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Effect of ionizing radiated gladiolus (*Gladiolus grandifloras*) on vase life attributes of various cultivars

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ABSTRACT

An experiment was conducted during winter (*rabi*) seasons of 2018–19 (vM_2), 2019–20 (vM_3) and 2020–21(vM_4) at Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand to evaluate the effect of gamma rays treated gladiolus (*Gladiolus grandiflorus* Andrews) on the post-harvest of different varieties along with their interaction for different qualitative traits The result showed that Praha was best cultivars for days to first floret opening, highest number of florets per spikes, highest number of open florets per spikes, rachis length and weight loss followed by cultivar Candyman for highest diameter of lowest floret, highest vase life and highest water uptake by spikes. Among the different gamma doses, the minimum days to first floret opening, the highest diameter of first floret, the days to first floret withering, the number of florets, the number of open florets, the rachis length, vase life, water uptake by spikes and the weight loss were recorded in non-irradiated corms. Among interaction, V_2G_0 (Praha + control) showed best result for days to first floret opening, total number of florets per spike, total number of open florets/spike and rachis length. Most important characters, vase life was positively correlated with rachis length at 5.0 and 6.0 Kr respectively, total number of florets/spike and total number of open florets/spike at 5.0 Kr. Study concluded that gamma rays affect the qualitative as well quantitative traits of gladiolus and do not have positive effect on vase life attributes.

Keywords: Correlation, Flower, Gladiolus, Gamma rays, Mutation, Vase life

Gladiolus (*Gladiolus grandiflorus* Andrews) is a perennial flowering plant, belongs to family of Iridaceae, also known as sword lily and corn flag. Gladiolus is one the leading flower crop gown in tropical, subtropical and some parts of temperate region. This significant bulbous ornamental is highly valued for its eye-catching spike of vibrantly coloured, shaped and sized florets that have a lengthy vase life. In nature, cut spikes are quite perishable. The vase life of a cut flower can be determined by the pace of floret senescence and the water relations of the spike (Kumar *et al.* 2009). The primary centre of origin of gladiolus is South Africa from where it was first bought in cultivation during the Greek period, with the exploration of more than 300 species and 10000 varieties in last 200 years (Randhawa and Mukhopadhyay 1986). Gladiolus is the 5th more demanding and producible flower crop in India. One of the top five speciality cut flowers in the world's cut flower industry is gladiolus, which has a significant economic value (Darras 2021).

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Due to high demand of gladiolus as a cut flower, various scientist tries to improve vase life by various methods (Singh *et al.* 2008, Saeed *et al.* 2014). Mutation is one of many effective techniques to determine the function and kind of a certain gene, which eventually broadens the genetic base of crop species and provides the building blocks for genetic advancements (Adamu *et al.* 2004). Depending on the kind of flower, gamma irradiation has varying effects on cut flowers (Kikuchi 2000). While certain flowers are more resilient to radiation than pests, others can tolerate the required radiation dosages. One of the major advantage of mutation is change in one or more traits without change in other traits. The enhancement of several economic characteristics is a constant goal for breeders, therefore understanding the connection between traits is crucial to understanding the changes that would occur in other traits concurrently with the selection of one feature (Bhatia *et al.* 2013). Also, the study of correlation among the different traits will help in improvements of one traits in response to other traits (Bisht *et al.* 2022). Therefore, the present investigation on gladiolus was conducted to optimise the radiation dosage and evaluate the efficacy of various doses of gamma radiation in inducing favourable change in vase life attribute.

