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Effect of gamma rays on flowering and vase life of gladiolus (*Gladiolus grandiflorus* L.)

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Abstract
The present investigation was conducted during the *Rabi* season of 2016 to study the effect of gamma rays on flowering and vase attributes associated with mutation and purification of novel types in gladiolus. The corms were treated with gamma rays (Source 60Co) at the dose of 15, 30, 45 and 60 Gy and were sown in the field along with control (un-irradiated corms). Low doses of gamma irradiation resulted in hormesis and induced encouraging vase life and novelties in flowering, while the higher doses induced higher degree of abnormalities which led to mortality and blindness. Six variants were also obtained exhibiting variation in spike length (cv. Candyman treated with 15 Gy), spike duoblness (cv. Candyman treated with 45 Gy), change in floret colour (cv. American Beauty and cv. Her Majesty treated with 30, 45, 60 Gy, respectively)

Keywords: Gamma rays, *Gladiolus*, corms, flowering

Introduction
Gladiolus, (*Gladiolus grandiflorus* L.) belongs to family of Iridaceae. It is native to South Africa and is attributed as "Queen of bulbous ornamentals" due to its popularity amongst the bulbous ornamentals in the world. Gladiolus is an important cut flower crop which possesses a great potential for export market to European countries especially during winter. The basic chromosome number of gladiolus is X=15, Gladiolus is an important flower crop and is very popular as cut flower both in the domestic and international market. It is relatively easy to grow and ideal for bedding and exhibition. In India, gladiolus is commercially grown in west Bengal, Odisha, Uttar Pradesh, Uttarakhand, Tamil Nadu, Punjab, Haryana, Madhya Pradesh, Delhi and Rajasthan. Ever increasing demand particularly in cities and towns of India make it an important cut flower which is now available in the Indian markets round the year. Development of new cultivars through conventional or modern techniques has been a prime objective in commercial floriculture. New colour, earliness in flowering, stem length, number of flowers, plant architecture, resistance to abiotic and biotic stresses, productivity and keeping quality are the main attributes required in new cultivars. Thus, mutation induction has proven to be a workable, sustainable, highly-efficient, environmentally acceptable, flexible, unregulated, non-hazardous and a low-cost technology to enhance crop improvement.
Mutation is a method by which novelty can be created in an already well-established cultivar. In crops mutation plays an important role to induced variability which can be used for further improvement. A large number of varieties have been developed in ornamentals through mutation breeding. Gladiolus is highly heterozygous in its genetic constitution which makes it promising test material for induced physical mutagenesis. The effects of physical mutagens on gladiolus have been studied by several workers. Therefore, present experiment was carried out to see the effect of gamma radiation on flowering and vase life of gladiolus.

Material and method
The gladiolus (*Gladiolus grandiflorus* L.) cultivars Candyman (V1), American Beauty (V2) and Her Majesty (V3), which have been found promising for 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 [15 Gy] (I_1), [30 Gy] (I_2), [45 Gy] (I_3), [60 Gy] (I_4), and control (I_0). The Gamma irradiation facility of the Bhabha Atomic Research Centre Mumbai, India is equipped with Gamma chamber-900 with source of 60Co, 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. Forty five plots of 1.3 m x 1.0 m were laid out to accommodate the fifteen 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 November. The plants were maintained under uniform cultural conditions throughout the period of investigation.

Result and Discussion

Days taken to spike initiation

A perusal of data presented in Table.1 shows there is significant effect of variety, mutagenic treatment on day to spike initiation. Within treatments, the minimum days for spike initiation (64.12) was observed in variety Her Majesty while the maximum days (75.39) was observed in variety Candyman, irradiation dose 15 Gy significantly taken minimum days (63.76) for day to spike initiation while maximum days was taken at 60 Gy (71.33 days). Similar results were obtained by Patil *et al.* (2010) [18]. Tiwari *et al.* (2010) [22]. And Sisodia and Singh (2015) [21] reported that spike initiation was delayed with increase in doses and maximum number of days was taken by corms which were treated with higher dose. There was no or less flowering observed at higher doses because of changes in plant metabolic activities, flowering physiology and negative response of plant hormones to irradiations (Misra *et al.*, 2009, Kim *et al.*, 2009) [15, 9].

