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INDUCED MUTATION STUDIES IN FINGER MILLET (*ELEUSINE CORACANA* GAERTN.)

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ABSTRACT

Varieties A404 and HR 374 of finger millet, treated with gamma rays, EMS, and their combinations gave mutant types of agronomic and academic interests. The deviations in M_1 generation included dwarf plants, dwarf plants with leaning growth habit, grassy nonflowering type, tall with elongated internode, panicle with gappy rachis, panicle with extra large glumes, panicle with extra distal thumb, sterile panicle with twisted fingers, panicle profusely branched. In M_2 generation chlorophyll mutants, albina, xantha, viridis, striata and tigrina were obtained. Higher doses of all mutagenic treatments affected pollen fertility adversely and produced morphological deformities. The efficiency and effectiveness were high at the lower doses of mutagens in both the varieties. EMS (0.2%) was more effective than the lower dose of gamma rays in both the varieties.

Key words: Finger millet, chlorophyll mutations, gamma rays, EMS.

Artificial hybridization and recombination breeding for varietal improvement in finger millet (*Eleusine coracana* Gaertn.) could not be taken up in a big way because of small floret size. Since in many crop species mutagenesis has been found to be effective as hybridization in supplying genetic variability resulting from polygenic mutation, induced mutagenesis on finger millet came as an alternative to hybridization. Ethyle methane sulphonate (EMS), a monofunctional alkylating agent is known to induce high frequency of mutation in higher plants and it has also been reported that the mutation spectrum induced by EMS is different from that of radiation [1, 2]. The present paper, a portion of the mutation breeding work, aims to report the effect of gamma rays and EMS in isolation and combination treatments on mutation frequency and spectrum in two established varieties of finger millet.

MATERIALS AND METHODS

Varieties A404 and HR374 of finger millet were used for treatment of dry and dormant seeds with 10% moisture content with five doses of gamma rays (^{60}Co) at interval of 10 kR, starting from 10 kR. For chemical treatment, the seeds were treated with five doses (0.2 to 1% v/v prepared in phosphate buffer at 7 pH) of EMS ($CH_3SO_2OC_2H_5$) for 8 h at room temperature (22 ± 2°C). For combination treatments, sets of gamma rays irradiated seeds of both the varieties were exposed to 0.2% EMS for 8 h at room temperature. The respective controls were simultaneously soaked in distilled water during the period of EMS treatments. The treated seeds were thoroughly washed and sown. Recommended agronomic practices were followed to raise M_1 and M_2 generations and observations recorded by the standard methods. M_2 generation of individual M_1 plants were raised in nursery. Efficiency and effectiveness of the treatments were estimated following Konzak et al. [3].

RESULTS AND DISCUSSION

Among the M_1 population of each treatment, the deviation observed in plant types were dwarf plant, dwarf plants with leaning growth habit, grassy non flowering plant type, tall with elongated internodes, panicle with gappy rachis, panicle with extra large glumes, panicle with extra distal thumb, sterile panicle with twisted fingers, and profusely branched panicle. These deviated plants showed high degree of pollen sterility. The frequency of deformities ranged from 1.9% (0.2% EMS) to 18.3% (50 kR) in variety A404, while in variety HR374, it ranged from 5.1% (0.2% EMS) to 15.4% (50 kR). These morphological changes in M_1 generation could be considered to be the secondary effect caused due to physiological disturbances [4].

Pollen fertility reduced gradually with increasing doses in both the varieties (Table 1). The reduction in pollen fertility ranged from 6.3 (10 kR) to 57.4% (50 kR + 0.2% EMS) in A404 and 5.1 (10 kR) to 54.2% (50 kR + 0.2% EMS) in HR374. According to Ekberg [5], the sterility caused by radiation is mainly because of chromosomal aberrations. The sterility produced by chemical mutagens may also have chromosomal origin or a result of physiological damage produced by EMS through hydrolysis products (!).

