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# Induction of Genetic Variability through Gamma Radiation on Vegetative and Floral Characters of Gladiolus (*Gladiolus grandiflorus* L.)

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**ABSTRACT: Field investigations were carried out to know the "Induction of genetic variability through gamma radiation on vegetative and floral characters of gladiolus (*Gladiolus grandiflorus* L.)" 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. To conduct field experiment five cultivars of gladiolus namely American Beauty ($V_1$), Dull Queen ($V_2$), Saffron ($V_3$), Candy Man ($V_4$) 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. Significantly minimum number of days required for sprouting, maximum number of sprouts per corm, number of leaves per plant and minimum days taken to spike initiation and maximum spike length, florets per spike and spikes yield was found in the lower dose of gamma irradiation treatment *i.e.* 15 and 25 Gy gamma rays in both $vM_1$ and $vM_2$ generations. The expressions of vegetative and floral characteristics were diminished and retarded at and after 45 and 55 Gy treatments. In order to produce adverse effects, doses of 15 Gy and 35 Gy were very low and, in some cases, also proved stimulatory.**

**Keywords:** Gladiolus, Varieties, Gamma Rays, Vegetative, Spikes and Mutants.

## INTRODUCTION

Gladiolus is commonly known as sword lily, corn flag and gladioli. It is also known as "Queen of bulbous flowers". Botanically gladiolus is known as *Gladiolus grandiflorus* L. and belongs to family Iridaceae. The flower is popular for its majestic spikes which contain attractive, elegant, dazzling and delicate florets. These florets open in sequence over longer duration and hence, have a good keeping quality of cut spikes. The colour range in gladiolus is fantastic and almost any colour from near to black to white, pink, violet, lilac or mauve, greenish, smoky and combinations of these colours are also available. The spikes of gladiolus are mainly used for garden, interior decoration and for making bouquets. It has been great market value on the festival like of Diwali, Holi, New Year, Christmas and also on marriage ceremony.

The demand of gladiolus is increasing therefore; it needs attention towards genetic improvement. These have mostly been evolved through conventional breeding but a few through mutation breeding. Mutations are induced in different crops to create variability for further improvement. In vegetatively propagated plants, mutation breeding offers great potentialities as the mutated part can be conveniently perpetuated by vegetative means resulting in the development of new forms. Gladiolus is highly heterozygous in its genetic constitution which makes it promising test material for inducing physical mutagenesis (Sahariya *et al.*, 2017).

The effects of gamma rays on gladiolus have been studied by several workers but very few varieties have been developed through gamma radiations. Hence, in the present investigation, emphasis was laid on finding out variations caused by gamma radiations in morphological characters including colour variations. An attempt was made to develop a variety by fixing the induced variation in succeeding generations.

## MATERIAL AND METHODS

The gladiolus (*Gladiolus grandiflorus* L.) cultivars American Beauty ($V_1$), Dull Queen ($V_2$), Saffron ($V_3$), Candy Man ($V_4$), Summer Sunshine ($V_5$) which have been 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 ($I_0$), [15 Gy] ($I_1$), [25 Gy] ($I_2$), [35 Gy] ($I_3$), [45 Gy] ($I_4$) and [55 Gy] ($I_5$). 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. Ninety plots of 1.2 m × 1.0 m were laid out to accommodate the thirty treatments replicated three times. The corms were planted at a spacing of 30 cm × 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

**Number of days required for sprouting**: Number of days required for sprouting was influenced significantly due to gamma irradiation treatment and varieties during both the years of investigation (Table 1). Minimum days to sprouting was recorded with 15 Gy (12.19 days) which was at par with 25 Gy and control. During $vM_2$ generation, observation minimum days to sprouting was recorded with lower dose of gamma irradiation *i.e.* 15 Gy (11.94 days), which was at par with 35 Gy, 25 Gy and control and significantly higher to all other gamma irradiation treatments. Maximum days to sprouting was observed at higher dose of gamma irradiation 55 Gy during $vM_1$ (14.58 days) and $vM_2$ (14.72 days) generation. Among the varieties, Minimum days to sprouting was observed with cv. Saffron (12.18 days) which was at par with cv. Dull Queen (12.72 days), while maximum days to sprouting of corms were noted in cv. American Beauty (14.02 days) during $vM_1$ generation. In $vM_2$ generation minimum days to sprouting observed in cv. Saffron (12.27 days) which was at par with cv. Candyman and Summer Sunshine while maximum number of days to sprouting recorded with cv. American Beauty (14.19 days).

