Research Article

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SELECTION OF EFFECTIVE AND SUPERIOR DOSES OF MUTAGENS FOR IMPROVEMENT IN FENNEL

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ABSTRACT

To evaluate the mutagenic effect of a mutagen, assessment of mutagenic effectiveness and efficiency is of foremost priority, which is index for the appropriate choice. In view to it, present investigation highlighted the effectiveness and efficiency of γ-ray and EMS (the two most used mutagens) on fennel (*Foeniculum vulgare* Mill., family: Umbelliferae), an important seed spice having profuse medicinal values. Duncan's test was performed to select the superior dose(s)/concentration(s) of the two-mutagen based on 8 yield and yield related (plant height, number of primary branches/plant, total branches/plant, number of compound umbels/plant, number of umbels/plant, number of umbellets of first inflorescence, seed weight and harvest index) traits. Results indicated that lower doses /concentrations of mutagens were most promising, which was in conformity with many earlier reports.

Keywords: Mutagenic effectiveness, Mutagenic efficiency, Superior dose, Fennel

INTRODUCTION

Induced mutagenesis has great relevance for raising superior plant types in different crop plants. But most mutations are lethal or semi-lethal possibly due to doses monitored or due to the mutagen(s) employed. According to Kaul[1] the most desirable mutagen is one that is least damaging and that yield highly useful mutants. Thus, for successful mutagenesis, selection of suitable mutagen and its doses is a pre-requisite as mutagens are potent tool for direct improvement or bringing about certain qualitative and quantitative changes in crop plants. The usefulness of mutagens in mutation breeding depends on its mutagenetic effectiveness (mutation per unit dose of mutagens) and mutagenic efficiency (mutation in relation to undesirable changes like sterility, lethality, injury and others).

Present investigation documents the effectiveness, efficiency and most superior doses of two mutagens (γ-ray and EMS) for improvement of fennel (*Foeniculum vulgare* Mill., Family: Umbelliferae; an important seed spice having various medicinal properties[2-4]) in relation to 8 different yield and yield related traits.

MATERIAL AND METHODS

Dry seed sample (moisture content- 9.3%) of fennel (2n=22) were treated with γ-rays (20, 40, 80 and 100 Gy doses at the rate of 2 minutes 24 seconds for 10 Gy from ^{60}Co source at CRIJAF, Nilganj, West Bengal) and EMS (0.25% and 0.50% aqueous solution of EMS- Kodak Chemical, USA - for 2h and 4h). The treated seeds along with control were sown in experimental field (50 seeds in each treatment and control) to raise M_1 generation.

Seeds grown in petriplates (lined with moist filter paper) were used to assess biological damages (per cent of control) like lethality (from germination frequency) and injury (from seedling length) as was suggested by Konzak *et al.*[5]. Seed sterility was estimated from the reduction in seed yield of M_1 plants in treatments in relation to per cent of control. Enhancement in seed germination, seedling growth and seed number per plant has been observed in some treatments and consequently lethality, injury and sterility could not be assigned in those treatments.

Selfed seeds of individual M_1 plant were harvested separately and grown as single plant progeny in M_2 generation. Mutant plants were screened at M_2 generation from seedling to maturity and mutation frequency (Mf) was estimated as per Gaul[6]. Mutagenic efficiency and effectiveness have been calculated from viable mutation frequency[7] using the formulae proposed by Konzak *et al.*[5].

Both control and treated plants from each treatment were compared at M_2 generation for yield (seed yield) and yield related traits (plant height, number of primary branches/plant, total branches/plant, number of compound umbels/plant, number of umbels/plant, number of umbellets of first inflorescence, seed weight and harvest index) from plants grown in randomized design in 3 replications (spacing of 25 cm between lines and 10 cm between plants). Five plants were randomly selected from each replication (unequal) of each treatment (control/mutant) for assessment of agronomic traits (plants were composited together). Duncan's test[8] was computed at 5% level of significance for each parameter to assess significant variation among the plants of each treatment. Homogenous treatment means were assessed following Duncan's test. Alphabets were used corresponding to each mean to denote the magnitude of performance of each trait in each treatment; the alphabets were arranged in descending order to indicate the gradation of superiority. Similar alphabets represented homogenous treatment and the more the common alphabets in the mean, the less the non-significant differences between them.

Table 1: Germination and survivability record at M_1 and M_2 generations

Doses/ Concentration	M_1 generation				M_2 generation	
	Petriplates		Field		Field	
	Germination (%)	Seedling length (mm)	Germination (%)	Survivability (%)	Germination (%)	Survivability (%)
0	66	35.62±5.44	34	88.24	56.00	92.86
20 Gy	30	30.25±5.11	56	100.00	20.86	80.82
40 Gy	32	31.55±3.80	40	90.00	21.56	64.95
80 Gy	32	31.15±4.12	48	91.67	17.36	71.20
100 Gy	22	22.20±3.09	56	78.57	14.18	93.59
0.25%,2h	60	35.83±6.96	26	76.92	22.20	89.19
0.25%,4h	56	44.10±5.73	44	90.91	26.00	98.85
0.50%,2h	40	47.80±8.84	26	61.54	18.00	79.17
0.50%,4h	20	13.50±5.08	34	100.00	35.18	90.30

