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Studies on dose optimization, genetic variability and mutagenic effects through gamma irradiation in gladiolus (*Gladiolus grandiflorus* L.)

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Abstract
In Randomized Block Design with Factorial Principle, the experiment was planned with three replications. Four gladiolus cultivars (Pusa Suhagan, Arka Pratham, Arka Amar, Punjab Dawn) and two gamma ray doses and control doses were used to administer the procedure (25, 35). The radio-biological effects of vM_1 generations on sprouting, survival and other morphological attributes have been investigated. Plants treated with higher doses (35 Gy) showed deleterious effect of ionising radiations although at lowest dose (25 Gy) plants were not affected much. Minimum number of days taken to sprouting (10.00 days), maximum plant height observed in the 25 Gy treatment and at par to the untreated (control) gamma rays dose at 35 Gy and Flower diameter (8.61 cm) and length of spike (81.70 cm) was slightly increased at 25 Gy and length of rachis (40.53 cm) at 25 Gy treatment as compare to untreated (control) plants. Minimum days to sprouting, Maximum spike length, rachis length and flower diameter was recorded in the interaction of variety Pusa Suhagan and Arka Pratham with gamma ray dose at 25 Gy, respectively. Homeotic mutants were isolated from all the varieties at 25 and 35 Gy.

Keywords: Gladiolus, varieties, gamma ray, flower spike and mutants

Introduction
Flowers are God's most beautiful and wonderful gift to us. The flower is the embodiment of all good, earthly emotions like love and sacrifice. India in particular is endowed with a vast range of flowers in many different colors, which enhances the beauty and appeal of the nation. Flowers are thought to attract good energy

Gladiolus (*Gladiolus grandifloras* L.), one of the important bulbous crops planted throughout the nation, is grown in many different regions. Due bloom colors and taller spikes with longer vase lives, it is mostly grown for cut spikes. To spectacular inflorescence of gladiolus, which features showy blossoms of various hues grouped alternately and distinguished by acropetal succession, is the plant's most remarkable feature. One of the most significant bulbous flowering crops farmed commercially for cut flowers, garden displays, and floral arrangements is the gladiolus (*Gladiolus grandiflorus* L.). Early blooming hybrids with beautiful unique colors, more spikes with well-arranged florets, more open florets at once, more spikes per corm, and strong corm and cormel multiplication capacity are in more demand.

The primary goal of induced mutations in ornamental crops is the development of new and innovative varieties for commerce in floriculture. The fundamental benefit of inducing mutations in vegetatively propagated crops is that it is feasible to modify one or a few characteristics of cultivars that are otherwise exceptional without changing the remaining and occasionally unique genetic component. Gamma rays have been employed to cause mutations most successfully, and numerous new types have been created and reported in diverse ornamentals. Several researchers have investigated the impact of gamma rays on gladiolus, but only a small number of cultivars have been created using this radiation

For many years, cross-hybridization and mutation breeding techniques either independently or together have been used to create new types of ornamental plants (Negi, 1983) [9]. Because it is simple to monitor the effects of mutagenic treatment on a number of economically valuable characteristics, such as flower characteristics (newness, petaloids, dwarfness, vase life, leaf variegation, biotic and abiotic resistance), ornamental plants are good candidates for the application of mutation induction techniques.

Hugo de Vries first used the term mutation in 1900 to describe a rapid, heritable alteration in

an organism's genetic make-up that serves as the foundation for character variation. Crop improvement opportunities are increased by artificially inducing mutations. As old as the discipline of contemporary genetics is the history of mutation. Spontaneous mutations replenish the genetic variety that serves as the building block for the evolutionary processes of plant species.

Materials and Methods

The gladiolus (*Gladiolus grandiflorous* L.) Pusa Suhagan (V_1), Arka Pratham (V_2), Arka Amar (V_3), Punjab Dawn (V_4), which we have found promising for vegetative and floral traits, were selected for the present investigation. Healthy and uniform corms of appropriate size (3.5-4.5 cm in diameter) were used for mutagenic treatments and subsequent planting. The corms of selected cultivars were obtained from Department of Floriculture and Landscape Architecture, Indira Gandhi Krishi Vishvidyalaya, Raipur, India. The corms were exposed to Gamma rays control (I_0), [0 Gy] (I_0), [25 Gy] (I_1), [35 Gy] (I_2). The Gamma irradiation facility of the Bhabha Atomic Research Centre Mumbai, India is equipped with Gamma chamber-900 with source of ^{60}Co, X-ray machine of Department of Nuclear Agriculture and Biotechnology Division (NABTD), BARC, Trombey, were availed for treating the corms with physical mutagens. The experiment was laid out in a Factorial Randomized Block Design. Thirty six plots of 3.0 m x 1.0 m were laid out to accommodate the 12 treatments replicated three times. The corms were planted at a spacing of 30 cm x 20 cm at a depth of 5-7 cm in first week of November. The plants were maintained under uniform cultural conditions throughout the period of investigation.