MATERIALS AND METHODS

The study was carried out during *rabi* seasons of 2018–19 (vM_2), 2019–20 (vM_3) and 2020–21(vM_4) at Govind Ballabh Pant University of Agriculture and Technology, Pantnagar [29.50°N latitude; 79.30°E longitude; elevation of 1129 feet (344 m) amsl], Uttarakhand. The experimental site is located in the lower Shivalik highlands of the Himalayas, in the wet subtropical zone. Summer temperature vary from 32 to 40°C, while winter temperature range from 4 to 13°C. Rainfall begins around the middle of June and lasts until September. Light rain showers are common during the winter. Frost usually appears in late December or early February. Between mid-June to the end of February, relative humidity is only around 80–90%. From then on, it steadily declines to 50% by May and stays there until mid-June. The experiment was laid out in randomized block design (RBD) with two factors, i.e. varieties namely, Nova Lux (V_1), Praha (V_2), Black Star (V_3), Nathan Red (V_4), Candyman (V_5), Punjab Dawn (V_6) and Tiger Flame (V_7) with seven doses of gamma rays, viz. 0.0 Kr (G_0), 4.0 Kr (G_1), 4.5 Kr (G_2), 5.0 Kr (G_3), 5.5 Kr (G_4), 6.0 Kr (G_5) and 6.5 Kr (G_6) consisting of 49 treatment combinations with three replications. The corms of gladiolus were irradiated with Cobalt isotope (^{60}Co) in the gamma chamber at College of Basic Science and Humanities, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. The gladiolus irradiated corms were raised by adopting standard cultural operations as followed in gladiolus. After the initiation, spikes were harvested in the morning hours. For the vase life analysis, spikes at paint brush stage were selected. The spikes were placed in coloured glass containers filled with 500 ml of distilled water. The spikes with the glass containers were placed in the laboratory in a steady temperature on 20 ± 5°C with 70% RH. The observations for the traits i.e. days to first floret opening (days), diameter of first floret (mm), days to first floret withering (days), total numbers of floret per spike, total numbers of open florets per spike, rachis length (cm), water uptake by spikes (ml), loss in spike weight (g) and vase life (days) till the senescence were recorded. The experiment was repeated for three consecutive years from the three consecutive generations of gamma irradiated gladiolus varieties. Further, analysis of variance (ANOVA) and Pearson's correlation coefficient was done through OPSTAT software (Sheoran *et al.* 1998).

RESULTS AND DISCUSSION

Effect of varieties and gamma irradiation: Among the varieties (Table 1), V_2 took least days for opening of first floret (3.71) and V_5 took maximum days for opening first floret (5.01). The diameter of first floret was found minimum in V_4 (7.59 mm) and maximum in V_5 (10.16 mm). The days to first florets withering was minimum in V_7 (4.61) and maximum in V_1 (5.68). The total number of florets per spike was found maximum in V_2 (12.63) and minimum in V_3 (10.73). The total number of open florets per spike was found maximum in V_2 (8.92) and minimum in V_4 (6.95). The rachis length was found maximum in V_2 (36.84 cm) and minimum in V_4 (32.18 cm). The vase life in days was found maximum in V_5 (14.79) and minimum in V_3 (10.76). The water uptake was found maximum in V_5 (44.61 ml) and minimum in V_4 (31.44 ml). The loss of weight was found maximum in V_2 (13.18 g) and minimum in V_4 (4.52 g). The life activities of cut flowers are sustained at the expense of reserve nutrients that have been accumulated in the form of proteins, lipids, and carbohydrate (Jain *et al.* 2021). Variations in genotypes' genetic makeup might be the cause of the character variance. The present findings are in conformity with the earlier findings of Pandey *et al.* (2012) and Kadam *et al.* (2014)

The pooled data revealed that among the different gamma ray doses (Table 1), the minimum days to first floret opening (4.00 days), the maximum diameter of first florets (8.73 cm), the days to first floret withering (5.50 days), the number of florets (12.68), the number of open florets (8.55), the rachis length (39.64 cm), vase life (13.85 days), water uptake by spikes (41.55 ml) and the highest weight loss (11.79 g) was recorded in non-irradiated corms (Control). Maximum days to opening of first floret was recorded in G_4 (4.65 days), minimum floret diameter was found in G_4 dose (8.16 cm), minimum days taken to withering of first floret was found at G_4 (4.66 days), minimum number of florets (10.98) was recorded in G_6 dose, minimum number of open florets (6.95) was observed at G_6 , minimum rachis length was found at G_5 (33.22 cm), minimum vase life was recorded at G_6 (12.48 days), minimum water uptake by spikes was found at G_5 (35.58 ml), the minimum loss of weight by spike was observed at G_5 (9.44 g). Tiwari *et al.* (2010) and Sisodia and Singh (2015) reported that vase life attributes decreases with increase in doses. Higher doses had little or less of an impact on vase life qualities due to changes in plant metabolism, flowering physiology, and a negative reaction of plant hormones to radiation (Kim *et al.* 2009). Additionally, they discovered that the flowers had greater TSS and lower total free amino acid content than the untreated flowers (control group), which may have contributed to the flowers' longer vase life. Fjeld *et al.* (1994) enhanced the irradiation level in cut roses, they saw a considerable improvement in vase life.

