rate than the mutations. Sharma et al. (2005) [22] in urdbean reported that the lower doses of mutagens were more efficient than the higher doses. According to Blixt (1968) [23], effectiveness of any mutagen depends on its dose or concentration and specificity to act on genes and genetic make-up of the cultivars.

The mutation rates were calculated using a mutagen is useful only if it is effective as well as efficient. Efficient mutagenesis is the production of desirable changes with minimum undesirable effects. In mutation breeding programme, a high mutation rate accompanied by minimal deleterious effects is described. But generally the

mutagen that gives the higher mutation rate also induces a high degree of lethality, sterility and other undesirable effects Blixt (1964) [24]. In the present investigation most effective mutagen was EMS than gamma rays in both the varieties of soybean.

When the mutation rates based on efficiency were compared, gamma ray was found to be most efficient as far as lethality and pollen sterility in both varieties of soybean are concerned (Table-2). Similar observation has been recorded by Girija and Dhanvel (2009)[12] and Sharma et al. (2005)[22], Kumar and Ratnam (2010) [25].

CONCLUSION

The results of the present study indicated that lower concentrations of the mutagens are more effective for the induction and recovery of mutations for improvement of soybean.

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