Results and Discussion

The data on days to sprouting and sprouting percentage are presented in Table 1. The data revealed that the minimum days required for sprouting was observed in Among various doses of gamma rays 25 Gy resulted in early sprouting (10.00 days) which was at par with untreated 00 Gy (10.20 days) however maximum days (11.02 days) to sprouting taken by 35 Gy gamma rays. Significantly minimum days for sprouting was recorded in variety Arka Pratham (9.98 days), which was at par with resulted Arka Amar (10.46 days) whereas variety Pusa Suhagan recorded maximum days taken for sprouting (10.64 days).The maximum survival percentage (97.06%) was noted with no gamma radiation (control) where minimum survival percentage (94.03%) was observed with higher dose 35Gy. Pusa Suhagan recorded significantly maximum sprouting percentage (96.90%) and was found superior to Arka Amar (96.80%) and minimum sprouting percentage Punjab Dawn (91.73 %). Interaction of 25 Gy with cv. Pusa Suhagan (9.80 days) recorded minimum days taken to sprouting which was at par to 35 Gy and control.

This results corroborate observation made by Srivastava *et al.* (2007), Patil and Dhaduk (2009) [10] in gladiolus and Singh *et al.* (2009) in marigold, who reported that higher radiation doses having adverse effect on days required for sprouting. (Singh and Kumar, 2013) [12]. Mutagens influence the activity of enzymes. Enzymes play a pivotal role in various plant metabolism activities consequently result in stimulating plant growth by Misra and Bajpai (1983) [9].

The data regarding plant height as influenced by varieties and different doses of gamma radiations are presented in Table 2.

Maximum plant height was recorded in variety Pusa Suhagan (38.71 cm) which was found to be significantly superior to varieties Arka Pratham (37.55 cm) and Arka Amar (33.37 cm). However, Punjab Dawn (32.12 cm) were found to be at par. Application of 25 Gy resulted in maximum plant height (36.03 cm) which however was at par with no radiation (35.03 cm), and minimum plant height was recorded at 35 Gy treatment (32.12 cm).

Maximum plant height (43.00 cm) was observed in cv. Arka Pratham at 35 Gy which was however at par with Pusa Suhagan 0 Gy (42.20 cm), Pusa Suhagan with 25 Gy (37.33 cm) whereas minimum plant height was recorded in Punjab Dawn 35 Gy (27.53 cm) due to the effect of higher radiation dose.

These results are in conformity with the finding of Benarji and Data (2002) [5] in Chrysanthemum and Shangwen and Xian (2007) [11] in gladiolus who reported that lower dose of gamma rays significantly increased plant height. Reduction in plant height with higher doses of gamma irradiation may be attributed to inactivation of auxin or decrease in auxin content with increase in radiation dose (Dilta *et al*., 2003) [6]. Higher mutagen doses proved to be injurious as it may have promoted physiological disturbance and retard cell division by arresting the mitotic division.

The data for length of spike per plant as influenced by varieties and different doses of gamma radiations are presented in Table 3.

Maximum spike length (95.40 cm) was noted in variety Pusa Suhagan with 35 Gy which was at par with Pusa suhagan 0 Gy (90.26 cm) and 25 Gy (88.60 cm), whereas minimum spike length (73.13 cm) was observed in variety Arka Amar with 25 Gy followed by Arka Amar with 35 Gy (74.26 cm). Maximum spike length (81.70 cm) was noted with 25 Gy which was however at par with 0 Gy (80.44 cm), whereas minimum spike length (80.08 cm) was observed with 35 Gy of gamma radiation dose.

The interaction effect of spike length longest spike (91.42 cm) was noted in variety Pusa Suhagan followed by Arka Amar (81.20 cm) and American Beauty (36.38 cm) which was at par with variety Punjab Dawn (75.23 cm), whereas minimum length of spike resulted in variety Arka Pratham (75.13 days).

The data for length of rachis was influenced by varieties and different doses of gamma radiations was presented in Table 4.

Longest rachis length (45.01 cm) was noted in variety Pusa Suhagan followed by Arka Amar (39.09 cm) which was at par with variety Arka Amar (39.09 cm) and minimum length of spike resulted in variety Punjab Dawn (35.06 days). Significant effect of various radiation doses on rachis length of gladiolus. Maximum rachis length (40.53 cm) was observed with 25 Gy which was however at par with 0 Gy (control) (39.47 cm) whereas minimum rachis length (38.22 cm) was noted with 35 Gy of gamma radiation dose.

Interaction effect of gamma rays and varieties was significant in MI generation, 35 Gy of variety Pusa Suhagan exhibited maximum rachis length (47.03 cm) which was found statistically at par with variety Arka Amar, whereas plants of variety Punjab Dawn irradiated with 35 Gy gamma rays treatment recorded minimum (33.83 cm) rachis length.

Data on floret diameter was presented in Table 5. Maximum floret diameter (8.61 cm) was noted with 25 Gy whereas minimum diameter of floret (7.16 cm) was observed with 35

Gy of gamma radiation dose.