In M_2 generation, the frequency of chlorophyll mutations in variety A404 ranged from 1.6% (0.6% EMS) to 2.8% (10 kR + 0.2% EMS), while in HR374, it ranged from 1.6 (0.6% EMS) to 2.9% (10 kR). The chlorophyll mutations observed were: albina (a lethal mutation with entirely white leaves, survived for about a week), xantha (also a lethal, orange yellow to yellowish-white leaves, survived up to 2–3 leaf stage), viridis (a viable mutant, leaves initially yellow green but gradually turn green), striata (another viable mutant, leaves with longitudinal yellow stripes), and tigrina (viable, leaves with horizontal yellow bands alternating with green stripes). In finger millet, chlorophyll mutations arise readily after after the mutagenic treatments [6–9]. Different types of chlorophyll mutants observed in the present study could be grouped into lethal and nonlethal types. The lethal group included albina and xantha, while viridis, striata and tigrina were nonlethals. The most frequent chlorophyll mutation induced either by gamma rays, EMS or their combinations in both the varieties was albina (Table 2). Similar, observations have been recorded earlier in finger millet [7, 9, 10]. The mutation spectrum was broader in 20 kR treatment of variety A404 and 50 kR + 0.2% EMS treatment of HR374, while at 40 kR it was narrowest in var. A404 with complete absence of xantha, viridis, striata and tigrina. The present finding of differential effect of mutagens in producing chlorophyll mutations is in agreement with earlier reports [11–15]. Moreover, the absence of chlorophyll mutants in the M_1 generation and there appearance in M_2 indicates the recessive nature of the chlorophyll mutants. Although much is not known about the origin of these mutations, Kapla [14], is of the view that chromosomal aberrations caused by irradiation of seeds were responsible for induction of these mutations. While Gowda [8] on the basis of segregation pattern of xantha, striata and tigrina mutants have suggested that these are controlled by a single dominant gene where as albina is controlled by three genes.

The data on effectiveness of gamma rays and EMS (Table 3) shows that lower doses/concentrations were most effective. The highest value of radiation

Table 1. Effect of gamma rays, EMS and their combination on the frequency of panicle deformities and fertility status in M_1 generation of finger millet

Treatment	Variety	Frequency of deformed panicles, %			Pollen fertility (%)
		fertile	sterile	total	
Gamma rays:					
10 kR	A-404	3.2	1.8	4.9	93.7
	HR-374	4.1	2.1	6.2	94.9
20 kR	A-404	3.7	4.5	8.3	90.4
	HR-374	3.2	3.9	7.1	89.1
30 kR	A-404	4.9	6.	11.1	80.9
	HR-374	4.4	6.0	10.3	82.3
40 kR	A-404	5.9	7.9	13.8	67.6
	HR-374	4.7	7.1	11.8	70.6
50 kR	A-404	7.4	10.9	18.3	58.1
	HR-374	6.5	8.8	15.4	61.3
EMS:					
0.2%	A-404	1.2	0.7	1.9	89.9
	HR-374	3.8	1.2	5.1	91.1
0.4%	A-404	3.1	3.3	6.3	80.8
	HR-374	3.2	3.2	6.3	85.7
0.6%	A-404	2.4	5.2	7.6	70.3
	HR-374	3.7	4.8	8.5	72.9
0.8%	A-404	4.7	8.4	13.1	56.3
	HR-374	5.5	7.8	13.2	60.2
1.0%	A-404	3.6	11.9	15.5	52.1
	HR-374	4.6	10.1	14.7	50.9
Combination treatments: (gamma rays +EMS)					
10 kR + 0.2%	A-404	2.1	1.1	3.2	86.4
	HR-374	3.3	1.9	5.1	88.8
20 kR + 0.2%	A-404	4.2	4.6	8.8	77.4
	HR-374	3.1	3.7	6.9	82.0
30 kR + 0.2%	A-404	3.2	5.7	8.9	64.8
	HR-374	4.1	6.2	10.3	69.5
40 kR + 0.2%	A-404	4.9	7.3	12.2	51.0
	HR-374	5.4	6.7	12.0	56.6
50 kR + 0.2%	A-404	5.0	7.3	12.2	45.8
	HR-374	5.6	8.3	13.9	42.6