Interaction effect of different varieties and gamma irradiation: The interactions of gamma doses and varieties were shown in Fig. 1 and 2. Result (Fig. 1) had showed minimum days (3.33 days) to opening of first floret was recorded in V_2G_0 and V_3G_0 (3.33 days) whereas, the maximum days to opening of first floret was observed in V_5G_3 and V_5G_0 (5.44 days). The maximum diameter of the lowest floret was recorded in V_5G_0 (10.47 cm) whereas, minimum was recorded in V_4G_5 (7.12 cm). The maximum days to withering of first floret was recorded in V_1G_0 (6.19 days) whereas, minimum was recorded in V_7G_4 (3.55 days). Number of florets/spike were highest in V_2G_0 (13.44) whereas, it was observed lowest in V_3G_3 (9.44). The highest number of open florets/spike was observed in V_7G_0 (9.55) (Fig. 2), while the minimum was recorded in

Table 1 Effect of gamma irradiation and gladiolus varieties on different vase life characters (Pooled data of 2018–19, 2019–20 and 2020–21)

Character	Generation	Varieties (Range)		Mean	Mutation doses (Range)		Mean
		Min.	Max.		Min.	Max.	
Days to first floret open	Pool	3.71	5.01	4.34	4.65	4.00	4.34
Diameter of first floret	Pool	7.59	10.16	8.29	8.16	8.73	8.31
Days to first floret withering	Pool	4.61	5.68	5.00	4.66	5.50	5.00
Total number of florets per spike	Pool	10.73	12.63	11.69	10.98	12.68	11.67
Total number of open florets per spike	Pool	6.95	8.92	7.59	6.95	8.55	7.59
Rachis length	Pool	32.18	37.42	34.71	30.67	39.64	34.69
Vase life	Pool	10.76	14.79	13.11	11.99	13.85	13.02
Water uptake by spikes	Pool	31.44	44.61	37.43	35.58	41.55	37.53
Weight loss of spike	Pool	4.52	13.18	10.50	9.44	11.79	10.74

V_4G_5 (5.33). The maximum rachis length was recorded in V_2G_0 (42.23 cm) whereas, minimum was recorded in V_3G_3 (26.15 cm). The longest vase life of spikes was observed in V_5G_2 (15.44 days) whereas, shortest (10.00 days) were recorded in V_3G_3 and V_3G_5. The interaction showed that, the maximum water uptake by spikes was recorded in V_5G_0 (52.44 ml) whereas, minimum water uptake by spikes was found in V_4G_5 (27.83 ml). The loss of weight was highest in V_3G_0 (14.99 g) whereas, minimum weight loss was recorded in V_4G_5 (4.20 g). Higher gamma ray radiation doses showed reduced flower production and vase life; this may be because greater gamma ray doses have an inhibitory influence on mutagenesis processes (Kumari *et al.* 2013, Muker and Bala 2016). Additionally, processes or inhibition of mitotic and chromosomal alterations or damage with a connection of secondary physiological damage might be the origin of radiation's detrimental effects on vase life characteristics (Kumari and Kumar 2015).

Correlations among different characters at different gamma irradiation: The correlation among characters were studied to reveal the nature and extent of relation among different vase life characters at different gamma doses (Table 2). Economically significant characteristics of cut flowers include rachis length, number of flowers per spike and vase life. Total number of florets/spike was negatively correlated with days to first floret opening at G_6. Total number of open florets/spike was negatively related with days to first floret opening (-0.78, -0.90) at G_1 and G_2 respectively and positively correlated with total number of florets/spike (0.92, 0.77, 0.77) at G_2, G_3 and G_4 respectively. Rachis length was positively related with total number of open florets/spike (0.76) at G_3. Vase life was positively correlated with rachis length (0.91, 0.80) at G_3 and G_5 respectively, total number of florets/spike (0.77) and total number of open florets/spike (0.78) at G_3. Water uptake was positively related with diameter of first florets (0.78, 0.90, 0.78, 0.88, 0.93) at G_3, G_4, G_5, G_6 and G_0 respectively, days to first floret opening (0.88) at G_1, vase life (0.85) at G_3. Loss of weight negatively correlated with days to first floret opening (-0.84), days to first floret withering (-0.83) and total number of florets/spike (-0.85) at G_2, G_3 and G_5 respectively and positively correlated with total number of