Table 1: Effect of varieties and gamma radiation on flowering characters

Varieties	Days to spike initiation	Number of Days to open floret	Length of spike (cm)	Rachis length	Number of florets per spike	Floret diameter (cm)	Yield of spike	Vase life of cut spike
V_1	75.39	86.56	69.95	38.39	13.29	9.97	28.53	7.42
V_2	66.52	76.93	52.85	29.89	11.23	9.19	43.67	8.24
V_3	64.12	72.24	62.69	36.03	12.19	9.27	28.27	8.22
S.E m±	0.87	1.01	1.30	0.92	0.25	0.17	1.51	0.17
CD at 5%	2.52	2.93	3.79	2.68	0.73	0.48	4.41	0.50
	Radiation doses							
I_0	68.04	78.11	63.58	37.80	12.58	10.15	33.00	8.29
I_1	67.36	75.64	67.18	38.11	13.42	9.60	37.11	9.11
I_2	68.02	77.40	61.20	34.04	12.20	9.62	33.89	7.77
I_3	68.62	81.33	60.33	32.20	11.78	9.53	33.33	7.52
I_4	71.33	80.40	56.87	31.66	11.21	8.47	30.11	7.11
S.E m±	1.12	1.30	1.68	1.19	0.33	0.22	1.95	0.22
CD at 5%	NS	3.78	4.90	3.46	0.95	0.63	NS	0.64
	Interaction							
V_1I_0	74.07	14.73	74.07	42.00	14.73	11.00	30.33	7.66
V_1I_1	78.87	14.73	78.87	45.13	14.73	10.04	31.67	7.77
V_1I_2	68.13	13.33	68.13	36.20	13.33	10.11	27.67	7.89
V_1I_3	65.20	12.40	65.20	35.67	12.40	9.91	27.67	7.44
V_1I_4	63.47	11.27	63.47	32.87	11.27	8.81	25.33	6.33
V_2I_0	51.47	10.20	51.47	32.73	10.20	9.40	42.67	8.66
V_2I_1	59.07	12.60	59.07	31.80	12.60	9.19	56.67	10.22
V_2I_2	52.60	11.40	52.60	30.40	11.40	9.42	49.00	7.66
V_2I_3	51.20	11.13	51.20	27.40	11.13	9.50	37.67	7.22
V_2I_4	49.93	10.80	49.93	27.13	10.80	8.42	32.33	7.44
V_3I_0	65.20	12.80	65.20	38.67	12.80	10.04	26.00	8.55
V_3I_1	63.60	12.93	63.60	37.40	12.93	9.57	23.00	9.33
V_3I_2	62.87	11.87	62.87	35.53	11.87	9.34	25.00	7.77
V_3I_3	64.60	11.80	64.60	33.53	11.80	9.19	34.67	7.52
V_3I_4	57.20	11.57	57.20	35.00	11.57	8.18	32.67	7.22
S.E m±	2.91	0.56	2.91	2.05	0.56	0.37	3.38	0.38
CD at 5%	NS	NS	NS	NS	NS	NS	9.86	NS
C.V. (%)	8.15	7.97	8.15	10.23	7.97	6.79	17.5	8.31

Length of spike

The maximum length of spike (69.95 cm) was recorded in variety Candyman while minimum length was observed in variety American Beauty (52.85 cm) and irradiation dose 15 Gy recorded maximum (67.18 cm) spike length, while the minimum was recorded at 60 Gy. Fowler and Mac Queen (1972) hypothesized that most of the reported stimulatory effects of low doses of radiation was due to early modifications in axillary bud development and changes in the initial rate of floral differentiation and higher doses of gamma rays have lethal effect on plant metabolic activities, flowering physiology and negative response of plant flowering hormones to irradiation. (Misra *et al.,* 2006, Kim *et al.,* 2009) [14, 9].

Rachis length

The maximum length of rachis (38.37 cm) was recorded in variety Candyman and followed by Her Majesty (36.03 cm), while minimum length was observed in variety American Beauty (29.89 cm). Irradiation dose 15 Gy recorded maximum (38.11 cm) rachis length followed by 0 Gy, 30 Gy, 45 Gy, while the minimum length (31.66 cm) was recorded at 60 Gy. The decrease in rachis length could be attributed to the poor growth of plant on the irradiated plants due to radiation damage. Earlier Kainthura and Srivastava (2015) [6] also recorded shorter rachis length in Tuberose and concluded that the reduced in rachis length could be due to physiological, morphological and cytological disturbance caused by gamma radiation.