Table 2. Spectrum of chlorophyll mutations in M_2 generation of finger millet (relative proportion in %)

Treatment	Variety	Mutant seedlings	Albina	Xantha	Viridis	Striata	Tigrina
Gamma rays:							
10 kR	A-404	43	48.8	30.2	13.9	6.9	—
	HR-374	55	85.4	10.9	1.8	1.8	—
20 kR	A-404	51	66.6	19.6	9.8	1.9	1.9
	HR-374	47	82.9	10.6	4.2	2.1	—
30 kR	A-404	39	76.9	20.5	2.6	—	—
	HR-374	35	82.8	14.2	2.8	—	—
40 kR	A-404	34	100.0	—	—	—	—
	HR-374	49	75.5	18.4	6.1	—	—
50 kR	A-404	36	86.1	8.3	5.5	—	—
	HR-374	50	82.0	8.0	8.0	—	2.0
EMS:							
0.2%	A-404	47	76.5	14.8	4.2	4.2	—
	HR-374	42	85.7	11.9	—	2.3	—
0.4%	A-404	34	82.3	5.8	—	—	11.7
	HR-374	39	87.1	5.1	7.6	—	—
0.6%	A-404	32	78.1	12.5	6.2	3.1	—
	HR-374	31	80.6	19.3	—	—	—
0.8%	A-404	39	94.8	2.5	—	2.5	—
	HR-374	36	80.5	13.8	2.7	2.7	—
1.0%	A-404	45	91.1	6.6	2.2	—	—
	HR-374	43	88.3	6.9	4.6	—	
Combination treatments: (gamma rays + EMS)							
10 kR + 0.2%	A-404	56	71.4	19.6	7.1	—	1.7
	HR-374	49	75.5	18.3	—	—	6.1
20 kR + 0.2%	A-404	43	88.3	9.3	—	2.3	—
	HR-374	51	68.6	21.5	—	1.9	7.8
30 kR + 0.2%	A-404	45	77.7	20.0	2.2	—	—
	HR-374	38	81.5	18.4	—	—	—
40 kR + 0.2%	A-404	33	90.0	9.0	—	—	—
	HR-374	46	80.4	17.3	2.1	—	—
50 kR + 0.2%	A-404	42	85.7	11.9	2.3	—	—
	HR-374	39	84.6	5.1	5.1	2.5	5.5

effectiveness was 0.21 and 0.29 for the varieties A404 and HR374, respectively, at 10 kR treatment. The value decreased gradually with increase in dose in both the varieties, the minimum being 0.03 (A404) and 0.05 (HR374). Similarly, the highest value for effectiveness of EMS was 1.72 (A404) and 1.36 (HR374) with 0.2% EMS treatment. The minimum values were 0.31 (1% in A404) and 0.27 (0.8 and 1% in HR374). The overall pattern of mutagenic effectiveness shows that effectiveness of EMS was generally higher than gamma rays, and that among different doses 0.2% EMS proved to be the most effective treatment in both varieties.

Maximum effectiveness was recorded with 0.2% EMS in both varieties, and minimum with 50 kR in A404. This is in agreement with the results of Gupta and Yashbir [16] in foxtail millet, Sharma and Sharma [17] in lentil, and Tikka and Desai [9] in different genotypes of finger millet.

Table 3. Effectiveness and efficiency of physical and chemical mutagens in two varieties of finger millet

