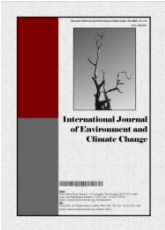

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Identification and Evaluation of Gamma Ray Induced Mutants in Gladiolus (*Gladiolus grandiflorus* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigations was carried out to isolate and evaluation of gamma ray induced mutants in gladiolus (*Gladiolus grandiflorus* L.) the experiments were carried out at Floriculture Research Farm, Department of Floriculture and Landscape Architecture, Indira Gandhi Krishi Vishvidyalaya, Raipur, India, during winter of 2018-19 and 2019-20. Five cultivars of gladiolus viz. American Beauty (V_1), Dull Queen (V_2), Saffron (V_3), Candyman (V_4) and Summer Sunshine (V_5) were irradiated with different doses (0, 15, 25, 35, 45 and 55 Gy) of gamma rays from ^{60}Co source and planted under open field condition in Randomized Block Design (RBD) with factorial concept. In this experiment different morphological characters *i.e.* maximum plant height, chlorophyll content, number of spikes per plot and minimum number of days required for first floret opening was observed at 15 Gy gamma rays. Ionising radiation had a negative effect on plants treated with greater doses (45 Gy and 55 Gy), but not so much on plants treated with lower levels (15 Gy and 25 Gy). Stable mutant were found and isolated in gladiolus cultivar American Beauty having yellow throat of red colour at 45 Gy, total spike colour of tepals was orange red at 55 Gy and light yellow colour was recorded in cv. Saffron at 45 Gy. A stable pinkish white colour mutant in cv. Dull Queen at 45 Gy.

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Keywords: Gladiolus; gamma irradiation; morphological characters; mutants.

1. INTRODUCTION

Gladiolus, a bulbous ornamental plant, is prized for its twigs with rows of florets in vibrant colours that last a long time. It is referred to as the "Queen of the Bulbous Flowers." It was given the name 'Sword lily' after the Latin word 'Gladius,' which means sword, because its foliage resembles that of a sword. It belongs to the family Iridiaceae, order Liliaceae, and class Monocotyledoneae. Gladiolus is a popular cut flower that is grown commercially all over the world. The ever-increasing demand, particularly in cities and towns, has made it a significant cut flower that is now accessible throughout the year in Indian market places. As a result, much work has been done in India and around the world to improve gladiolus, and a number of cultivars have resulted. In crops, mutations play a significant function in causing variability that may be utilised to improve the crop. Through mutation breeding, a vast number of ornamental variations have been generated. Gladiolus genetic makeup is extremely heterozygous, making it an ideal test subject for induced physical mutagenesis. Several researchers have looked into the effects of physical mutagens on gladiolus. As a result, the current experiment was conducted to investigate the effects of gamma radiation.

2. RESEARCH METHODS

The present investigation was carried out at Floriculture Research Farm, Department of Floriculture and Landscape Architecture, Indira Gandhi Krishi Vishvidyalaya, Raipur, India during winter of 2018-19 and 2019-20. Five cultivars *viz.,* American Beauty (V_1), Dull Queen (V_2), Saffron (V_3), Candyman (V_4) and Summer Sunshine (V_5) were used as experiment material. Healthy and uniform size of corms were treated with gamma radiation at various doses *viz.,* 0, 15, 25, 35, 45 and 55 Gy and planted at 8 cm depth, with a spacing of 30 × 20 cm. The experiment was carried out in Randomized Block Design with three replications with factorial concept. Standard package of cultural practices were followed throughout the experiment to grow a successful crop. Data of different morphological parameters were recorded regularly and mean value of data were analyzed through statistical method. Any abnormality or variation in plants in different treatments was recorded. Desirable variants were identified and evaluated in vM_2 generation.

3. RESEARCH FINDINGS AND DISCUSSION

3.1 Height of the Plant

It is evident from the data (Table 1), that the height of the plant decreased steadily with the rise in the dose of gamma rays. The dose effect shows that in the vM_1 generation, plants treated with 55 Gy gamma rays reported minimum plant height at 60 days after planting (54.33 cm) while maximum plant height was observed at 15 Gy (67.72 cm) gamma dose equal to untreated plants and 25 Gy gamma rays. In the vM_2 generation, plants treated with 35 Gy gamma rays showed significantly longer plants (70.69 cm) (55 Gy).

