International Journal of Agriculture, Environment and Biotechnology
Citation: *IJAEB*: **15**(02): 229-237, June 2022
DOI: 10.30954/0974-1712.02.2022.11

ASSOCIATION FOR AGRICULTURE ENVIRONMENT AND BIOTECHNOLOGY

HORTICULTURE

Effect of Gamma Rays on Flowering, Post-harvest Life and Morphological Changes in Gladiolus Varieties

Minakshi Padhi* and Anil K. Singh

Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, U.P., India

*Corresponding author: minakshipadhi@gmail.com (**ORCID ID:** 0000-0003-1201-9836)

Paper No. 981 **Received:** 14-02-2022 **Revised:** 26-04-2022 **Accepted:** 29-05-2022

ABSTRACT

Present investigation was carried out for three years (2017-2018, 2018-2019 and 2019-2020) at Banaras Hindu University, Varanasi, India to find out effect of various gamma doses i.e., 20 Gy, 30 Gy, 40 Gy and 50 Gy along with control (untreated plants) in nine gladiolus varieties such as Gulal, Jyotsna, Mohini, Pusa Kiran, Pusa Srijana, Pusa Vidushi, Swarnima, Pusa Shubham and Urvashi. Lower dose of gamma (20 Gy) registered late withering of last floret, maximum length of spike and water uptake on 3rd day in vase during 1st year and 2nd year. Maximum length of 5th floret was observed with 20 Gy during 1st year and it was maximum with 40 Gy during 2nd year. Among varieties, late withering of 5th floret was registered with cv. Jyotsna and maximum water uptake on 3rd day was recorded with cv. Pusa Shubham. Late withering of 5th floret was obtained with 30 Gy in field condition and in vase it was maximum with 20 Gy gamma dose. Various morphological abnormalities and deformities were observed at higher gamma doses (40 and 50 Gy) in all three years of experimentation. Anomalous change in flower shape, size and colour was identified in irradiated plants when compared to parents.

HIGHLIGHTS

- Gamma doses of 20 Gy and 30 Gy were found beneficial for flowering and post harvest life.
- Cultivar Jyotsna, Pusa Shubhama and Swarnima responded positively with various gamma doses.
- Morphological changes in growth and flowering characters were observed in cvs. Jyotsna, Pusa Kiran and Pusa Srijana at 40 and 50 Gy.

Keywords: Gladiolus, gamma doses, flowering, post-harvest and morphological changes

Among the bulbous flowering plants, gladiolus is a very popular cut flower. It was introduced into cultivation towards the end of 16th century. Their flowers are used for interior decorations and making bouquets and flower arrangements. It ranks next to tulip in the Netherlands and other European countries in the trade for use as cut flower of bulbous ornamentals (Singh 2006 and Singh and Sisodia 2017). Asynchronous flowering in different gladiolus varieties is a big hurdle in the breeding. Dehiscence starts at 8.00 am in several cultivars and its peak is between 8.00-9.30 am (Roychoudhary 1980 and Singh 2014). Therefore, mutation breeding is one of the option to induce variability and induced mutants. There are several radiation sources *i.e.*, X-rays, gamma rays, UV rays and visible lights. Among these, gamma rays are the most energetic form of such electromagnetic radiation. Gamma rays belong to ionizing radiation and interact to in terms of molecules to produce free radicals in cells, which modify important components of plants (Wi *et al*. 2007). Successful coloured mutants have been evolved through gamma irradiation in different flowering plants *i.e.*, rose (Arnold *et al*. 1998), chrysanthemum (Matsumura *et al*. 2010 and Wang *et*

How to cite this article: Padhi, M. and Singh, A.K. (2022). Effect of Gamma Rays on Flowering, Post-harvest Life and Morphological Changes in Gladiolus Varieties. *Int. J. Ag. Env. Biotech.*, **15**(02): 229-237.

Source of Support: None; **Conflict of Interest:** None

al. 2020), gladiolus (Sisodia and Singh 2014; Sisodia and Singh 2015; Singh and Sisodia 2015; Sisodia *et al*. 2015) and lilium (Hajizadeh *et al*. 2022). Therefore, present study was carried out to find out mutagenic effect of gamma rays on flowering and post harvest parameters and morphological changes in gladiolus.