Treatment	Variety	Mutated M_2 progenies (%) (MPL)	Lethality % (L)	Efficiency (MPL/L)	Effectiveness (MPL/dose)
Gamma rays:					
10 kR	A-404	2.11	1.66	1.27	0.21
	HR-374	2.90	2.79	1.04	0.29
20 kR	A-404	2.58	2.23	1.15	0.13
	HR-374	2.33	3.18	1.07	0.12
30 kR	A-404	1.95	1.89	1.03	0.07
	HR-374	2.08	2.01	1.03	0.07
40 kR	A-404	1.89	1.89	1.00	0.05
	HR-374	2.27	2.13	1.06	0.06
50 kR	A-404	1.72	1.63	1.05	0.03
	HR-374	2.50	2.24	1.11	0.05
EMS:					
0.2%	A-404	2.76	2.52	1.09	1.72
	HR-374	2.17	2.11	1.02	1.36
0.4%	A-404	1.74	1.53	1.13	0.53
	HR-374	1.95	1.79	1.09	0.61
0.6%	A-404	1.57	1.42	1.10	0.32
	HR-374	1.64	1.63	1.01	0.34
0.8%	A-404	1.85	1.80	1.02	0.29
	HR-374	1.72	1.62	1.06	0.27
1.0%	A-404	2.48	2.42	1.03	0.31
	HR-374	2.18	2.07	1.05	0.27

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REFERENCES

1. E. A. Fevret. 1964. Somatic mutations of four genes for albinism in barley induced by X-rays and EMS. Hereditas, **46**: 622–634.

2. A. Seetharam, R. Sreekantharadhya and K. M. D. Nayer. 1974. Induced interchanges in finger millet (*Eleusine coracana* Gaertn.). Experientia, **30**: 313–314.

3. C. F. Konzak, J. Wanger and R. J. Foster. 1965. Efficient chemical mutagenesis. *In*: Proc. Symp. on the Use of Induced Mutations in Plant Breeding. Suppl. Radiat. Bot., **5**: 49–70.

4. A. H. Sparrow and J. E. Gunckel. 1956. The effects on plant of chronic exposure to gamma radiation from radio cobalt. *In*: Peaceful Uses of Atomic Energy. Prod. Conf. Geneva: 52–59.

5. I. Ekberg. 1969. Different types of sterility induced in barley with ionizing radiations and chemicals mutagens. Hereditas, **63**: 257–278.

6. D. N. Singh and M. B. E. Godward. 1974. Radiation studies in (*Eleusine coracana* (L.) Gaertn.). Cytologia, **39**: 729–740.

7. S. B. S. Tikka. 1985. Mutation Research in Finger Millet. Sharda Publication, New Delhi: 1–55.

8. M. B. Gowda. 1987. Studies on mutation frequency and rectification of defects in four finger millet (*Eleusine coracana* Gaertn.) cultivars following gamma irradiation. Mysore J. Agric. Sci., **21**(1): 93–94.

9. S. B. S. Tikka and K. B. Desai. 1989. Sensitivity in finger millet (*Eleusine coracana* Gaertn.) to physical and chemical mutagens. Indian J. Hered., **21**(1–2): 1–7.

10. T. S. Raveendran, K. Meenakshi and R. Appadurai. 1980. Biological effects and chlorophyll mutations induced by N. G. Ragi. Madras Agric. J., **69**(10): 637–638.

11. A. Gustafsson. 1947. Mutation in agricultural plants. Heriditas, **33**: 1–100.

12. L. Ehrenberg, A. Gustafsson and V. Lundquest. 1961. Viable mutants induced in barley by ionizing radiations and chemical mutagen. Heriditas, **47**: 243–282.

13. L. J. Sahai and K. C. Dala. 1974. Gamma rays induced variability in M_1 generation of safflower. Indian J. Genet., **34A**: 716–717.

14. R. W. Kaplan. 1954. Being flussing des durch Rontgens frahlen induziertn Fleetmosaeks aush dev Blattem des soiabline durch zustsbehandlung. Stratilenther, **94**: 101–118.

15. R. Sreekantaradhya and P. Madhavamenon. 1979. 'Rosette habit,' an induced physiological mutation in ragi or finger millet (*Eleusine coracana* Gaertn.) with gamma rays and ethyle methane sulphonate. II. Chlorophyll mutation frequency and spectrum. Environ. Expt. Bot., **19**: 123–126.

16. P. K. Gupta and Yashbir. 1975. Induced mutation in foxtail millets. I. Chlorophyll mutations induced by gamma rays, EMS and dES. Theor. Appl. Genet., **45**: 242–249.

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