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Effectiveness and efficiency of gamma rays in some inbreds of sunflower (*Helianthus annuus* L.)

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Mutagenic effectiveness and efficiency of gamma rays were studied in the four inbreds of sunflower. Gamma rays produced high frequency as well as a wide spectrum in mutation. The frequency of mutation was high at higher dose of mutagen. The mutagenic effectiveness and efficiency was calculated based on biological damage. In M1 generation based on seed lethality and pollen sterility and M2 generation was carefully screened for various chlorophyll and viable mutation. Mutagenic effectiveness and efficiency reduced with the increase in dose or concentration. In present investigation higher dose of 20kR was very effective and efficient in induction of mutation in all the genotypes studied except CMS-104B where 15 kR dose was effective and efficient.

Key words : Gamma rays, Effectiveness, Efficiency, Sunflower

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INTRODUCTION

The main objective of sunflower breeding is to develop productive sunflower hybrid cultivars that are stable, high yielding, and resistant to biotic and abiotic stresses. Induced mutations have been applied from the past 40 years to produce mutant cultivars in sunflower by changing plant characteristics for significant increase in plant productivity. Undoubtedly gamma rays have proved to be the most efficient and effective physical mutagen in different crops species either individually or in combination with chemical mutagens. Radiations were known to produce more of chromosomal aberrations such as deletions and translocations, in contrast, chemical mutagens are likely to produce more of gene or point mutations (Amano and Smith, 1965 and Amano, 1968). Swaminathan *et al*. (1962) inferred that randomness in the action of radiations make them capable of inducing variation in most genetically controlled properties.

The mutagenic effect of a mutagen, which is an index for the appropriate choice, can be evaluated in terms of "mutagenic effectiveness and efficiency" (Konzak *et al*., 1965). Mutagenic effectiveness is a measure of the frequency of mutations induced by a unit dose of mutagen. Mutagenic efficiency refers to the proportion of mutation in relation to other associated undesirable biological effects such as gross chromosomal aberrations, lethality and sterility, induced by the mutagen in question.

RESEARCH METHODOLOGY

The base material for the present study comprised of both the parental (B and R) lines of popular sunflower hybrid RSFH-130 hybrids (CMS-104B and R630), and maintainer lines of RFSH-1hybrid (CMS-103B) and KBSH-44 hybrid (CMS-17B). Selfed seeds of the above mentioned lines were obtained from Principal scientist and Head AICRP on sunflower, Main Agricultural Research Station, Raichur. Bold and viable dry seeds of uniform size, weighing 100 g each with 12 per cent moisture were irradiated with 10, 15 and 20 kR doses of gamma rays from ^{60}CO source at the gamma chamber of Bhabha Atomic Research Centre, Trombay, Mumbai for the required duration. A total of 100 seeds were sown in each treatment. All plants in the first generation, in each treatment, were observed for the following parameters: germination on the 30th day, survival on the 45th day, pollen fertility, frequency of chlorophyll abnormalities and mutagenic effectiveness and efficiency. Seeds obtained from M_1 plants in each treatment were advanced to raise the M_2 generation as progeny rows. Each

plant was raised in one row with the spacing of 60 × 30 cm during *Rabi*/summer, season 2010-2011. The above biometric characters were recorded and individual plant data were used for statistical analysis.

RESEARCH FINDINGS AND ANALYSIS

Increase in frequency of chlorophyll abnormalities with increases in dosage was observed in M_1 and M_2 generations of all the four genotypes. The frequency of chlorophyll abnormalities indicates, CMS-104B genotype as the radio sensitive genotype since the overall frequency of abnormalities were highest in 20 kR in both M_1 (18.28) and M_2 (5.33) generations (Table 1). Chlorophyll abnormalities observed in a M_1 and M_2 generations are due to somatic mutations (Sparrow and Woodwell, 1962).These usually results due to periclinal chimeras or plastid mutations. Hence, these chlorophyll Abnormalities do not breed true in subsequent generations as there is irregular distribution of the cytoplasmic organelles like plastids, to daughter cells (Goud, 1967). In the present study, most of the chlorophyll mutants were observed at seedling stage and were not distinct to assign definite categories *viz.*, xantha, viridis, chlorina and albino types as suggested by Gustafsson (1940). Most of the abnormalities observed were in the form of white and light green streaks; white, light green and yellow patches and various mosaic patterns.