Interaction of 25 Gy with cv. Saffron (11.24 days) recorded minimum days taken to sprouting while, Interaction of 55 Gy with cv. American Beauty (16.10 days) was recorded maximum number of days to sprouting during $vM_1$ generation. Interaction of 35 Gy with cv. Saffron (10.67 days) recorded minimum days taken to sprouting which was at par to 15 Gy, 25 Gy with cv. Saffron, 25 Gy, 35 Gy, 15 Gy with cv. Candyman, 15 Gy, 25 Gy with cv. Summer Sunshine and control, 15 Gy with cv. Dull Queen control. Interaction of 55 Gy with cv. American Beauty (16.50 days) was recorded maximum number of days to sprouting during $vM_2$ generation.

Similar results were observed by Srivastava *et al.* (2007); Patil and Dhaduk (2009) in gladiolus and Singh *et al*. (2009) in marigold, who reported that higher radiation doses having adverse effect on days required for sprouting. Low level of mutagen itself is not responsible for early sprouting of gladiolus but it influence the activity of enzymes (Singh and Kumar, 2013). Mutagens affect enzyme function. Enzymes play a pivotal role in different activities of plant metabolism, so stimulate plant growth Misra and Bajpai (1983).

**Number of sprouts per hill**: Data provided in Table 2 during the $vM_1$ and $vM_2$ generation indicate that different doses of gamma irradiation resulted in substantial differences during both generations of testing with respect to the amount of sprouts per hill. The 25 Gy gamma dose resulted in a maximum number of sprouts per hill (2.33) that was statistically equivalent to the 15 Gy gamma dose and meaningful for all other gamma irradiation doses. Corms produced a minimum number of sprouts per hill during $vM_1$ output control (without gamma irradiation) (1.76). The maximum number of sprouts per hill (2.70) was recorded as a gamma irradiation dose of 15 Gy, which was statistically equivalent to the 25 Gy gamma dose and control care. No substantial difference between 25 Gy and untreated corms was observed (control). The minimum number of sprouts per hill observed during $vM_2$ generation at the gamma irradiation dose of 55 Gy.

Among all varieties, Maximum number of sprouts per hill was recorded with cv. American Beauty (2.67) followed by cv. Saffron and Dull Queen. Minimum number of sprouts per hill was recorded with cv. Candyman during $vM_1$ generation. During $vM_2$ also maximum number of sprouts per hill was recorded with cv. American Beauty generation which was at par with cv. Saffron (2.76) whereas, minimum number of sprouts was recorded in cv. Candyman (1.57). Treatment 15 Gy with cv. American Beauty resulted in maximum number of sprouts per hill which was statistically at par with interaction of 35 Gy and cv. American Beauty whereas, minimum number of sprouts was recorded in cv. Candyman (1.27) during $vM_1$ generation. However, during $vM_2$ generation interaction of 15 Gy with cv. American Beauty (3.56) resulted in minimum number of sprouts per hill which was at par with control and 25 Gy of cv. American Beauty and 25 Gy with cv. Dull Queen, control, 25 Gy and 35 Gy of cv. Saffron. Combination of cv. Dull Queen at 55 Gy corms produced minimum number of sprouts per hill (1.00) during $vM_2$ generation.

The number of sprouts per corm was slightly increased at lower doses, but decreased at higher doses. These results are corroborated by the results of Bowen (1965). While discussing the enhancement of germination, the low-dose levels of mutagens are responsible for stimulating the germination of substances, such as enzymes free from irradiation, and play an important role in the metabolic activities of plants resulting in stimulated plant growth. Higher doses may have harmful effects on auxins and other growth substances, chromosome structures and cell division, which suppress growth or cause a lethal effect on plant cells and, as a result, lead to less number of sprouts per hill and low plant survival.