MATERIALS AND METHODS

The present investigation was carried out at Horticulture Research Farm and Post harvest Laboratory, Department of Horticulture, Banaras Hindu University, Varanasi, Uttar Pradesh, India during 2017-2018, 2018-2019 and 2019-2020. In this experiment corms of nine gladiolus varieties *i.e*., Gulal, Jyotsna, Mohini, Pusa Kiran, Pusa Srijana, Pusa Vidushi, Swarnima, Pusa Shubham and Urvashi were exposed to gamma doses at 20 Gy, 30 Gy, 40 Gy and 50 Gy at C.S.I.R- National Botanical Research Institute, Lucknow. These treated corms were planted in the well prepared beds with a spacing of row to row 30 cm and plant to plant 20 cm during November 2017. Harvested corms from 1st year were stored in the cold storage and planted again during 2nd year (2018). Same process was followed during 3rd year. During 1st year and 2nd year, various flowering and post harvest studies were observed, whereas during 3rd year, morphological characters were observed due to gamma doses in different gladiolus varieties. The experiment was laid out in Randomized Block Design with three replications. Various flowering and post harvest parameters *i.e*., length of 5th floret, days to withering of 5th floret, length of spike on 3rd day, days to withering of 5th and last floret and water uptake on 3rd day in vase were recorded. Morphological changes in different varieties due to gamma effect were observed during 1st year, 2nd year and 3rd year.

RESULTS AND DISCUSSION

Length of 5th floret

The result pertaining to length of 5th floret was found significant due to various gamma doses, varieties and their interactions during both the years of investigation (Table 1). Maximum length of 5th floret was observed with control which was at par with 20 Gy treatment during 1st year of investigation. Whereas, 40 Gy treatment registered maximum length of 5th floret during 2nd year, which was at par with all treatment except 50 Gy treatment. Among the varieties, cv. Mohini produced bigger size of 5th floret during 1st year, whereas during 2nd year it was observed with cv. Pusa Vidushi. Treatment combination of 40 Gy with cv. Jyotsna registered maximum length of 5th floret which was at par with combination of 20 Gy with cv. Mohini. During 2nd year, maximum length of 5th floret was recorded with combination of 40 Gy with cv. Jyotsna Minimum length of 5th floret was recorded with treatment combination of 50 Gy with cv. Jyotsna. An adequate gamma dose (higher) is usually based on the extent of physiological damages which manifest themselves in inhibiting cell division process and DNA breakage in plant cells, leading to damage to plant cell division and developmental process resulting in reduced plant growth and flower size (Schum 2003 and Doná *et al*. 2013). Voluminous work has been done by are Hajizadeh *et al*. (2022) and Aslam *et al*. (2016) in lilium, Sisodia and Singh (2014) in gladiolus.

Days to withering of 5th floret in field

Data regarding days to withering of 5th floret was depicted in Fig. 1 due to the effect of gamma doses and gladiolus varieties during 1st year. Treatment 30 Gy resulted in maximum days to withering of 5th floret which was significant to 50 Gy gamma dose and at par with other treatments during 1st year of investigation. Whereas, all the treatments failed to show any striking effect during 2nd year of observation. Cultivar Pusa Vidushi resulted late withering of 5th floret during 1st year. However, during 2nd year cv. Swarnima showed late withering of 5th floret, although there was no significant difference between cvs. Pusa Vidushi and Swarnima and significant to other varieties. Late withering of 5th floret was registered in the treatment combination of 50 Gy with cv. Pusa Vidushi during 1st year. Late withering of florets was also observed with higher doses in this experiment. In general, higher doses of gamma are detrimental in several plants. It was also advocated by earlier workers. Higher gamma doses cause structural and physiological changes in plant cell; affecting plant cell division and elongation process which may cause the senescence process faster (Li *et al*. 2022). However, slender and thicker stems having more endogenous metabolites,

Table 1: Effect of gamma irradiation on length of 5th floret in different Indian gladiolus varieties