Varietal differences were also significant in both vM_1 and vM_2 generations. Maximum plant height was recorded in variety Candyman in vM_1 (75.74 cm) and Summer Sunshine in vM_2 (83.87cm) and minimum plant height in variety American Beauty in both the generations (43.98and 44.67 cm in vM_1 and vM_2, respectively).

Gamma dose 15 Gy treated plants of variety Candyman resulted in maximum plant height (82.07 cm), which was at par with 25 Gy and untreated plants of variety Candyman and 15 Gy and control of 15 Gy of variety Summer Sunshine and significantly higher than the other interactions, whereas variety American Beauty with 55 Gy treatment resulted in minimum plant height (41.40 cm), which was significantly shorter than other interactions during in vM_2 generation. In vM_2 generation also 35 Gy of variety of Summer Sunshine exhibited maximum plant height (99.33 cm), whereas minimum plant height was recorded in American Beauty with 55 Gy (40.00 cm) and significantly shorter than the other interactions.

In general, after gamma irradiation, the plant height declined and the variations increased at higher doses. Dhara and Bhattacharya [1] reported stunted plant growth while studying the impact of gamma irradiation on dormant gladiolus corms. These results are also consistent with the chrysanthemum findings of Kumari et al. [2]. Gamma irradiation is ionizing radiation which interacts with atoms and molecules to create free radicals in cells and, depending on the degree of irradiation, these radicals destroy or alter essential cell

components and affect plant morphology, anatomy and physiology differently [3]. A variety of other reasons for decreased growth following mutagenic treatments have also been given, such as the destruction of auxin, inhibition of auxin synthesis [4], failure of the assimilation mechanism, and changes in the specific activity of enzymes [5]. After 60 days of planting, the slightly longer plant height in Purple Flora may be due to the fact that it was early and that the growth was faster than in other varieties.

3.2 Chlorophyll Content

The observations of chlorophyll content, which influenced with varieties and treatments, is recorded in Table 2 for vM_1 generation and vM_2 generation. The treatments of gamma rays are non-significant in the chlorophyll content, but application of 15 Gy recorded the maximum chlorophyll content (60.00 SPAD). Whereas, minimum chlorophyll content was obtained at 55 Gy treatment (57.09). In vM_2 generation, similar trend in observations was recorded for plant height. The 15 Gy treatment recorded maximum height of the plant (64.32 SPAD) which found to be at par with control, 25 Gy and 35 Gy. Significantly minimum chlorophyll content (55.41 SPAD) was recorded at 55 Gy treatment of gamma radiations.

The chlorophyll content was significantly affected due to effect of varieties in both the generations. Maximum chlorophyll content was recorded in cv. Candyman in vM_1 generations (64.41 SPAD) which was at par with cv. Saffron while, minimum chlorophyll content was recorded in cv. Dull Queen (54.89 SPAD). In vM_2 generation maximum chlorophyll content was noted with cv. Candyman (65.75 SPAD) which was statistically at par with cv. Saffron however, minimum chlorophyll content was observed with cv. American Beauty (57.80 SPAD).

The interaction of varieties and gamma rays are non-significant in the chlorophyll content, but here data showed that maximum chlorophyll content registered in 15 Gy with cv. Candyman. Whereas, interaction of 55 Gy with cv. American Beauty (52.05 SPAD) resulted in minimum height of the plant during vM_1 generation. However, during vM_2 generation, maximum chlorophyll content (69.81 SPAD) was registered with interaction of 25 Gy and cv. Candyman. Interaction of 55 Gy with cv. Dull Queen (52.77 SPAD) was recorded minimum chlorophyll content.

