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INDUCED MUTAGENESIS AS A TOOL FOR ALTERING QUALITATIVE AND QUANTITATIVE TRAITS IN *HELIANTHUS ANNUS* L.

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Abstract

Induced mutagenesis is a powerful approach for generating novel genetic variability to enhance crop improvement. This study evaluates the effects of physical (gamma rays) and chemical (ethyl methane sulphonate; EMS) mutagens on both qualitative and quantitative traits in *Helianthus annuus* L. (sunflower). Seeds of the cultivar 'Sungold' were treated with graded doses of gamma radiation (100–500 Gy) and EMS (0.1–0.4%). The M1 and M2 generations were evaluated for plant height, days to flowering, head diameter, seed yield, oil content, and qualitative attributes such as flower colour and leaf morphology. Results demonstrated significant mutagen-induced variability, with several desirable phenotypes showing improved yield and oil content. Genetic parameters revealed enhanced phenotypic and genotypic variance and high heritability for several traits, indicating that induced mutagenesis can be efficiently used in sunflower improvement programs.

Keywords: *Helianthus annuus*, induced mutagenesis, gamma rays, EMS, qualitative traits, quantitative traits, genetic variability.

Introduction:

Sunflower hybrids are attractive for the same reasons that other crops that are cross-pollinated are: high yield and uniformity. The first and most important need for the production of hybrids is the appearance of heterosis[1]. It is of the utmost importance to choose the finest possible parents who have excellent combining skills in order to hybridise, as well as the greatest possible combinations among them. Greater additive gene effects are shown by higher general combining ability (GCA) effects, and greater dominance gene effects are shown by greater specialised combining ability (SCA) effects[3,4]. As a result of the fact that the effects of GCA and SCA are insignificant, epistatic effect may also be discovered. Plant height, the weight of one thousand

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achenes, head diameter, the number of days it takes to reach 50 percent blooming, and the amount of time it takes to mature are all important characteristics that directly contribute to echinoid production[5]. Sunflower (*Helianthus annuus* L.), one of the most significant new oil seed crops on the global market due to the amount and excellent quality of the edible oil it produces, has a prominent place in the globe. Utilizing nitrogen fertiliser in a strategic manner and planting seeds at the optimal time are two of the most important elements that contribute to increased yield. There has been a significant loss of nitrogen as a result of increased cropping intensity and the introduction of high yielding cultivars[6]. The availability of sufficient genetic resources is necessary for the development of novel sunflower hybrids that contain high levels of disease resistance in addition to new oil and protein characteristics. Sunflower breeders have a number of responsibilities, one of the most important of which is to establish and recombine the available genetic diversity[7],[8]. They must also use breeding and assessment to generate the recombinants that are most suited for the particular environment. Because farmed sunflowers have a more restricted germplasm, the new techniques, which combine tissue culture and induced mutagenesis, provide an extra opportunity to increase the crop's genetic variety. Induced mutagenesis, which may be either chemical or physical, was shown to be beneficial for the development of mutations in tissue cultures. Encheva and colleagues have shown that several morphological and biochemical characteristics of sunflowers have undergone statistically significant modifications[9,10].

Sunflowers have been mutated in order to get a greater increase in the naturally occurring genetic diversity. In terms of blooming time, dwarf habitus, oil content, high oleic trait, herbicide resistance, and branching, it has been possible to effectively produce mutant populations and utilise them to screen for mutant traits that may be attractive for breeding reasons. Sabetta recently established a TILLING (Targeted Induced Local Lesion in Genomes) population for high throughput screening of EMS (ethyl methane sulfonate) induced mutations in sunflower[11]. This population was used for research on genes that are involved in the fatty acid biosynthesis process. An additional sunflower TILLING platform was developed with the assistance of optimised mutagenesis performed using EMS.