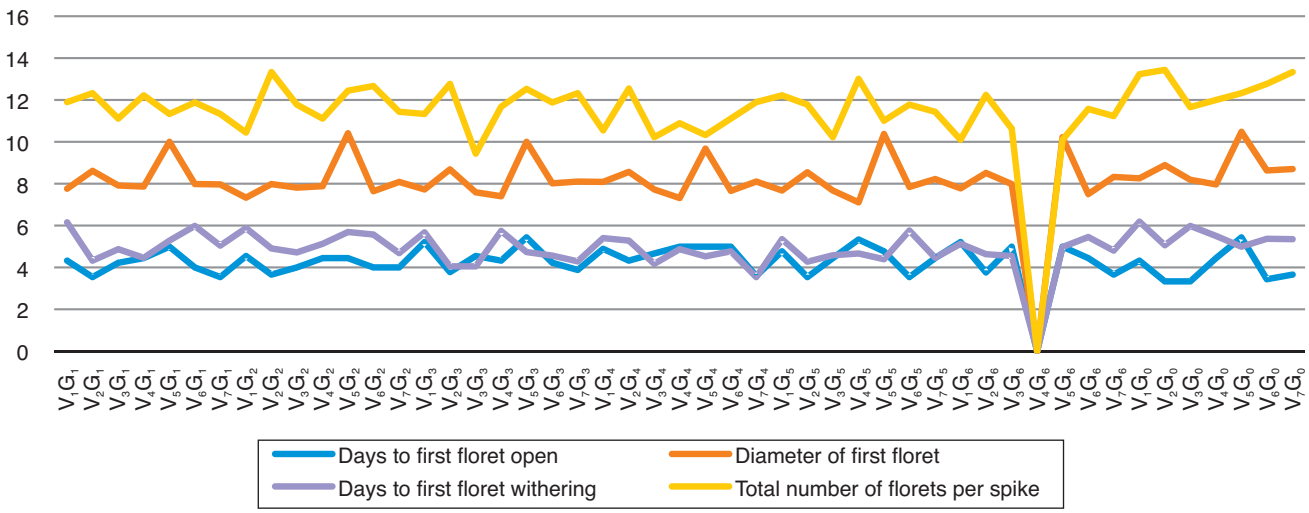

Fig. 1 Interaction effect of different variety and gamma irradiation on days to first floret open, diameter of first floret, days to first floret withering and total number of florets/spike.

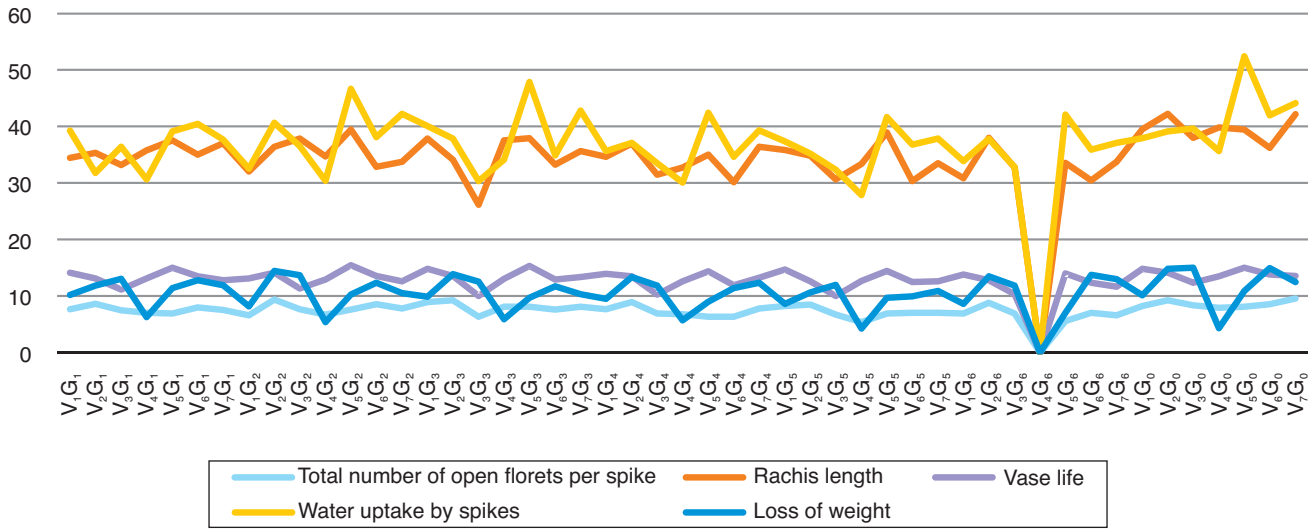

Fig. 2 Interaction effect of different variety and gamma irradiation on total number of open florets/spike, rachis length, vase life, water uptake by spikes and loss of weight.