These results are consistent with the findings of Kim et al. (2004). Giacomelli et al. [6] have opinioon that the degradation of chlorophyll in leaves was accelerated by irradiation. Irradiation has also caused the chloroplastic organization to break down, which has led to chlorophyll degradation more easily. The primary influence of irradiation was on the growth of meristematic cells, and the effect of the supply of auxin may be the same. The developmental regression of chloroplasts can be assumed primarily due to the destruction of grana. In particular, the developmental regression of chloroplasts from the destruction of grana can be assumed. As previously stated, irradiation of seeds at high doses of gamma rays disrupts protein synthesis, hormone balance, leaf gas exchange, water exchange, and enzyme activity. These findings are also consistent with Hasbullah et al. [7], where low-dose gamma irradiation was visually insensitive to chlorophyll.

3.3 Number of Days Required for First Floret Opening

It is apparent from the data presented in Table 3 that, the effect of gamma rays treatment on number of days taken to opening of first floret was non-significant. In vM_1 generation, 15 Gy treated plants took least number of days for the opening of basal floret *i.e.* 82.23 days, whereas a significant delay in opening of floret was recorded as the gamma rays dose increased above 25 Gy. Maximum number of days for the opening of lowermost floret *i.e*. 88.19 days was recorded at 55 Gy gamma rays treatment. In vM_2 generation, 35 Gy gamma rays irradiated plants exhibited earliest opening of first floret (78.40 days), whereas in plants treated with 55 Gy dose basal floret opening was most delayed (82.89 days).

Among the different varieties irrespective of gamma rays treatment, variety Dull Queen took minimum number of days (81.06) for the opening of its lowermost floret, whereas variety Saffron took maximum time for basal floret opening (87.52 days) in vM_1 generation. All the varieties were significantly differed for days to opening of first floret in vM_1 generation. In vM_2 generation, minimum number of days for basal floret opening was recorded in variety Dull Queen (74.24), which was significantly at par with number of days taken to first floret opening in variety American Beauty (75.79 days). Delayed first floret opening was exhibited by variety Summer

Sunshine that took 85.63 days for opening of first floret.

The interaction between gamma rays treatment and varieties are non-significant during both the generations of the experiment. The interaction effect of treated with gamma rays 15 Gy of variety American Beauty took least number of days for the opening of their lowermost floret in vM_1 generation (75.47 days). Maximum days for basal floret opening (90.47) were recorded in plants of variety Summer Sunshine treated with 55 Gy of gamma irradiation. In vM_2 generation, plant of variety Dull Queen treated with 25 Gy took least days (72.13) for opening of first floret. The opening of first floret was most delayed in plants of variety Summer Sunshine treated with 55 Gy (88.68 days).

Similar results were also reported by Dobanda [8] and Patil [9] who observed lower gamma ray doses induced earliness with regard to opening of first floret. Whereas, opening of first floret was delayed with increase in doses. Initiation of flowering may be affected as a result of mutagenic treatments because many biosynthetic pathway are believed to be altered, which are directly as well as indirectly associated with the flowering physiology [10].

3.4 Number of Spikes Per Plot

It is clear from the data on the number of spikes per plot that different doses of gamma irradiation and gladiolus varieties had a pronounced effect during both years of observation (Table 4). The observations clearly indicate that the number of spikes per plot was significantly affected due to varieties, treatments and their interactions in both the generations.

The mutagenic treatments of gamma radiations significantly affected the total number of spikes per plot. The 15 Gy treatments increased spike production *i.e.* 22.13 which was at par with untreated plants in vM_1 generation. The significant reduction in number of spikes per plant was noted with increase in gamma rays doses and significantly minimum number of spikes was obtained at 55 Gy (11.47) treatments. In vM_2 generation, significantly maximum number of spikes was observed at 15 Gy treatment (23.07) followed by control, 25 Gy, 35 Gy, 45 Gy and 55 Gy. While minimum spikes were observed at 55 Gy treatment (11.93). Higher doses of gamma radiations adversely affected the spike production.

The mean number of spikes per plot was significantly affected by different varieties. The maximum number of spikes was obtained in cv. Saffron (29.22 and 31.17) in first and second generations, respectively. It was followed by cv. American Beauty and Candyman in both generations while cv. Dull Queen produced significantly minimum spikes per plant in both generations (11.39 and 10.11, respectively).