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

| Number of days required for sprouting | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $vM_1$ 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 | 13.66 | 12.73 | 12.48 | 14.30 | 14.87 | 16.10 | 14.02 | 13.17 | 12.00 | 13.44 | 13.94 | 16.05 | 16.50 | 14.19 |
| Dull Queen | 12.40 | 11.87 | 11.27 | 12.90 | 13.37 | 14.50 | 12.72 | 12.04 | 11.56 | 14.28 | 13.78 | 14.83 | 16.39 | 13.81 |
| Saffron | 12.13 | 11.69 | 11.24 | 11.50 | 12.50 | 14.00 | 12.18 | 12.67 | 11.94 | 12.44 | 10.67 | 12.61 | 13.28 | 12.27 |
| Candyman | 14.35 | 12.81 | 13.40 | 14.40 | 13.40 | 13.23 | 13.60 | 13.17 | 12.33 | 11.56 | 11.22 | 12.06 | 13.50 | 12.31 |
| Summer Sunshine | 12.17 | 11.83 | 14.07 | 14.13 | 14.00 | 15.07 | 13.55 | 12.68 | 11.89 | 12.11 | 12.50 | 13.17 | 13.94 | 12.71 |
| Mean | 12.94 | 12.19 | 12.49 | 13.45 | 13.63 | 14.58 | | 12.74 | 11.94 | 12.77 | 12.42 | 13.74 | 14.72 | |
| | Sem. ± | C.D. (0.05) | | | | | | Sem. ± | C.D. (0.05) | | | | | |
| Treatment | 0.27 | 0.79 | | | | | | 0.285 | 0.81 | | | | | |
| Variety | 0.25 | 0.72 | | | | | | 0.26 | 0.74 | | | | | |
| Treatment × Variety | 0.62 | 1.76 | | | | | | 0.637 | 1.80 | | | | | |

**Table 2: Effect of gamma irradiation on number of sprouts per corm in different varieties of gladiolus.**

| Number of sprouts per corm | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $vM_1$ 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 | 2.20 | 3.20 | 3.07 | 2.87 | 2.93 | 2.80 | 2.84 | 3.00 | 3.56 | 3.44 | 2.50 | 2.37 | 2.17 | 2.84 |
| Dull Queen | 2.20 | 1.93 | 2.47 | 2.00 | 2.67 | 2.00 | 2.21 | 2.89 | 3.11 | 2.11 | 2.17 | 1.50 | 1.00 | 2.13 |
| Saffron | 1.73 | 2.33 | 2.33 | 2.27 | 2.22 | 2.53 | 2.24 | 3.03 | 2.78 | 3.39 | 3.00 | 2.22 | 2.11 | 2.76 |
| Candyman | 1.20 | 1.67 | 1.67 | 1.47 | 1.40 | 1.27 | 1.44 | 1.50 | 1.44 | 1.33 | 1.89 | 1.39 | 1.89 | 1.57 |
| Summer Sunshine | 1.47 | 2.07 | 2.13 | 1.73 | 2.07 | 1.93 | 1.90 | 2.17 | 2.61 | 2.50 | 1.89 | 1.50 | 1.67 | 2.06 |
| Mean | 1.76 | 2.24 | 2.33 | 2.07 | 2.26 | 2.11 | | 2.52 | 2.70 | 2.56 | 2.29 | 1.80 | 1.77 | |
| | Sem. ± | C.D. (0.05) | | | | | | Sem. ± | C.D. (0.05) | | | | | |
| Treatment | 0.07 | 0.21 | | | | | | 0.08 | 0.23 | | | | | |
| Variety | 0.07 | 0.19 | | | | | | 0.07 | 0.21 | | | | | |
| Treatment × Variety | NS | NS | | | | | | 0.18 | 0.53 | | | | | |

**Number of leaves per plant:** The number of leaves per plant was found to be significant due to effect of gamma radiations (Table 3 and Fig. 1). The treatment of 25 Gy enhanced number of leaves per plant (12.88), which was found at par with 15 Gy treatment (12.37). Significantly maximum reduction in number of leaves per plant was noted at highest gamma rays treatment *i.e.* 55 Gy (10.85) in $vM_1$ generation. The significant effect of maximum number of leaves per plant was recorded at treatment 15 Gy (15.02) which was found at par with control (13.89) and 25 Gy (13.42) treatment, while lower number of leaves per plant was observed at 55 Gy gamma rays treatment (9.91) in $vM_2$ generation.