	I Year						II Year					
Gamma dose Variety	**Control**	**20 Gy**	**30 Gy**	**40 Gy**	**50 Gy**	**Mean**	**Control**	**20 Gy**	**30 Gy**	**40 Gy**	**50 Gy**	**Mean**
Gulal	9.07	8.93	8.45	9.05	9.37	8.97	7.85	7.40	6.56	7.36	7.86	7.41
Jyotsna	9.27	9.23	9.40	11.27	6.93	9.22	7.78	9.77	9.43	10.93	6.03	8.79
Mohini	10.83	10.67	10.07	10.17	9.80	10.31	8.17	8.71	7.43	8.08	7.88	8.05
Pusa Kiran	10.53	9.75	9.13	9.00	8.83	9.45	8.12	9.27	8.67	9.03	7.63	8.54
Pusa Srijana	10.07	9.37	9.50	9.22	8.35	9.30	8.87	8.31	8.95	8.43	8.16	8.54
Pusa Vidushi	10.30	9.38	9.45	8.75	8.42	9.26	10.63	10.12	9.76	10.30	10.83	10.33
Swarnima	9.87	9.87	9.73	8.84	8.54	9.37	8.46	10.13	8.13	9.47	8.60	8.96
Pusa Shubham	8.90	8.78	7.60	8.06	7.13	8.09	7.73	6.17	7.17	6.93	6.87	6.97
Urvashi	7.80	8.03	7.53	7.60	8.73	7.94	7.87	8.12	8.31	8.30	7.35	7.99
Mean	9.63	9.34	8.98	9.11	8.46		8.38	8.67	8.27	8.76	7.91	
C.D. (0.05%)												
T	0.30						0.55					
V	0.34						0.74					
T×V	0.72						1.66					

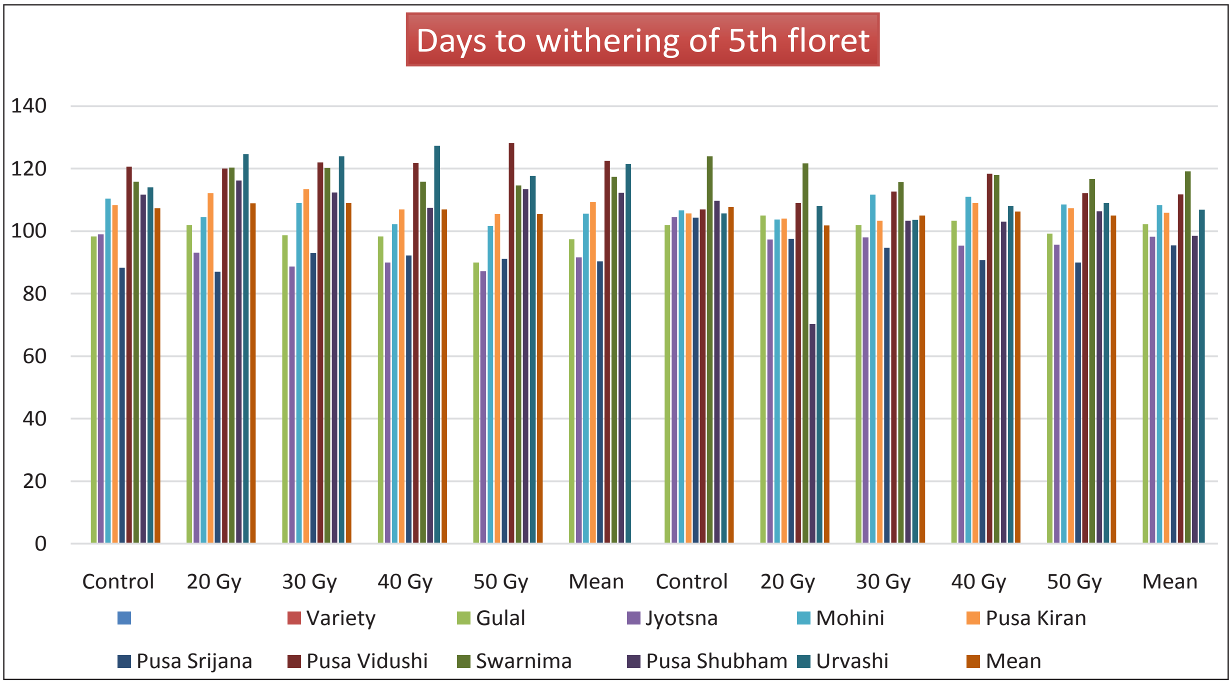

Fig. 1: Effect of gamma irradiation on days to withering of 5th floret in different gladiolus varieties