As the number of spikes per plot was concerned, it was significantly affected due to interaction effect of varieties with gamma rays doses. In vM_1 generation, significantly maximum number of spikes was produced in cv. Saffron at 35 Gy treatment (35.00) which was at par with cv. Saffron at 15 Gy, 25 Gy, 35 Gy and control, while significantly minimum spikes were produced by cv. Dull Queen at 55 kR (5.67) gamma radiation dose. In vM_2 generation, significantly maximum number of spikes was produced in cv. Saffron at 35 Gy treatment (3.00) which was at par with cv. Saffron at 25 Gy, 15 Gy and control, while significantly minimum spikes were produced by cv. Dull Queen at 55 kR (6.00) gamma radiation dose.

This is in parallel line to the results obtained by Isaeve *et al.* [11] who stated that this may be due to reduction in growth and development of corms. The number of spikes per plant has been raised, which may be attributable to a small rise in photosynthetic activities that irradiation has promoted. Due to changes in plant metabolic activities and a negative response of plant hormones to irradiation, no or less flowering was observed at higher doses [12].

3.5 Abnormalities in Vegetative Characters

The data presented in Table 5 reveal that the per cent abnormalities in vegetative stage increased after gamma irradiation as compared to control and was highest at highest dose (55 Gy) in both the generations. Among the treatments, maximum of abnormalities in vegetative stage *i.e*. 13.13 per cent in vM_1 and 10.67 per cent in vM_2 were recorded in plants treated with 55 Gy gamma rays.Varietal differences for per cent of abnormalities in vegetative stage were also significant. Variety Dull Queen exhibited significantly higher abnormalities than the other varieties *i.e.* 8.89 per cent in vM_1 generation, whereas in vM_2 generation variety Dull Queen (7.78%) exhibited maximum number of abnormalities in vegetative stage. (Table 5 and Plate I).

Table 1. Effect of gamma irradiation on plant height at 60 DAP (cm) in different varieties of gladiolus

Plant height at 60 DAP (cm)														
	vM_1 Generation (2018-19)							vM_2 Generation (2019-20)						
Treatment Variety	**0 Gy**	**15 Gy**	**25 Gy**	**35 Gy**	**45 Gy**	**55 Gy**	**Mean**	**0 Gy**	**15 Gy**	**25 Gy**	**35 Gy**	**45 Gy**	**55 Gy**	**Mean**
American Beauty	45.47	46.65	44.13	42.53	43.67	41.40	43.98	48.22	52.56	47.67	42.89	36.67	40.00	44.67
Dull Queen	53.80	58.20	56.00	52.07	44.53	41.53	51.02	63.22	62.33	49.78	60.11	55.11	48.33	56.48
Saffron	73.00	74.80	71.60	71.27	64.40	61.53	69.43	62.22	64.67	64.89	69.89	61.33	60.00	63.83
Candyman	76.20	82.07	80.00	74.60	73.60	68.00	75.74	76.44	81.33	76.44	81.22	75.22	68.44	76.52
Summer Sunshine	77.81	76.87	73.80	70.83	54.27	59.20	68.80	90.89	85.44	82.44	99.33	78.22	66.89	83.87
Mean	65.26	67.72	65.11	62.26	56.09	54.33		68.20	69.27	64.24	70.69	61.31	56.73	
	Sem. ±	**C.D. (0.05)**						**Sem. ±**	**C.D. (0.05)**					
Treatment	1.14	3.23						1.20	3.40					
Variety	1.04	2.95						1.09	3.11					
Treatment x Variety	2.55	7.23						2.69	7.62					

Table 2. Effect of gamma irradiation on chlorophyll content in different varieties of gladiolus