Number of days for open of first floret

Significantly earliest days to first floret opening was recorded in Her Majesty (72.24) followed by variety American Beauty (76.93 days) and Candyman (86.56 days). The result indicate that treatment 15 Gy induced earliness in opening of first floret (75.64 days) which however, was *at par* with treatments of 30 Gy (77.40 days) and 0 Gy (78.11 days). Higher dose of 60 Gy gamma rays took more days (80.40) for opening of first floret. Similar results were also reported by Dobanda (2004) [2]. And Patil (2014) [19]. 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 (Mahure *et al.,* 2010 and Ismael and Mohmoud 2015) [5, 13].

Number of florets spike^{-1}

The results indicate that number of florets per spike maximum (13.29 florets) was recorded in variety Candyman, while minimum (11.23 florets) recorded in variety Her majesty, In respect of gamma Irradiation 15 Gy recorded maximum number of florets (13.42 florets), whereas minimum number of florets (11.21 florets) was recorded at 60 Gy. Similar results were obtained by Tiwari *et al.,* (2010) [22]. And Patil (2014) [19]. In gladiolus, who observed that increase in the radiation dose, resulted in reduction in the floret number per spike in vM1 generation? The adverse effect of radiation on floret number may be because of mechanisms or inhibition of mitotic and chromosomal changes or damage with association of secondary physiological damage (Kumari and Kumar, 2015) [12].

Floret diameter

Data on floret diameter was significantly maximum (9.97 cm) recorded in variety Candyman, while the minimum floret diameter (9.19 cm) was recorded in variety American Beauty, gamma dose 30 Gy observed maximum (9.62 cm) floret diameter, while minimum (8.47 cm) was recorded in 60 Gy. Banerji and Datta (2002) [1] also observed a decrease in number of flowers per plants with increase in gamma rays working with chrysanthemum. The decrease in flower head production with higher doses could mainly be due to decrease in plant growth, and in lower doses plant growth not affected much as reported by Dwivedi and Banerji (2008) [3]. In dahlia and Kainthura and Srivastava (2015) [6] in Tuberose. Similar results were also reported by Dobanda (2004) [2]. And Patil (2014) [19]. Who observed lower gamma ray doses induced earliness, increase diameter of florets and number of florets. Whereas, decrease of diameter and number of floret with increase in irradiation doses. 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 (Mahure *et al.,* 2010) [13].

Yield of spike

Significantly maximum yield of spike per plot recorded in variety American Beauty (43.67 spike), however minimum (28.27 spike) was recorded in variety Her Majesty, In respect of gamma Irradiation 15 Gy recorded maximum number of spike (37.11 spike) whereas, minimum number of spike was recorded at 60 Gy. Similar results with gamma radiation in gladiolus have been reported by Karki (2008) [7], Patil and Dhaduk (2009) [17]. And Singh and Kumar (2013) [20] who observed that the yield of spikes is a varietal character and depends on the genetic makeup of the variety coupled with environment influence. The findings support the suggestions that the effect of dose rate on mutation flowering might different among varieties (Kim *et al.,* 2016) [9]

Vase life

The maximum vase life of cut spike was recorded in variety American Beauty (8.24 days) while minimum vase life was observed in variety Candyman (7.42 days) and among all the gamma irradiation doses 15 Gy recorded maximum vase life (9.11 days), whereas the minimum vase life was observed at 60 Gy (7.11 days). Similarly Karki and Srivastava (2010) [8] in Gladiolus who also concluded that lower doses was effective in improving some important vegetative, floral parameters and floral yield. Whereas, longer vase life at lower radiation doses may be due to slight increase in photosynthesis activities encouraged by irradiation (Patil, 2014) [19]. Leading to higher carbohydrate accumulation and thus causing delay in flower senescence. Irradiation with higher gamma rays doses decrease flower yield and vase life which may be attributed to inhibitory effect of higher mutagenic doses of gamma rays (Kumari *et. al.* 2013 and Muker and Bala, 2016) [11, 16].

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