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An analysis of chemical mutagenesis in rice (*Oryza sativa* L.)

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Abstract
The present investigation was carried out to study the effect of the chemical mutagen EMS in the popular rice varieties ADT 43 and ADT 45. The LD_{50} values of EMS were fixed as 0.6 per cent for ADT 43 and 0.8 per cent for ADT 45 which are suitable for inducing viable mutants. The widest spectrum of viable mutants like early, spreading, narrow leaf, lax panicle, long grain, awned grains and hairy grains were noticed in the M_2 generation. The mutagenic effectiveness was maximum at 0.8 per cent EMS in ADT 43. The mutagenic efficiency based on injury was maximum at 0.6 per cent EMS in ADT 43 and the mutagenic efficiency was maximum at 0.8 per cent EMS in ADT 43 based on lethality.

Keywords: Rice, mutation, viable mutants, effectiveness and efficiency

Introduction
Rice is the most important cereal crop cultivated widely in many parts of the world. Rice is the staple food grain for the people of Asia. Rice is rich in B group vitamins and the fat content of rice is low. For crop improvement, induced mutagenesis can be utilized. Mutation breeding has been effectively employed to generate the desired variability in morphological and physiological characters besides inducing new plant ideotypes. Inducible mutation is a suitable source of producing variation in crop improvement (Domingo *et al.*, 2007). The small or large changes in phenotype are classified as viable mutants and are of great significance in plant breeding. Experiences have shown that the frequency of desirable mutations depend upon the effectiveness and efficiency of the mutagens used. The aim is to derive more efficiency with an optimum dose of mutagen. The present investigation deals with the frequency and spectrum of viable mutants and the results of effectiveness and efficiency of the chemical mutagen EMS in rice varieties namely ADT 43 and ADT 45.

Materials and Methods
Two popular rice varieties namely ADT 43 and ADT 45 were chosen to study the effect of the chemical mutagen EMS. LD_{50} values were determined for the mutagen used. Based on this, in both varieties 200 well-dried seeds were soaked in double distilled water for 12 hours. Then they were heated with 0.4, 0.6 and 0.8 per cent concentration of EMS for 4 hours under controlled condition with intermittent shaking. After the treatment, the seeds were thoroughly washed with running tap water for eight to ten times. Pre-soaked seeds in distilled water for 16 hours were used as the control.
The seeds subjected to EMS at different doses were sown in the field along with control as M_1 generation. In each treatment, a total number of 200 seeds were sown. Ten randomly selected M_1 plants per treatment along with control were advanced to M_2 generation. They were sown in randomized block design replicating twice. The scheduled cultural practices and plant protection measures were adopted.
During M_2 generation, some viable mutants were screened. All the viable changes in comparison to the control were scored and described in respect of altered characters from the normal plants. The frequencies of morphological deviants in respect to duration, leaf size, panicle type and grain size were described as viable mutants. Mutation frequency was estimated on M_2 plant basis.
Mutagenic effectiveness is a measure of the frequency of mutation induced by unit dose of mutagen. Mutagenic efficiency gives an indication of the proportion of mutagens in relation to undesirable changes like lethality, injury and sterility. The effectiveness and efficiency of mutagen EMS was worked out by using the formula suggested by Konzak *et al.* (1965).

Results and Discussion

The two rice verities ADT 43 and ADT 45 of Tamil Nadu were treated with the chemical mutagen EMS. The optimum dose of 0.6 per cent in ADT 43 and 0.8 per cent in ADT 45 can be treated as the LD_{50} value for EMS. Due to mutagenic treatments, a general reduction in germination and seedling length were recorded in M_1 generation.

A mutational event may be accompanied by a larger or smaller changes in phenotype. Such changes have the highest significance in plant breeding and have been stressed by Sigubjornsson (1972). All characters which are of interest to plant breeders can be either altered or amended by mutation. Various types of viable mutants were obtained by earlier workers using different mutagenic treatments in rice (Rajendra Kumar and Mani, 1997 and Vennila, 2005). In the present investigation, wide spectrum of viable mutants were observed in the mutagenic treatments (Table 1). The spectrum of viable mutants were early, spreading, narrow leaf, lax panicle, long grain, awned grain and hairy grain.