Chlorophyll content														
	vM_1 Generation (2018-19)							vM_2 Generation (2019-20)						
Treatment Variety	**0 Gy**	**15 Gy**	**25 Gy**	**35 Gy**	**45 Gy**	**55 Gy**	**Mean**	**0 Gy**	**15 Gy**	**25 Gy**	**35 Gy**	**45 Gy**	**55 Gy**	**Mean**
American Beauty	57.41	56.53	52.96	57.97	54.09	52.05	55.17	60.69	59.28	57.26	60.13	54.94	54.47	57.80
Dull Queen	56.33	53.84	56.97	53.66	53.64	54.88	54.89	64.47	64.43	62.72	60.44	60.74	52.77	60.93
Saffron	60.81	62.84	61.94	64.06	62.06	58.32	61.67	63.34	65.49	63.15	63.89	63.12	54.69	62.28
Candyman	63.88	69.58	64.95	63.49	60.62	63.94	64.41	67.44	67.69	69.81	64.74	64.02	60.77	65.75
Summer Sunshine	54.28	57.19	55.46	57.07	59.80	56.28	56.68	62.10	64.72	61.39	59.84	56.80	54.32	59.86
Mean	58.54	60.00	58.46	59.25	58.04	57.09		63.61	64.32	62.87	61.81	59.92	55.41	

Chlorophyll content				
	vM_1 Generation (2018-19)		vM_2 Generation (2019-20)	
	Sem. ±	**C.D. (0.05)**	**Sem. ±**	**C.D. (0.05)**
Treatment	1.25	3.56	1.25	3.56
Variety	1.14	3.25	1.14	3.25
Treatment x Variety	NS	NS	NS	NS

Table 3. Effect of gamma irradiation on days to first floret open in different varieties of gladiolus

Days to first floret open														
	vM_1 Generation (2018-19)							vM_2 Generation (2019-20)						
Treatment Variety	**0 Gy**	**15 Gy**	**25 Gy**	**35 Gy**	**45 Gy**	**55 Gy**	**Mean**	**0 Gy**	**15 Gy**	**25 Gy**	**35 Gy**	**45 Gy**	**55 Gy**	**Mean**
American Beauty	80.80	75.47	78.47	81.07	83.53	88.33	81.28	72.13	76.22	78.65	75.85	74.73	77.13	75.79
Dull Queen	80.60	78.27	79.80	80.07	80.20	82.00	80.16	68.07	73.03	72.13	72.60	78.78	80.82	74.24
Saffron	89.33	86.13	86.87	86.80	85.87	88.07	87.18	83.67	83.00	82.75	78.93	81.87	83.82	82.34
Candyman	87.53	85.00	84.53	87.13	88.73	87.13	86.68	83.58	83.80	82.83	81.37	83.52	84.02	83.19
Summer Sunshine	84.33	86.07	85.73	89.13	87.80	89.33	87.07	85.93	83.37	84.73	83.27	87.80	88.68	85.63
Mean	84.52	82.19	83.08	84.84	85.23	86.97		78.68	79.88	80.22	78.40	81.34	82.89	
	Sem. ±	**C.D. (0.05)**						**Sem. ±**	**C.D. (0.05)**					
Treatment	NS	NS						1.07	3.03					
Variety	1.36	3.87						0.97	2.77					
Treatment x Variety	NS	NS						NS	NS					

Table 4. Effect of gamma irradiation on number spikes per plot in different varieties of gladiolus

Number spikes per plot														
	vM_1 Generation (2018-19)							vM_2 Generation (2019-20)						
Treatment Variety	**0 Gy**	**15 Gy**	**25 Gy**	**35 Gy**	**45 Gy**	**55 Gy**	**Mean**	**0 Gy**	**15 Gy**	**25 Gy**	**35 Gy**	**45 Gy**	**55 Gy**	**Mean**
American Beauty	21.00	25.00	20.67	11.67	8.33	6.00	15.44	25.33	27.33	20.67	11.33	8.00	6.33	16.50
Dull Queen	17.33	14.33	11.67	12.33	7.00	5.67	11.39	15.00	14.00	10.67	8.33	6.67	6.00	10.11
Saffron	32.00	30.33	30.00	35.00	26.00	22.00	29.22	31.00	33.00	33.33	37.33	27.67	24.67	31.17
Candyman	15.67	19.67	19.67	17.00	17.33	15.00	17.39	14.67	18.33	18.33	15.33	16.33	15.67	16.44
Summer Sunshine	16.33	21.33	14.00	16.67	9.67	8.67	14.44	16.00	22.67	12.33	15.00	7.00	7.00	13.33
Mean	20.47	22.13	19.20	18.53	13.67	11.47		20.40	23.07	19.07	17.47	13.13	11.93	
	Sem. ±	**C.D. (0.05)**						**Sem. ±**	**C.D. (0.05)**					
Treatment	0.73	2.09						0.86	2.44					
Variety	0.67	1.90						0.78	2.23					
Treatment x Variety	1.65	4.67						1.93	5.47					