Table 2: Mutagenic effectiveness and efficiency of γ-irradiation and EMS

Doses/ Concentration	M_1 biological damages (% of control)			M_2 mutation	Mutagenic effectiveness Mf/C×t or Gy	Mutagenic efficiency		
	Lethality (L)	Injury (I)	Seed sterility (S)	Viable mutation frequency (%)		Mf/L	Mf/I	Mf/S
20 Gy	54.6	15.1	-	1.37	0.69	0.03	0.09	-
40 Gy	51.5	11.4	69.4	3.61	0.90	0.07	0.32	0.05
80 Gy	51.5	12.6	81.0	4.71	0.59	0.09	0.37	0.06
100 Gy	66.7	37.5	72.4	8.97	0.90	0.13	0.24	0.12
0.25%,2h	09.1	-	29.1	6.31	12.62	0.69	-	0.22
0.25%,4h	15.6	-	22.9	3.85	3.85	0.25	-	0.17
0.50%,2h	39.4	-	-	2.78	2.78	0.07	-	-
0.50%,4h	69.7	62.1	-	4.01	2.01	0.06	0.06	-

Table 3: Duncan's test analysis for homogenous treatment mean of different parameters at M_2

Doses/ Conc.	Quantitative traits							
	Plant Height (cm)	No. of primary branches /plant	*Total branches /plant	No. of compound umbels/ plant	*No. of umbels /plant	*No. of umbellets of first inflorescence	Seed yield (gm)	Harvest index (%)
0	63.0 bc	5.4 a	22.9	16.9 ab	102.7	37.1	0.83 abc	18.8 ab
20 Gy	66.3 ab	5.1 ab	18.2	14.3 ab	99.5	40.7	0.85 abc	22.6 a
40 Gy	59.4 c	4.7 abc	20.6	16.2 ab	95.3	39.1	0.67 bc	20.6 a
80 Gy	69.6 a	5.0 ab	21.1	19.1 a	107.8	52.4	0.97 abc	22.7 a
100 Gy	67.8 ab	4.5 bc	17.3	14.0 b	104.8	51.6	1.23 a	23.2 a
0.25%,2h	69.3 a	4.8 abc	18.2	15.4 ab	107.0	47.7	0.96 abc	22.7 a
0.25%,4h	68.4 ab	4.3 c	18.5	14.9 ab	106.9	46.9	1.06 ab	24.4 a
0.50%,2h	66.7 ab	4.5 bc	18.8	14.9 ab	90.8	36.1	0.62 c	15.0 b
0.50%,4h	69.5 a	4.9 abc	21.7	17.1 ab	111.8	48.6	1.08 ab	24.0 a

*non-significant variations among the treatments.

RESULTS AND DISCUSSIONS

Estimates of different mutagenic parameters are presented in tables 1 and 2. If we consider germination and survivability percentage together in both M_1 and M_2 generation, we find that 20 Gy in γ-rays and 0.25%, 4h treatment in EMS are the best. Lethality was more than 50% in all doses of γ-rays and 0.50%, 4h EMS treatment. The later treatment also causes more than 50% injury in the samples. Sterility seems to be higher in irradiated samples; however, sterility was found not to be related with lethality and injury in most treatments. Analysis of mutagenic parameters at M_1 generation indicated that mutation frequency was not dose dependent. Frequency of induced mutations in M_2 generation has been reported to have a direct relationship with various mutagenic responsiveness parameters studied in M_1 generation[9-10]. The mutagenic effectiveness was noted to be more in EMS than in the γ-rays. Such type of findings is also reported in Cluster Bean[11], Pea[12], Soybean[13], Isabgol[14], French bean[15] and many other crops also. No such definite inference can be made regarding mutagenic efficiency of the two mutagens used. Kharkwal[16] are of opinion that mutagenic effectiveness and efficiency show differential behaviour depending upon mutagen and its applied doses as well as varietal type. Present investigation shows that both mutagenic effectiveness and efficiency are higher at lower doses of EMS, but γ-ray manifests variable responses in different doses.

Higher mutagenic effectiveness and efficiency at lower concentrations/doses of mutagens was reported in *Lathyrus sativus*[17], *Cicer arietinum*[18], *Vigna unguiculata*[19] amongst others. Decrease in effectiveness and efficiency with the increasing concentrations/doses of mutagens was reported in different crops (*Trigonella foenum-graecum*[20], *Vigna unguiculata*[21], *Cyamopsis tetragonoloba*[11], *Glycine max*[13], *Vigna radiata*[22] and many others).

Duncan's test analysis reveal (Table 3) that, except 40 Gy γ-rays for plant height and 0.50%, 2h EMS treatment for harvest index, all the treatments are superior over control for these two characters. Total branches/plant, number of umbels/plant and number of umbellets of first inflorescence show no significant variation among the treatments. For number of compound

umbels/plant and seed yield the treatments are neither superior nor much inferior to control, but more or less homogenous to control. For number of primary branches/plant 100 Gy γ-rays and both 0.25%, 4h and 0.50%, 2h EMS treatments are inferior to control; while, other treatments are more or less homogenous to control.

CONCLUSION

Considering overall performance of all treatments, it can be stated that 20 Gy γ-rays and 0.25%, 2h EMS treatments are the best treatments for improvement in fennel, although, 40 Gy γ-rays and 0.25%, 4h EMS treatments can also be administered promisingly.

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