In the present study, effectiveness and efficiency of different gamma irradiation doses, *viz.*, 10 kR, 15 kR and 20 kR, were measured to assess the effect of these doses on different plant characters in all the genotypes. In a similar experiment Konzak *et al.* (1965) studied the effectiveness efficiency of radiations for inducing changes in various in plant characters. They proposed that mutagenic effectiveness gives the mutation rate per unit dose of the mutagens, while mutagenic efficiency is ratio of the mutation rate to undesirable changes like lethality, injury and sterility. They also opined that efficiency of a mutagenic agent depends on the reaction of the plant to the mutagen and the degree of physiological damage, chromosomal aberrations and sterility caused by the mutagen. A dose dependent increase in mutagenic effectiveness and efficiency was noticed (Wang and Yu, 1991) in the present study. The highest dose of 20 kR was found to be the most effective dose inducing maximum number of mutations in all the genotypes except CMS-104B in which effectiveness was more in 15 kR (Table 2).

The gamma ray doses were more effective in case of CMS-104B compared to other three genotypes studied, in inducing physiological damage, seedling injury, and chlorophyll abnormalities lethality. Particularly the higher dose

Table 1: Frequency of chlorophyll abnormalities in M_1 and M_2 generations

Genotypes	Dose (kR)	Number of plants in M_1		Frequency (%) in M_1	Over all frequency of genotype	Number of plants in M_2		Frequency (%) in M_2	Over all frequency of genotype
		Total	Abnormal			Total	Abnormal		
CMS-104B	0	86	0	0.00	18.28	100	0	0	5.33
	10	1110	125	11.26		18120	761	4.20	
	15	895	251	28.04		9926	675	6.80	
	20	319	49	15.36		4090	294	7.20	
CMS-103B	0	78	0	0.00	9.50	100	0	0	2.09
	10	710	62	8.73		4233	63	1.50	
	15	659	44	6.67		4178	104	2.50	
	20	219	45	20.54		548	21	3.80	
CMS-17B	0	66	0	0.00	8.5	100	0	0	2.00
	10	25	2	8.00		394	5	1.16	
	15	7	1	14.20		514	11	2.14	
	20	3	0	0.00		238	7	2.80	
R630	0	77	0	0.00	12.5	100	0	0	2.20
	10	1190	117	9.80		1164	19	1.60	
	15	1274	155	12.20		1542	31	2.00	
	20	1208	187	15.50		1542	31	3.20	

Over all frequency of chlorophyll abnormalities on M_2 plant basis = $\frac{2022}{46867} \times 100 = 4.31\%$

Over all frequency of chlorophyll abnormalities in $M_1 = \frac{1038}{8019} \times 100 = 12.94\%$

Table 2: Mutagenic effectiveness and efficiency of different doses of gamma rays

Genotypes	Dose (kR)	Mutagenic effectiveness	Mutagenic efficiency
CMS104B	0	-	-
	10	0.36	0.14
	15	0.45	0.59
	20	0.42	0.16
CMS103B	0	-	-
	10	0.15	0.12
	15	0.17	0.19
	20	0.19	0.23
CMS17B	0	-	-
	10	0.12	0.09
	15	0.14	0.24
	20	0.14	0.36
R630	0	-	-
	10	0.10	0.11
	15	0.13	0.14
	20	0.16	0.18

of 20 kR was effective in all the genotypes in inducing seedling injuries and lethality. The possible reason may be that, genetic background of the material under study could play an important role in determining the effectiveness and efficiency of the mutagen.

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