Table 5. Effect of gamma irradiation on abnormalities in vegetative characters in different varieties of gladiolus

Abnormalities in vegetative characters														
	vM_1 Generation (2018-19)							vM_2 Generation (2019-20)						
Treatment Variety	**0 Gy**	**15 Gy**	**25 Gy**	**35 Gy**	**45 Gy**	**55 Gy**	**Mean**	**0 Gy**	**15 Gy**	**25 Gy**	**35 Gy**	**45 Gy**	**55 Gy**	**Mean**
American Beauty	0.00	5.00	6.67	8.33	10.00	11.67	6.94	0.00	5.00	6.67	8.33	10.00	11.67	5.28
Dull Queen	0.00	6.67	5.00	10.00	11.67	20.00	8.89	0.00	6.67	5.00	8.33	8.33	20.00	8.06
Saffron	0.00	6.67	6.67	6.67	8.33	13.33	6.94	0.00	6.67	8.33	6.67	8.33	11.67	6.94
Candyman	0.00	8.33	6.67	10.00	6.67	10.00	6.94	0.00	8.33	6.67	10.00	6.67	10.00	6.94
Summer Sunshine	0.00	5.00	6.67	8.33	8.33	11.67	6.67	0.00	6.67	6.67	8.33	8.33	10.00	6.67
Mean	0.00	6.33	6.33	8.67	9.00	13.33		0.00	6.67	6.67	8.33	8.33	10.67	

	Abnormalities in vegetative characters			
	vM_1 Generation (2018-19)		vM_2 Generation (2019-20)	
	Sem. ±	**C.D. (0.05)**	**Sem. ±**	**C.D. (0.05)**
Treatment	0.87	2.46	0.80	2.27
Variety	NS	NS	NS	NS
Treatment x Variety	NS	NS	1.79	5.09

Table 6. Performance of mutants isolated after gamma irradiation in gladiolus variety "American Beauty"

S. No.	Characters	American Beauty (Parent)	AB_1	AB_2
1	**Floret colour**	Red group (Moderate reddish orange) C 41	Red group (Vivid orange red) B 40	Red group (light pale yellow)
2	**Stability**		Stable	Stable
3	**Gamma ray dose**		45 Gy	55 Gy
4	**Plant height (cm)**	46.22	43.00	40.00
5	**Number of leaves**	16.36	15.22	13.00
6	**Leaf length (cm)**	34.67	34.47	30.60
7	**Leaf width (cm)**	2.18	2.23	1.81
8	**Number of tillers per plant**	2.67	2.00	2.00
9	**Days to spike initiation**	68.25	67	68.00
10	**Diameter of first floret**	71.98	77.40	65.22
11	**Number of florets**	7.86	7.00	5.00
12	**Spike length (cm)**	59.44	48.00	45.62
13	**Rachis length (cm)**	33.28	29.00	23.33
14	**Blooming period**	16.47	13.00	9.00
15	**Number of spikes per plant**	2.24	2.00	2.00
16	**Number of corms per plant**	2.89	2.00	2.00
17	**Weight of corm (g)**	71.78	49.22	31.83
18	**Diameter of corm (cm)**	4.24	3.63	3.35
19	**Number Cormels per plant**	14.59	13.00	15.28
20	**Weight of cormels (g)**	39.31	6.53	8.28

Table 7. Performance of mutants isolated after gamma irradiation in gladiolus variety "Dull Queen"