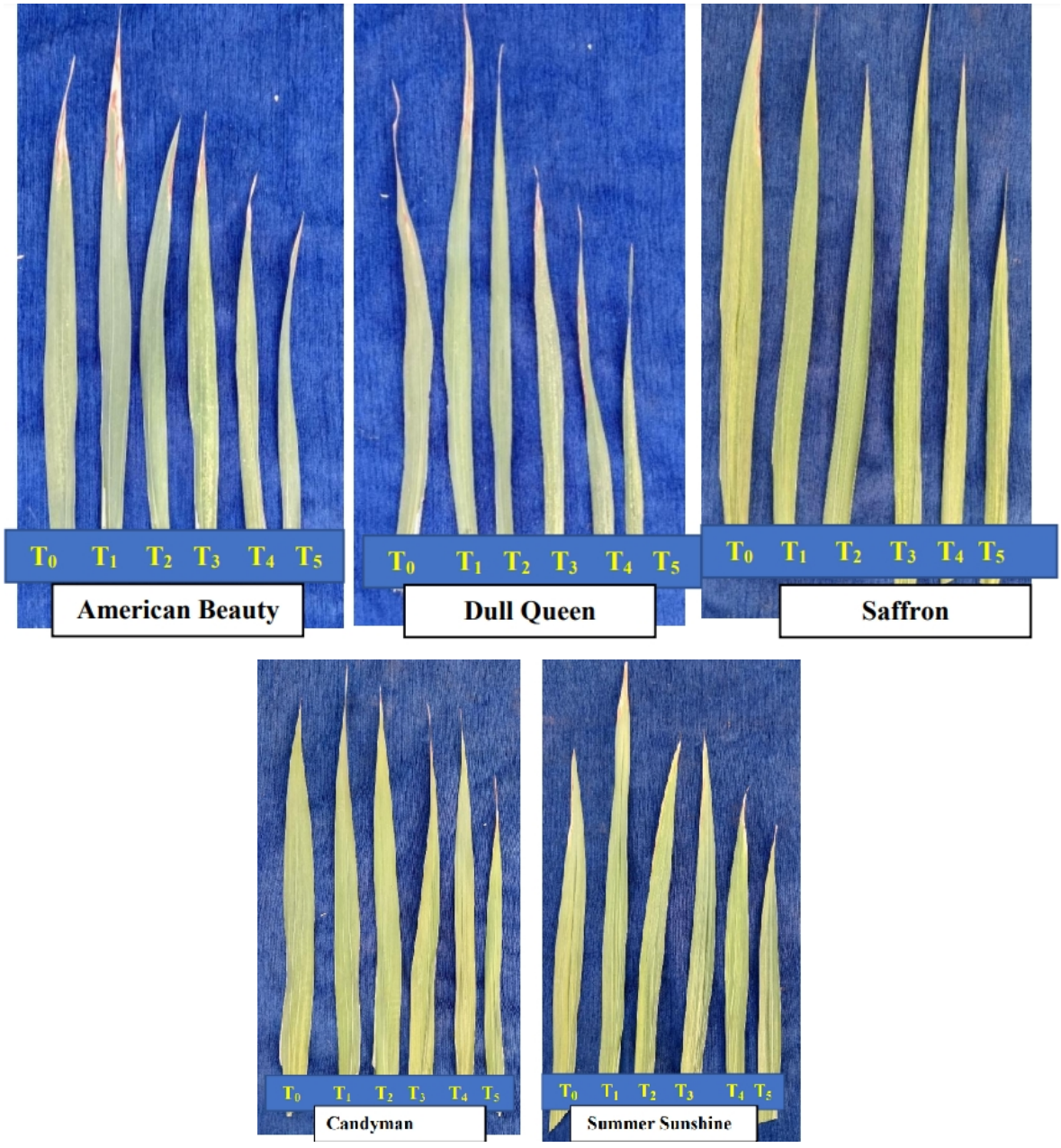


**Fig. 1.** Leaf area of gamma irradiated corms of gladiolus.

The highest number of leaves per plant *i.e.* 14.15 leaves per plant, was recorded in cv. American Beauty which was at par with cv. Saffron (13.34) while minimum number of leaves were noted in cv. Candyman *i.e.* 9.93 in $vM_1$ generation. In $vM_2$ generation maximum number of leaves was noted in cv. Saffron (16.52) followed by cv. American Beauty (14.78) while minimum in cv. Summer Sunshine (9.52). Such results have also been reported by Misra (1998); Misra and Mahesh (1993) which may be due to activation of physiological substances present in corms at lower doses, while higher doses retard cell division by arresting mitotic cell division and causing ill effects on auxins.