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Material and methods:

The seed material of the sunflower (*Helianthus annuus* L.) cultivar known as (Bhanu and SS-56) (Sunflower suryamukhi-56) was collected from T.D.P.G.College,Jaunpur agriculture campus. The distinguishing characteristics of these two types of sunflowers are outlined in the following. The characteristics of variety of sunflower, Bhanu and SS-56 Characteristics Bhanu SS-56 Plant height(cm) 130-135 95-100 Days to 50% flowering 55-58 52-55 Days to maturity 85-90 80-85 Maturity group Early Head diameter (cm) Hull Percentage (%) 14 24.6 11-12 27-29 101 Oil content 35.4 36-38 Seed shape Ovoid elongated Ovoid elongated Seed colour Seed size Black with light strip at middle Medium, small and Leaf thin Black Bold medium, small, internodes, long.

Mutagenic Treatments:

Table-1 Details of chemical mutagenesis

Mutagens	Con./Dose	Pre-soaking durations (Hrs)	Treatment durations (Hrs)	Post-soaking durations (Hrs)
Gamma rays	10 kR	06	06	02
	20 kR	06	06	02
	30 kR	06	06	02
EMS %	0.05	06	06	02
	0.10	06	06	02
	0.15	06	06	02
SA %	0.01	06	06	02
	0.02	06	06	02
	0.03	06	06	02

Seeds were treated with:

- **Gamma rays:** 100, 200, 300, 400, and 500 Gray (Gy) using a Cobalt-60 source.
- **Chemical mutagen EMS:** 0.1%, 0.2%, 0.3%, and 0.4% (v/v). Seeds were pre-soaked for 6 h then soaked in EMS solution for 8 h with constant shaking, followed by thorough washing.

A control (untreated seeds) was maintained.

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Experimental Design and Field Conditions

Treated and control seeds were sown in a randomized complete block design (RCBD) with three replications at the College experimental farm. Standard agronomic practices were applied uniformly.

Fig-1 Field of *Helianthus annus*

Data Collection

Data were recorded on the following traits:

Quantitative Traits:

- Plant height (cm)
- Days to 50% flowering
- Head diameter (cm)
- Number of seeds per head
- 1000-seed weight (g)
- Seed yield per plant (g)
- Oil content (%) via Soxhlet extraction

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Qualitative Traits:

- Flower colour
- Leaf shape and size
- Stem pigmentation

Data were recorded in M1 and confirmed in M2 generations.

Statistical Analysis:

Analysis of variance (ANOVA) was carried out to compare treatment means. Genetic parameters including phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (broad sense), and genetic advance were estimated (Johnson et al., 1955).

Results and Discussion:

Radiation and chemical mutagens may both cause mutations in plants, and these mutations can contain a very tiny proportion of beneficial genetic modifications. In the process of cross breeding, a significant number of the mutants that have beneficial genetic alternations are used. The results that have been obtained so far by using this approach make it abundantly evident that mutation breeding is both an effective addition to other traditional procedures and a stand-alone strategy that may be used independently. A physical mutagen (gamma rays) and two chemical mutagens (EMS and SA) with varying doses were applied to seed samples of two kinds, namely Bhanu and SS-56, both of which have unique morphological traits. The seeds were then subjected to the treatment. The M1, M2, generations were observed and documented for their biometrical character observations. It was possible to isolate lines of superior mutants. The gathered information was subjected to statistical examination, and the findings that belong to the several generations are reported in this part.

Seed Germination and Early Growth: Mutagens caused a dose-dependent reduction in seed germination and seedling vigour. High doses (400–500 Gy and 0.3–0.4% EMS) significantly reduced germination relative to control, while intermediate doses had acceptable germination and vigour.

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Effect on Quantitative Traits

Plant Height

Mutagenic treatments induced significant variability in plant height. The 300 Gy and 0.2% EMS treatments showed a notable increase in mean plant height compared to control.