S. No.	Characters	Dull Queen (Parent)	DQ_1	DQ_2
1	**Floret colour**	Red purple group (Deep purplish pink) A 68	White group (Pinkish white) B N 155	Red purple group (light purplish pink)
2	**Stability**		Stable	Stable
3	**Gamma ray dose**		45 Gy	35 Gy
4	**Plant height (cm)**	63.22	53.00	44.00
5	**Number of leaves**	14.56	11.00	9.00
6	**Leaf length (cm)**	43.67	40.00	35.00
7	**Leaf width (cm)**	2.07	2.06	1.38
8	**Number of tillers per plant**	2.89	1.00	1.00
9	**Days to spike initiation**	64.47	65.00	67.00
10	**Diameter of first floret**	73.49	70.60	61.66
11	**Number of florets**	9.50	5.00	6.00
12	**Spike length (cm)**	49.92	42.53	41.87
13	**Rachis length (cm)**	30.25	25.58	20.42

S. No.	Characters	Dull Queen (Parent)	DQ_1	DQ_2
14	**Blooming period**	13.11	10.00	9.00
15	**Number of spikes per plant**	1.94	1.00	1.00
16	**Number of corms per plant**	2.89	1.00	1.00
17	**Weight of corm (g)**	57.33	21.39	19.22
18	**Diameter of corm (cm)**	4.28	3.84	2.93
19	**Number Cormels per plant**	89.67	63.00	42.00
20	**Weight of cormels (g)**	70.22	43.67	37.98

Table 8. Performance of mutants isolated after gamma irradiation in gladiolus variety "Saffron"

S. No.	Characters	Saffron (Parent)	SF_1
1	**Floret colour**	Orange red group (Vivid reddish orange) A 30	Yellow group (Light greenish yellow) C 3
2	**Stability**		Stable
3	**Gamma ray dose**		45 Gy
4	**Plant height (cm)**	64.22	61.00
5	**Number of leaves**	16.33	13.00
6	**Leaf length (cm)**	44.00	41.67
7	**Leaf width (cm)**	2.40	2.24
8	**Number of tillers per plant**	3.03	2.00
9	**Days to spike initiation**	78.00	70.00
10	**Diameter of first floret**	73.70	79.24
11	**Number of florets**	14.44	11.00
12	**Spike length (cm)**	77.67	73.00
13	**Rachis length (cm)**	49.17	38.60
14	**Blooming period**	14.48	11.53
15	**Number of spikes per plant**	2.64	2.00
16	**Number of corms per plant**	2.33	2.00
17	**Weight of corm (g)**	74.78	52.58
18	**Diameter of corm (cm)**	4.41	43.40
19	**Number Cormels per plant**	70.33	67.00
20	**Weight of cormels (g)**	67.36	28.10