Observations on floral characteristics are presented in Table 4 were recorded at gamma irradiation 15 Gy exhibited earliest spike emergence in (66.05 and 73.02 days) and delayed spike initiation with increase in doses and maximum number of days was taken by corms (73.02 and 78.39 days) which were treated with the dose of 55 Gy gamma raysv$M_1$ as well as v$M_2$ generation. Minimum number of days for emergence of spike in v$M_1$ generation was recorded in variety Dull Queen (63.99 days) which was found statistically at par to variety American Beauty. Whereas, maximum in Candyman (73.34 days). All the varieties differed significantly for this trait in v$M_1$ generation. In v$M_2$, minimum days to spike emergence was taken by variety Dull Queen (65.97 days), which had significantly earlier spike emergence than the other varieties. Plants of variety Summer Sunshine took maximum days to spike emergence (80.97).

In Dutch iris, Rather and John (2000) also studied days for floret emergence. Early floret emergence resulted in some doses of gamma rays; however, variations were not important to the control. Misra *et al*. (2009) who figure out early bud initiation in chrysanthemum when different gamma doses are applied than control have also been similarly observed. The latest results are also in line with the flowering days of gladiolus cv. Sylvia and Eurovision (Srivastava *et al*., 2007), which documented early flowering at 20 Gy and 40 Gy compared to day-to-day flowering controls.

**Number of florets per spike:** Number of florets per spike reduced due to application of gamma doses (Table 5), as doses increased and higher doses of gamma rays resulted in minimum number of florets per spike. At 25 Gy gamma irradiation, the maximum number of florets per spike (10.99) was reported, which was statistically equivalent to 15 Gy (10.68 florets) and significantly higher than the rest of the treatments. A similar reduction in the number of florets was also recorded at higher doses during the v$M_2$ generation, whereas the 15 Gy dose resulted in a slightly higher number of florets (11.43) relative to the control (11.14). Among the varieties, Candyman exhibited maximum number of florets per spike (13.26) in v$M_1$ generation whereas, minimum number of florets per spike in v$M_1$ generation were observed in variety Dull Queen (6.71). In v$M_2$ generation, again the variety Candyman exhibited maximum number of florets per spike (14.54) and it was at par with floret number in variety Saffron (14.30 florets per spike). Whereas, minimum number of florets per spike was registered in variety American Beauty (7.13).

Gamma irradiation 15 Gy dose treated plants of variety Candyman exhibited maximum number of florets per spike in v$M_1$ (14.20) generation. In v$M_2$ generation variety Candyman at 15 Gy treatment exhibited maximum number of florets per spike (15.81), which was at par with 25 Gy, control, 35 and 45 Gy of variety Candyman and 15, 25, 35 Gy and control of variety Saffron. Misra and Mahesh (1993) also found positive results in which number of florets per spike was maximum at 1 kR gamma rays dose in four gladiolus cultivars *viz*., *Gladiolus callianthus* var. *Murielae*, Christian Jane, Psittacinus Hybrid and Oscar but drastically reduced at 5 kR dose. Dhaduk (1992) had also noted enhancement in number of florets per spike that was produced from corms treated with 1 kR dose while all higher levels of gamma rays (3 kR to 10 kR) reduced florets number. The gamma radiation treatments caused reduction in number of florets per spike at and beyond 5 kR in cv. Little Giant, Monsoer and Wild Rose (Raghava *et al.,* 1981; Negi *et al.*, 1983).

Various doses of gamma rays exhibited significantly effect on number of spikes per plant (Table 6). The 15 Gy treatments increased spike production *i.e*. 1.86 in v$M_1$ generation and 2.25 in v$M_2$ generation. Higher doses of gamma radiations adversely affected the spike production. The maximum number of spikes was obtained in cv. Saffron (2.07 and 2.59) in first and second generations, respectively. It was followed by cv. American Beauty (1.69 and 2.00) in both generations while cv. Dull Queen produced significantly minimum spikes per plant in both generations (1.28 and 1.50, respectively). In v$M_1$ generation, significantly maximum number of spikes was produced in cv. Saffron at 15 Gy treatment (2.40), while significantly minimum spikes were produced by cv. Dull Queen at 55 kR (1.00) gamma radiation dose. In v$M_2$ generation, significantly maximum number of spikes was produced in cv. Saffron at 25 Gy treatment (3.00) which was at par with cv. Saffron at 35 Gy, and cv. American Beauty at 15 Gy, while significantly minimum spikes were produced by cv. Dull Queen and Summer Sunshine at 55 kR (1.00) gamma radiation dose.