Early mutants were observed maximum at 0.8 per cent EMS in ADT 43. Similar findings were given by Arun Raja (2002) and Devagi (2004). Spreading mutants were maximum at 0.8 per cent EMS in ADT 45. Spreading mutants had wider angle among tillers and require more spacing. Similar results were reported by Karthikeyan (2003). Leaf mutants include narrow leaf mutant. The maximum narrow leaf mutants were observed at 0.6 per cent EMS in ADT 43. The gene responsible could be 'nl'. Similar reports were given by Ganesh Kumar (2000). Lax panicle type was observed in all the treatments with maximum at 0.8 per cent EMS in ADT 43.

Observations were made on the frequency of viable mutants in M_2 generation. The highest frequency of viable mutants were observed at 0.8 per cent EMS in ADT 45 (Table 2).

The mutagenic effectiveness and efficiency of the mutagen were worked out in Table 3. The mutagenic effectiveness was maximum at 0.8 per cent EMS in

ADT 43. The aim is to derive more efficiency with an optimum dose of mutagen. For obtaining high efficiency, the mutagenic effect should over come other effects in the cells such as chromosomal aberrations and toxic effects. The efficiency

of mutagen was worked out based on injury and lethality. On the basis of injury, 0.6 per cent EMS showed more efficiency in ADT 43. On the basis of lethality,

0.8 per cent EMS showed more efficiency in ADT 43. This was in conformity with Vennila (2005).

Table 1: Spectrum of viable mutants in M_2 generation

Treatment (Conc.)	Early	Spreading	Narrow leaf	Lax panicle	Long grain	Awned grain	Hairy grain	Total
ADT 43								
0.4 % EMS	1	1	2	2	-	-	2	**8**
0.6 % EMS	6	3	4	4	2	1	5	**25**
0.8 % EMS	10	2	1	7	26	32	30	**108**
Total	**17**	**6**	**7**	**13**	**28**	**33**	**37**	**141**
ADT 45								
0.4 % EMS	-	-	2	-	2	-	-	**4**
0.6 % EMS	2	2	2	5	4	-	-	**15**
0.8 % EMS	4	5	1	3	6	1	2	**22**
Total	**6**	**7**	**5**	**8**	**12**	**1**	**2**	**42**

Table 2: Frequency of viable mutants in M_2 generation

Treatments (Conc.)	Total plants studied	Viable mutants observed	Mutation frequency (%)
ADT 43			
Control	420	-	-
0.4 % EMS	480	8	1.66
0.6 % EMS	510	25	4.90
0.8 % EMS	620	108	17.42
ADT 45			
Control	410	-	-
0.4 % EMS	440	4	0.91
0.6 % EMS	480	15	3.12
0.8 % EMS	610	22	3.61

Table 3: Mutagenic effectiveness and efficiency based on viable mutation in M_2 generation

Treatment (Conc.)	Percentage of height reduction (Injury) (I)	Percentage of survival reduction (Lethality) (L)	Mutation for 100 plants (M)	Effectiveness $\frac{M \times 100}{c \times t}$	Efficiency $\frac{M \times 100}{I}$	Efficiency $\frac{M \times 100}{L}$
ADT 43						
0.4 % EMS	1.39	35.18	1.66	25.93	119.42	4.71
0.6 % EMS	1.92	49.88	4.90	51.04	255.20	9.82
0.8 % EMS	0.03	53.27	17.42	136.09	58.06	32.70
ADT 45						
0.4 % EMS	1.77	36.69	0.91	14.21	51.41	2.48
0.6 % EMS	4.23	47.04	3.12	32.50	73.75	6.63
0.8 % EMS	2.93	55.04	3.61	28.20	123.20	6.55

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