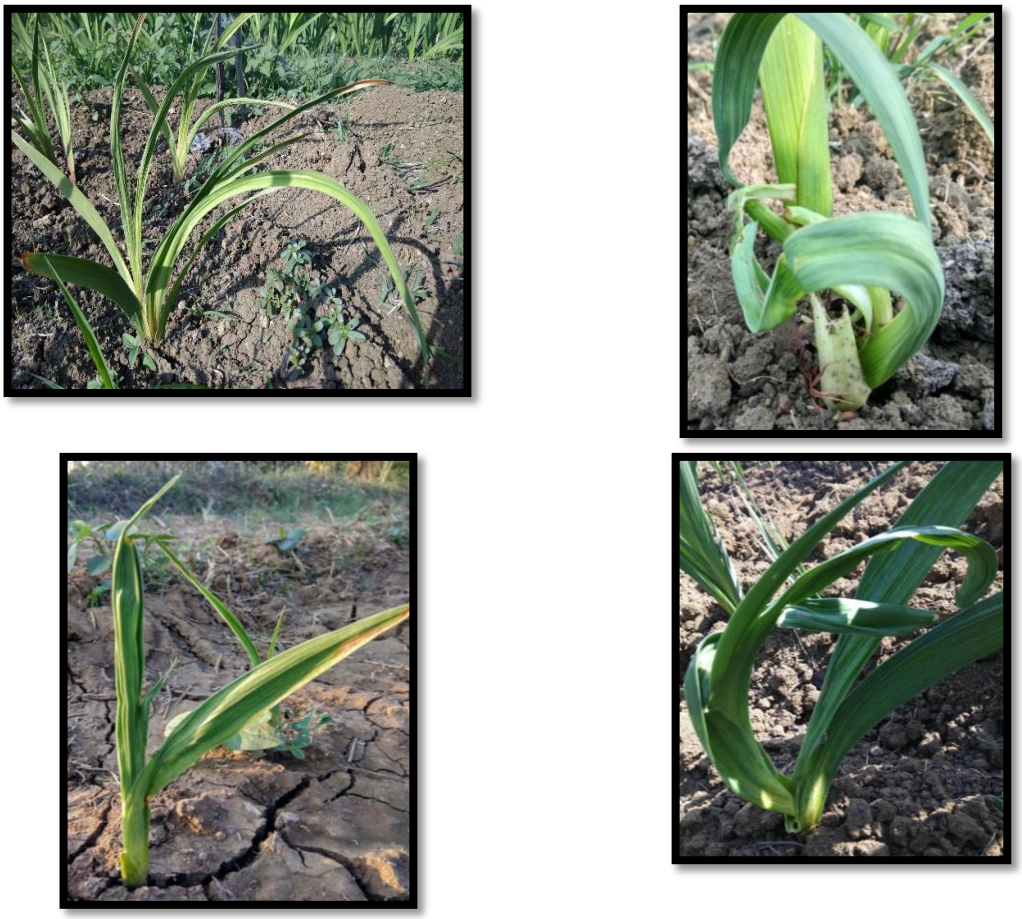

Plate I. Leaf abnormalities developed after gamma irradiation in different gladiolus varieties

Parent (Control) **45 Gy, Orange Red**

Plate. II. Effect of gamma irradiation on gladiolus cv. American Beauty

Parent (Control)

45 Gy, White colour mutant

Plate III. Effect of gamma irradiation on gladiolus cv. Dull Queen

Parent (Control)

45 Gy, Greenish yellow with red strip on throat

Plate IV. Effect of gamma irradiation on gladiolus cv. Saffron

AB_1: This mutant was isolated from the variety American Beauty at 45 Gy gamma irradiation. The mutant was different from the American Beauty in its floret colour. It had inner throat tepals of light yellow and outside petals are light red colour. The floret colour was matched with Royal Horticulture Society (R.H.S) Colour Chart as Red Purple Group N74 where as in AM_1 colour of tepals of some florets was Red Group 33D in vM_1 with some patches (Table 6 and Plate II).

AB_2: Mutant AB_2 was isolated at 55 Gy dose from variety American Beauty, total spike colour of tepals was orange red. The colour was very different than original variety and matches as Red group (Vivid orange red) B 40 on R.H.S colour chart (Plate II).

DQ_1: The mutant DQ_1 was different from the Dull Queen in its floret colour. It had tepals of pinkish white colour. This mutant was isolated at 45 Gy gamma irradiation. The floret colour of original variety Dull Queen was pink whereas mutant DQ_1 was matched as White group (Pinkish white) B N 155 on R.H.S Colour Chart (Table 7 and Plate III).

SF_1: SF_1 mutant was also screened from the vM_1 population of Saffron at 45 Gy dose. It had magnificent light yellow colour florets (Table 8 and Plate IV) and matched as Yellow group (Light greenish yellow) C 3 with R.H.S. colour chart. The centre of florets was darker orange stripe and matched as Orange red group (Vivid reddish orange) B N30. It was stable for its colour in vM_2 also.

4. CONCLUSION

From the study it may be concluded that medium gamma rays dose of 15 and 25 Gy was better for enhancement of few vegetative and floral characters, whereas doses of 45 and 55 Gy dose was best for induction of colour mutation. Stable mutant were found and isolated in gladiolus cultivar American Beauty of yellow throat of red colour at 45 Gy and total spike colour of petals was orange red at 55 Gy. A stable pinkish white colour mutant in cv. Dull Queen at 45 Gy and light yellowish pink colour was recorded in cv. Saffron at 45 Gy and mutant yellow petals with orange stripe on middle of petal of total spike in cv. Saffron at 45 Gy.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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