Indian J. Genet., **54** (1): 72–76 (1994)

MUTAGENIC EFFECTIVENESS AND EFFICIENCY OF GAMMA RAYS, ETHYLENE IMINE AND N-NITROSO-N-ETHYL UREA IN MACROSPERMA LENTIL (*LENS CULINARIS* MEDIK.)

I. S. SOLANKI* AND B. SHARMA

Division of Genetics, Indian Agricultural Research Institute, New Delhi 110 012

(Received: July 24, 1993; accepted: October 12, 1993)

ABSTRACT

Seeds of a large seeded lentil cv., Precoz Selection, were treated with three doses each of gamma-rays, ethylene imine (EI) and N-nitroso-N-ethyl urea (NEU). In general, both mutagenic effectiveness and efficiency decreased with increasing doses of mutagens, however, the highest dose of gamma rays and medium doses of the two chemicals were found to be most efficient for inducing mutations. Effectiveness of mutagens differed considerably; NEU was 1.2 and 241 times more effective than EI and gamma rays, respectively. The order of effectiveness of mutagens was: NEU (168.6) > EI (138.6) > gamma rays (0.7). Mutagenic efficiency was not as variable as their effectiveness. However, the trend among the mutagens was similar to that observed for mutagenic effectiveness. NEU showed the highest efficiency (0.38), followed by EI (0.33) and gamma rays (0.31). Thus, NEU was 1.2 and 1.1 times as much efficient as gamma rays and EI, respectively.

Key words: Lentil, mutagenic effectiveness & efficiency, chlorophyll, morphological mutations.

Lentil is an important crop of the Indian subcontinent where generally the small seeded (*Lens culinaris* Medik. var. *microsperma* Zhukovsky) varieties are grown. Studies on experimental mutagenesis in this crop are limited and confined to *microsperma* varieties [1–4]. For any mutation breeding programme, selection of effective and efficient mutagen(s) is very essential to recover high frequency of desirable mutations. The present report deals results on effectiveness and efficiency of physical and chemical mutagens in a large seeded variety of lentil (*Lens culinaris* Medik. var. *macrosperma* Zhukovsky).

MATERIALS AND METHODS

The samples comprising 500, 1000 and 1500 dry and well filled seeds of uniform size of the *macrosperma* lentil cv., Precoz Selection, were treated with gamma rays (5, 10 and 20 kR),

*Present address: Department of Plant Breeding, CCS Haryana Agricultural University, Hisar 125004.

N-nitroso-N-ethyl urea (NEU) and ethylene imine (EI). The doses of chemical mutagens were 0.005, 0.01 and 0.02%. Dry seeds were irradiated with gamma rays in a Co^{60} gamma cell delivering 5000R/min and treated with freshly prepared aqueous solution of NEU and EI with the above concentrations for 6 h at 21°C. The treated seeds along with control were sown immediately in the field to raise M_1 generation. Different biological parameters like germination, plant survival and seed fertility were recorded in M_1 generation. In M_2, the treated as well as control progenies were screened for lethal chlorophyll mutations during the first four weeks after germination, whereas viable chlorophyll and morphological mutations were scored throughout the crop duration. Mutation frequency was calculated as percentage of mutated M_2 progenies for both chlorophyll and morphological mutations in each treatment. The mutagenic effectiveness and efficiency were computed using the formulae suggested by Konzak et al. [5].

RESULTS AND DISCUSSION

Some definite patterns regarding various biological parameters were recorded in M_1 generation (Table 1). NEU was the most effective mutagen, followed by EI (medium damage) and gamma rays (least damaging) in respect of all the biological parameters studied. Dose-dependent relationship was noticed with all the three mutagens, i.e. with increase in dose, there was corresponding increase in damage. In general, the biological damage caused by the medium dose of gamma rays (10 kR) was comparable with that of the lowest doses of EI and NEU (0.005%) in respect of all the biological parameters studied [6]. The highest doses of EI and NEU (0.02%) caused a comparable biological damage. The biologically comparable doses are most appropriate for comparing the genetic effects of various mutagens, and their efficiency and effectiveness at comparable levels of damage.

Table 1. Effect of mutagens on germination, plant survival and seed ferility in M_1 generation of macrosperma lentil

Treatment	Germination	Plant survival	Seed fertility
Control	100	100	100
Gamma rays (kR):			
5	91.1	82.2	76.5
10	85.5	74.6	72.6
20	79.1	58.2	65.2
EI (%):			
0.005	87.0	76.2	74.0
0.01	77.0	61.8	70.5
0.02	68.9	47.2	64.7
NEU (%):			
0.005	83.1	73.2	72.3
0.01	73.3	55.6	68.9
0.02	65.3	44.0	62.6

Note. Data presented as percentage of control.

Mutagenic effectiveness pertains to the rate of mutation induction as related to mutagenic dose. In the present study, effectiveness of mutagenic doses differed considerably (Table 2). With all doses of both the radiations (gamma rays) and the chemical mutagens (EI and NEU), mutagenic effectiveness decreased with increase in dose. It was found that the lowest dose of NEU (0.005%) was the most effective for induction of

mutations followed by the lowest of doses of EI (0.005%) and gamma rays (5 kR). Taking the mean values over all three doses of each mutagen, NEU was 1.2 and 241 times more effective than EI and gamma rays respectively. The order of effectiveness of mutagens was NEU (168.6) > EI (138.6) > gamma rays (0.7), which clearly showed the superiority of the nitroso compound (NEU) over other physical and chemical mutagens. The higher mutagenic effectiveness of nitroso compounds (NEU/NMU) over other chemicals and ionizing radiations has also been reported earlier [3, 6–9].