Table 2 Pearson's correlations among different characters at different gamma irradiation population of gladiolus (only of significant doses)

Character	Gamma dose	Days to first floret open	Diameter of first floret	Days to first floret withering	Total number of florets/ spike	Total number of open florets/ spike	Rachis length	Vase life	Water uptake by spikes	Weight loss of spike
Days to first floret open	G_0, G_1, G_2, G_3, G_4, G_5, G_6				No significant at any dose					
Diameter of first floret	G_0, G_1, G_2, G_3, G_4, G_5, G_6				No significant at any dose					
Days to first floret withering	G_0, G_1, G_2, G_3, G_4, G_5, G_6				No significant at any dose					
Total number of florets/spike	G_6	-0.84*	-0.31	-0.13	1.00					
Total number of open floret/spike	G_1	-0.78*	-0.26	-0.03	0.47	1.00				
	G_2	-0.90**	0.03	-0.34	0.92**	1.00				
	G_3	-0.05	0.27	0.32	0.77*	1.00				
	G_4	-0.62	0.05	0.24	0.77*	1.00				
Rachis length	G_3	0.29	0.32	0.66	0.73	0.76*	1.00			
Vase life	G_3	0.43	0.59	0.44	0.77*	0.78*	0.91**	1.00		
	G_5	0.26	0.43	0.16	0.46	0.31	0.80*	1.00		
Water uptake by spikes	G_1	0.22	0.13	0.88**	-0.56	-0.11	0.05	0.32	1.00	
	G_3	0.41	0.78*	0.07	0.69	0.51	0.69	0.85*	1.00	
	G_4	-0.34	0.90**	-0.27	0.14	0.11	0.60	0.62	1.00	
	G_5	-0.29	0.78*	0.05	-0.39	0.54	0.54	0.55	1.00	
	G_6	-0.21	0.88*	0.06	0.004	-0.31	0.41	0.57	1.00	
	G_0	0.53	0.93**	-0.56	0.004	0.08	-0.01	0.44	1.00	
Weight loss of spike	G_2	-0.84*	-0.001	-0.37	0.74	0.85*	0.34	-0.03	0.52	1.00
	G_3	-0.31	0.20	-0.83*	-0.07	-0.08	-0.61	-0.29	-0.13	1.00
	G_5	-0.64	0.34	-0.12	-0.85*	0.55	-0.16	-0.36	0.54	1.00
	G_6	-0.74	-0.62	-0.11	0.88*	0.65	0.24	-0.64	-0.36	1.00

G_0, 0.0 Kr; G_1, 4.0 Kr; G2, 4.5 Kr; G_3, 5.0 Kr; G_4, 5.5 Kr; G_5, 6.0 Kr and G_6, 6.5 Kr *

open florets/spike (0.85) and total number of florets/spike (0.88) at 4.5 G_2 and G_6 respectively. From the above study it is clear that mutation can break the linkage among different traits and can change the association strength among different traits which are present among normal plants (Zafar *et al.* 2022). That is why vase life was positively correlated with rachis length at G_3 and G_5 respectively, total number of florets/spike and total number of open florets/spike at G_3. Similar study on correlation among different traits was done by Zafar *et al.* (2022) in tomato.

Vase life is one of the important traits of cut flower. The breeding goal in mutation breeding should be focused on attractive colours, high vase life, more number of flowers/spike, higher spike length etc. in order to meet competition and market demand. From the finding, higher doses of gamma rays had inverse effect on vase life and associated parameters as compare to lower doses. The untreated (G_0) gladiolus has shown superior vase life attributes than irradiated gladiolus in present study. At higher dose (G_4) flower take maximum days to opening of first floret, minimum floret diameter, minimum days taken to withering of first floret at G_5, minimum rachis length, minimum water uptake by spikes, the minimum loss of weight by spike and at G_6, minimum number of florets, minimum number of open florets, minimum vase life was observed. This might be due to chromosomal and mitotic damage inhibitory systems or damage linked to subsequent physiological damage. Hence, lower doses has positive increment in vase of gladiolus spike and also enhance export and allow farmers to get the appropriate value of their produce. Further, these mutant lines or population can be used in future plant improvement programme for improvement in gladiolus.

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