**Number of spikes per plant:** 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 (Takau *et al*., 1977). The reduction in the number and size of florets as a result of somatic rivalry, which occurs during intra-somatic selection. The radiation decreased the amount of florets and adversely affected those that could be due to the destruction of auxin, abnormal synthesis of auxin, assimilation failure, mechanisms or inhibition of mitotic and chromosomal changes or damage associated with secondary physiological damage that support current findings (Kumari and Kumar 2015).

**Table 3: Effect of gamma irradiation on number of leaves per plant in different varieties of gladiolus.**

| Number of leaves per plant | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $vM_1$ 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 | 15.22 | 15.57 | 13.50 | 13.93 | 13.80 | 12.88 | 14.15 | 17.44 | 18.33 | 14.67 | 12.89 | 13.44 | 11.89 | 14.78 |
| Dull Queen | 11.20 | 12.70 | 10.97 | 8.33 | 9.30 | 8.33 | 10.14 | 14.56 | 14.22 | 11.33 | 11.89 | 7.00 | 5.33 | 10.72 |
| Saffron | 10.21 | 14.47 | 15.23 | 14.13 | 13.17 | 12.82 | 13.34 | 16.33 | 17.78 | 18.89 | 18.67 | 14.00 | 13.44 | 16.52 |
| Candy Man | 8.10 | 8.73 | 12.80 | 12.20 | 8.86 | 8.87 | 9.93 | 10.56 | 12.33 | 10.67 | 13.56 | 9.89 | 12.22 | 11.54 |
| Summer Sunshine | 9.20 | 10.40 | 11.92 | 9.60 | 10.13 | 11.33 | 10.43 | 10.56 | 12.44 | 11.56 | 8.22 | 7.67 | 6.67 | 9.52 |
| Mean | 10.78 | 12.37 | 12.88 | 11.64 | 11.05 | 10.85 | | 13.89 | 15.02 | 13.42 | 13.04 | 10.40 | 9.91 | |
| | Sem. ± | C.D. (0.05) | | | | | | Sem. ± | C.D. (0.05) | | | | | |
| Treatment | 0.32 | 0.93 | | | | | | 0.41 | 1.16 | | | | | |
| Variety | 0.30 | 0.85 | | | | | | 0.37 | 1.05 | | | | | |
| Treatment × Variety | 0.73 | 2.08 | | | | | | 0.91 | 2.59 | | | | | |

**Table 4: Effect of gamma irradiation on days to spike initiation in different varieties of gladiolus.**

| Days to spike initiation | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $vM_1$ 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 | 67.07 | 64.81 | 65.22 | 65.70 | 66.67 | 71.89 | 66.89 | 68.25 | 70.40 | 67.33 | 69.20 | 71.67 | 73.53 | 70.06 |
| Dull Queen | 64.42 | 60.92 | 61.37 | 62.33 | 65.23 | 69.67 | 63.99 | 64.47 | 63.07 | 65.40 | 63.45 | 67.67 | 71.77 | 65.97 |
| Saffron | 70.50 | 69.00 | 69.07 | 69.53 | 69.40 | 71.05 | 69.76 | 78.00 | 77.67 | 79.17 | 75.00 | 78.23 | 80.00 | 78.01 |
| Candy Man | 74.22 | 69.39 | 73.73 | 73.00 | 75.23 | 74.49 | 73.34 | 81.50 | 77.53 | 78.67 | 77.23 | 80.03 | 82.37 | 79.56 |
| Summer Sunshine | 68.67 | 66.13 | 67.30 | 68.93 | 72.53 | 72.49 | 69.34 | 82.07 | 76.42 | 78.40 | 81.75 | 82.89 | 84.30 | 80.97 |
| Mean | 68.97 | 66.05 | 67.34 | 67.90 | 69.81 | 71.92 | | 74.86 | 73.02 | 73.79 | 73.33 | 76.10 | 78.39 | |
| | Sem. ± | C.D. (0.05) | | | | | | Sem. ± | C.D. (0.05) | | | | | |
| Treatment | 1.20 | 3.41 | | | | | | 1.26 | 3.56 | | | | | |
| Variety | 1.10 | 3.11 | | | | | | 1.15 | 3.25 | | | | | |
| Treatment × Variety | NS | NS | | | | | | NS | NS | | | | | |