Mutagenic efficiency is referred to as the mutation rate in relation to M_1 damage. Effectiveness and efficiency are two different properties of mutagens. A highly effective mutagen may not necessarily show high efficiency and vice versa. The results indicated that mutagenic efficiency is not as variable as mutagenic effectiveness among the mutagens and their doses used (Table 2). In case of gamma rays, the mutagenic efficiency decreased with the increase in dose, whereas in case of both chemical mutagens medium dose (0.01%) was found to be most efficient. Efficiency increased with increase in dose from the lowest dose (0.005%) to medium dose (0.01%), but declined drastically with further increase in dose from medium to the highest (0.02%). This shows that the highest dose of all the mutagens, causing maximum sterility, is least efficient of all the three doses used. The medium dose of NEU was found to be the most efficient (0.43) for mutations induction, followed by the medium dose of EI (0.39) and the lowest dose (5 kR) of gamma rays (0.33). The increase in the mutagenic efficiency at the medium doses of chemical mutagens suggests that the increase in seed sterility was of a lower magnitude than the response for mutation induction by both the mutagens. Similar observations have been reported in foxtail millet [10].

Table 2. Mutagenic effectiveness and efficiency of gamma rays, ethylene imine and N-nitroso-N-ethyl urea in macrosperma lentil

Treatment	Sterility (%)	Mutated progenies (%)	Mutagenic effectiveness	Mutagenic efficiency
Gamma rays (kR):				
5	23.5	7.7	1.54	0.33
10	27.4	8.6	0.86	0.31
20	34.8	9.6	0.48	0.28
mean	28.6	8.6	0.70	0.31
EI (%):				
0.005	26.0	8.3	276.7	0.32
0.01	29.5	11.6	193.3	0.39
0.02	35.3	9.4	78.3	0.27
mean	30.3	9.7	138.6	0.33
NEU (%):				
0.005	27.7	10.8	360.0	0.39
0.01	31.1	13.3	221.7	0.43
0.02	37.4	11.5	95.8	0.31
mean	32.1	11.8	168.6	0.38

With regard to efficiency also, the trend observed among the mutagens was similar to that of effectiveness. Taking all the doses together, NEU showed the highest efficiency (0.38), followed by EI (0.33) and gamma rays (0.31). Thus, NEU was 1.2 and 1.1 times as much

efficient as gamma rays and EI, respectively. Similar to this study, higher efficiency of the nitroso compounds than other mutagens has been reported earlier [3, 6, 7, 9]. However, Nerkar [11] obtained different results where the order of mutagens based on their efficiency was gamma rays > EMS > NMU. The low efficiency of certain mutagens may be attributed to the use of low doses corresponding to their mutation induction [2]. The higher efficiency of a mutagen indicates relatively less biological damage (seedling injury, sterility, etc.) in relation to mutations induced.

ACKNOWLEDGEMENTS

The award of Senior Research Fellowship by the Indian Council of Agricultural Research, New Delhi, to the first author is gratefully acknowledged.

REFERENCES

1. S. K. Sharma. 1977. Induction of Mutations for Qualitative and Quantitative Characters in Lentil (*Lens culinaris* Medik.). Ph. D. Thesis. IARI, New Delhi: 174.

2. A. Sarker. 1985. Efficiency of Early Generation Selection for Polygenic Mutations in Lentil (*Lens culinaris* Medik.). Ph. D. Thesis, IARI, New Delhi.

3. P. Dixit and D. K. Dubey. 1986. Mutagenic efficiency of gamma- rays, NMU and their combinations in lentil (*Lens culinaris* Med.) var. T. 36. Indian J. Genet., **46**(3): 501–505.

4. N. R. Kalia and V. P. Gupta. 1989. Induced polygenic variation in lentils. Lens Newsl., **16**(1): 8–16.

5. C. F. Konzak, R. A. Nilan, J. Wanger and R. J. Foster. 1965. Efficient chemical mutagenesis. Rad. Bot. (Suppl.), **5**: 49–70.

6. N. P. Singh. 1988. Mutation Studies with Early Generation Selection for Polygenic Variability in Peas (*Pisum sativum* L.). Ph. D. Thesis, IARI, New Delhi.

7. S. K. Sharma and B. Sharma. 1979. Mutagenic effectiveness and efficiency of gamma rays and N-nitroso-N-methyl urea in lentil. Indian J. Genet., **39**(3): 516–520.

8. S. K. Sharma and B. Sharma. 1981. Induced chlorophyll mutations in lentil. Indian J. Genet., **41**(3): 328–333.

9. A. Sarker and B. Sharma. 1989. Frequency and spectrum of chlorophyll mutations in lentil (*Lens culinaris* Medik.). Thai J. Agril. Sci., **22**(2): 107–111.

10. P. K. Gupta and Yashvir. 1975. Induced mutations in foxtail millet (*Setaria italica* Beauv.). 1. Chlorophyll mutations induced by gamma-rays, EMS and DES. Theor. Appl. Genet., **45**: 242–249.

11. Y. S. Nerkar. 1977. Mutagenic effectiveness and efficiency of gamma rays, ethyl methane sulphonate and nitrosomethyl urea in *Lathyrus sativus*. Indian J. Genet., **37**: 137–141.