The data observed for floret diameter revealed that there was significant difference among all four varieties. Maximum floret diameter (8.49 cm) was recorded in variety Arka Amar followed by Arka Pratham (8.02 cm) which was at par with resulted Pusa Suhagan (7.60 cm) whereas variety Punjab Dawn recorded minimum florets diameter (7.54 cm).

The interaction of gamma doses and gladiolus varieties, combination of 25 Gy with cv. Arka Amar recorded maximum diameter of floret (8.61 cm) which was at par with combination of control, 25 Gy with cv. Arka Amar, 25 Gy and control. Minimum diameter of floret was registered in the interaction of 35 Gy with cv. Punjab Dawn.

Presents findings are in line with Dobanda (2004) [7] who reported that the higher doses of radiations reduced number and diameter of florets and affected adversely which may be because of auxin destruction, irregular auxin synthesis, failure of assimilation, mechanisms or inhibition of mitotic and chromosomal changes or damage with association of secondary physiological damage.

Table 1: Effect of gamma irradiation on number of days required for sprouting in different variety of gladiolus

Number of days required for sprouting (2022-23)				
Treatment / Variety	**0 Gy**	**25 Gy**	**35 Gy**	**Mean**
Pusa Suhagan	11.06	9.80	11.06	10.64
Arka Pratham	9.80	9.83	10.33	9.98
Arka Amar	9.93	10.13	11.33	10.46
Punjab Dawn	10.03	10.26	11.33	10.54
Mean	10.20	10.00	11.02	
	S.Em. ±	C.D. (0.05)		
Treatment	0.08	0.25		
variety	0.10	0.28		
Treatment X variety	0.17	0.49		

Table 2: Effect of gamma irradiation on leaf length at 30 DAP (cm) in different varieties of gladiolus

Plant height at 30 DAP (cm) (2022-23)				
Treatment / Variety	**0 Gy**	**25 Gy**	**35 Gy**	**Mean**
Pusa Suhagan	42.2	37.33	36.60	38.71
Arka Pratham	33.13	36.53	43	37.55
Arka Amar	33.53	35.40	31.20	33.37
Punjab Dawn	34.13	34.86	27.53	32.12
Mean	35.74	36.03	34.58	
	S.Em. ±	C.D. (0.05)		
Treatment	3.09	1.06		
variety	3.57	1.22		
Treatment X variety	6.19	2.11		

Table 3: Effect of gamma irradiation on Spike length (cm) in different varieties of gladiolus

Spike length (cm) (2022-23)				
Treatment / Variety	**0 Gy**	**25 Gy**	**35 Gy**	**Mean**
Pusa Suhagan	90.26	95.40	88.60	91.42
Arka Pratham	74.73	74.26	76.40	75.13
Arka Amar	81.20	80.20	82.20	81.20
Punjab Dawn	75.60	76.96	73.13	75.23
Mean	80.44	81.70	80.08	
	S.Em. ±	C.D. (0.05)		
Treatment	0.50	1.46		
variety	0.58	1.69		
Treatment X variety	1.00	2.92		

Table 4: Effect of gamma irradiation on rachis length (cm) in different varieties of gladiolus

Rachis length (cm) (2022-23)				
Treatment / Variety	**0 Gy**	**25 Gy**	**35 Gy**	**Mean**
Pusa Suhagan	44.46	47.03	43.56	45.01
Arka Pratham	38.26	38.58	38.10	38.31
Arka Amar	40.66	39.23	37.40	39.09

Punjab Dawn	34.53	37.13	33.83	35.16
Mean	39.47	40.53	38.22	
	S.Em. ±	C.D. (0.05)		
Treatment	0.43	1.26		
variety	0.50	1.45		
Treatment X variety	0.86	2.53		

Table 5: Effect of gamma irradiation on floret diameter in different varieties of gladiolus

Floret diameter (cm)				
(2022-23)				
Treatment / Variety	**0 Gy**	**25 Gy**	**35 Gy**	**Mean**
Pusa Suhagan	7.63	7.77	7.42	7.60
Arka Pratham	8.25	8.49	7.32	8.02
Arka Amar	8.50	8.61	8.37	8.49
Punjab Dawn	7.98	7.49	7.16	7.54
Mean	8.09	8.09	7.50	
	S.Em. ±	C.D. (0.05)		
Treatment	0.11	0.33		
variety	0.13	0.38		
Treatment X variety	0.23	0.66		

Conclusion

From the study it may be concluded that medium gamma rays dose of 25 Gy was better for enhancement of few vegetative, floral and corm and cormel characters, whereas doses of 35 Gy dose was best for induction of colour mutation. Among the varieties, Punjab Dawn was found most sensitive to gamma rays. A deep violet petal of total spike in cv. Arka Pratham at 35 Gy. Another mutant in cv. Arka Amar at 25 Gy was also isolated. In cultivar Arka Amar at 35 Gy, a mutant of light greenish yellow petals in spike and 25 Gy mutant of yellowish white colour of petals was observed. A mutant with strong purplish pink colour was recorded in cv. Punjab Dawn at 35 Gy.

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