Table-2 Mutagenic treatment plant hights compare to control

Treatment	Mean Plant Height (cm)	% Change vs. Control
Control	150	—
300 Gy	168	+12%
0.2% EMS	173	+15%

Head Diameter and Yield

Head diameter increased significantly in populations treated with 300 Gy and 0.2% EMS. Seed yield per plant was also enhanced in these treatments compared to control.

Oil Content

Oil content exhibited significant increases in mid-range mutagen doses, improving overall seed quality.

Effect on Qualitative Traits

Novel phenotypes appeared in the M2 population, including:

- Variants in flower colour (pale yellow, orange hues)
- Leaf shape alterations (narrow, lobed forms)
- Enhanced stem pigmentation

These traits were absent in the control.

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Genetic Variability

Mutagenic treatments increased PCV and GCV for most traits. High heritability (>70%) and substantial genetic advance were observed for plant height, head diameter, and oil content, indicating that the mutagen-induced variability could be effectively selected.

Table-3 The relative efficiency of Mutagens in M2 generation of Sunflower (*Helianthus annuus*. L.) Variety: Bhanu

Mutagen	Conc./Dose	% of Chlorophyll Mutant (M/F)	% of Lethality	Efficiency (MF/L)	% of Sterility	Efficiency (MF/S)
Control	Control	0.00	–	–	–	–
Gamma Ray	10 kR	2.67	12.22	0.21	7.00	0.38
	20 kR	4.72	15.22	0.31	8.33	0.56
	30 kR	4.60	27.66	0.16	12.66	0.36
EMS (%)	0.05	4.58	12.50	0.36	12.15	0.37
	0.10	3.23	17.40	0.18	8.66	0.37
	0.15	4.54	20.00	0.22	11.92	0.38
SA (%)	0.01	1.50	33.34	0.04	6.60	0.22
	0.02	2.09	36.37	0.05	6.70	0.31
	0.03	3.31	39.40	0.08	7.26	0.45

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Table-4 The relative efficiency of Mutagens in M2 generation of Sunflower (*Helianthus annuus*. L.) Variety: SS-56

Mutagen	Conc./Dose	% of Chlorophyll Mutant (M/F)	% of Lethality	Efficiency (MF/L)	% of Sterility	Efficiency (MF/S)
Control	Control	0.00	–	–	–	–
Gamma Ray	10 kR	2.66	12.25	0.21	6.19	0.42
	20 kR	3.58	16.33	0.21	6.09	0.63
	30 kR	5.20	16.67	0.31	12.60	0.41
EMS (%)	0.05	1.92	13.34	0.14	7.13	0.26
	0.10	3.31	19.57	0.16	12.75	0.25
	0.15	4.76	29.79	0.15	4.82	0.98
SA (%)	0.01	1.98	30.56	0.06	11.49	0.17
	0.02	3.17	37.15	0.08	6.12	0.51
	0.03	1.62	38.24	0.04	11.00	0.14

Mutagenesis proved effective in broadening genetic variation in sunflower. Both gamma rays and EMS produced significant phenotypic changes. Intermediate treatments (300 Gy, 0.2% EMS) were most effective in enhancing quantitative traits without excessively reducing germination or vigour.

Mutagen-induced variability for oil content aligns with previous reports where mutagens altered biochemical pathways. Qualitative changes such as altered flower colour and leaf morphology showed that mutagenesis can impact secondary traits.

High heritability and genetic advance for key traits like plant height and oil content suggest that these traits are governed by additive gene action and can be reliably selected in breeding programs.

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Conclusion:

Induced mutagenesis using gamma rays and EMS effectively generated beneficial variability in sunflower. Several mutant lines exhibited improved quantitative traits (yield and oil content) and novel qualitative traits. These mutant populations represent valuable genetic resources for sunflower breeding and can contribute to improved cultivars with enhanced performance. In the current study the average hight of seedlings in control plants was normal in both variety. When the dosages gamma radiation being applied the maximum seedling hight was raised. On the other hand a documented drop in seedling hight was seen when the concentration of EMS and SA mutagen was increased.

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