**Table 5: Effect of gamma irradiation on number of florets per spike in different varieties of gladiolus.**

| Number of florets per spike | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $vM_1$ 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 | 7.67 | 9.67 | 8.80 | 7.48 | 5.47 | 4.67 | 7.29 | 7.86 | 8.64 | 6.83 | 5.92 | 7.00 | 6.50 | 7.13 |
| Dull Queen | 7.00 | 7.87 | 7.57 | 6.57 | 6.27 | 5.00 | 6.71 | 9.50 | 7.42 | 8.06 | 8.89 | 6.56 | 6.28 | 7.78 |
| Saffron | 11.00 | 11.60 | 13.53 | 12.73 | 10.60 | 10.73 | 11.70 | 14.44 | 15.17 | 14.47 | 14.25 | 13.64 | 13.83 | 14.30 |
| Candy Man | 13.22 | 13.93 | 14.20 | 12.87 | 13.60 | 11.72 | 13.26 | 15.11 | 15.81 | 15.16 | 14.91 | 14.92 | 11.33 | 14.54 |
| Summer Sunshine | 11.00 | 10.33 | 10.87 | 9.23 | 9.44 | 6.00 | 9.48 | 8.81 | 10.14 | 10.70 | 12.39 | 9.19 | 5.58 | 9.47 |
| Mean | 9.98 | 10.68 | 10.99 | 9.78 | 9.08 | 7.62 | | 11.14 | 11.43 | 11.04 | 11.27 | 10.26 | 8.70 | |
| | Sem. ± | C.D. (0.05) | | | | | | Sem. ± | C.D. (0.05) | | | | | |
| Treatment | 0.27 | 0.76 | | | | | | 0.21 | 0.60 | | | | | |
| Variety | 0.24 | 0.70 | | | | | | 0.19 | 0.55 | | | | | |
| Treatment × Variety | 0.60 | 1.71 | | | | | | 0.47 | 1.35 | | | | | |

**Table 6 : Effect of gamma irradiation on number of spikes per plant in different varieties of gladiolus.**

| Number of spikes per plant | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $vM_1$ 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 | 2.27 | 1.90 | 1.90 | 1.40 | 1.46 | 1.20 | 1.69 | 2.18 | 2.82 | 1.88 | 1.64 | 1.59 | 1.47 | 1.93 |
| Dull Queen | 1.80 | 1.60 | 1.20 | 1.23 | 1.10 | 1.00 | 1.32 | 1.94 | 1.64 | 1.41 | 1.64 | 1.36 | 1.00 | 1.50 |
| Saffron | 2.10 | 2.40 | 2.30 | 2.10 | 1.90 | 1.60 | 2.07 | 2.64 | 2.41 | 3.00 | 3.00 | 2.18 | 2.29 | 2.59 |
| Candy Man | 1.30 | 1.50 | 1.70 | 1.30 | 1.00 | 1.00 | 1.30 | 1.64 | 2.00 | 2.18 | 2.58 | 2.23 | 1.82 | 2.08 |
| Summer Sunshine | 1.60 | 1.90 | 1.68 | 1.25 | 1.33 | 1.00 | 1.46 | 1.82 | 2.36 | 1.64 | 1.61 | 1.18 | 1.00 | 1.60 |
| Mean | 1.81 | 1.86 | 1.76 | 1.46 | 1.36 | 1.16 | | 2.05 | 2.25 | 2.02 | 2.10 | 1.71 | 1.52 | |
| | Sem. ± | C.D. (0.05) | | | | | | Sem. ± | C.D. (0.05) | | | | | |
| Treatment | 0.04 | 0.13 | | | | | | 0.07 | 0.20 | | | | | |
| Variety | 0.04 | 0.12 | | | | | | 0.06 | 0.19 | | | | | |
| Treatment × Variety | 0.10 | 0.30 | | | | | | 0.16 | 0.46 | | | | | |

## CONCLUSION

The current study concluded that the lower dose of gamma irradiation treatment, i.e. 15 and 25 Gy gamma rays, significantly reduced the number of days required for sprouting, maximum number of sprouts per corm, number of leaves per plant, and minimum days taken to spike initiation and maximum spike length, florets per spike, and spike yield in both vM1 and vM2 generations. At and after 45 and 55 Gy treatments, expressions of vegetative and floral characteristics were reduced and delayed. Doses of 45 and 55 Gy were found to be the most effective for inducing colour mutation.

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