carbohydrate as well as respiratory substrates that prevent breakage of cut spikes and keeps the flower blooming for longer duration. The results are in close conformity with the findings of Fjeld *et al*. (1994) in Cardinal and Madelon varieties of cut roses and Sisodia and Singh (2014) in different cultivars of gladiolus.

Length of spike on 3rd day

Various gamma doses, varieties and their interactions were found significant on spike length during 3rd day in vase on 1st year and 2nd year (Table 2). Maximum length of spike on 3rd day was observed with 20 Gy treatment and minimum was observed with higher dose of gamma (50 Gy) during 1st year and 2nd year. Among varieties, maximum length of spike on 3rd day in vase was recorded with cv. Pusa Kiran which was at par with cv. Swarnima during 1st and 2nd year. Interaction of 30 Gy with cv. Pusa Vidushi registered maximum length of spike on 3rd day during 1st

Table 2: Effect of gamma irradiation on spike length (cm) on 3rd day in different Indian gladiolus varieties during post harvest studies

Gamma dose / Variety	I Year						II Year					
	Control	20 Gy	30 Gy	40 Gy	50 Gy	Mean	Control	20 Gy	30 Gy	40 Gy	50 Gy	Mean
Gulal	61.67	63.23	55.93	51.73	47.77	56.07	62.23	68.13	59.20	47.73	41.77	55.81
Jyotsna	67.00	67.87	57.60	54.80	45.33	58.52	67.73	70.10	62.13	55.60	48.17	60.75
Mohini	65.30	69.23	59.37	58.67	56.30	61.77	68.77	72.23	57.70	61.60	58.10	63.68
Pusa Kiran	67.93	66.87	60.07	68.17	62.97	65.20	70.67	71.78	66.20	73.93	66.53	69.82
Pusa Srijana	64.57	64.73	52.03	34.57	31.50	49.48	65.00	68.50	54.20	31.57	32.17	50.29
Pusa Vidushi	64.03	59.67	69.60	53.80	59.67	61.35	70.90	64.26	69.43	60.77	65.20	66.11
Swarnima	61.20	66.27	66.17	66.20	44.47	60.86	70.03	69.30	67.90	70.33	69.60	69.43
Pusa Shubham	61.53	55.90	44.60	53.43	48.07	52.71	56.40	55.80	53.87	59.77	51.20	55.41
Urvashi	61.23	67.63	57.23	50.40	48.80	57.06	63.67	76.03	58.97	53.77	58.87	62.26
Mean	63.83	64.60	58.07	54.64	49.43		66.16	68.46	61.07	57.23	54.62	
C.D. (5%)												
T	3.60						2.51					
V	4.82						3.36					
T×V	10.79						7.52					

Table 3: Effect of gamma irradiation on days to withering of 5th floret in different Indian gladiolus varieties during post harvest studies

Gamma dose / Variety	I Year						II Year					
	Control	20 Gy	30 Gy	40 Gy	50 Gy	Mean	Control	20 Gy	30 Gy	40 Gy	50 Gy	Mean
Gulal	8.00	8.50	8.33	8.33	7.00	8.03	8.83	8.83	8.33	8.50	6.50	8.20
Jyotsna	10.83	11.50	11.67	10.67	8.83	10.70	9.67	9.50	10.67	10.33	7.83	9.60
Mohini	9.50	9.50	7.83	6.83	7.50	8.23	8.83	7.83	8.83	7.00	7.67	8.03
Pusa Kiran	7.83	7.50	7.17	7.00	6.00	7.10	8.00	8.00	7.33	7.33	6.33	7.40
Pusa Srijana	8.50	9.00	8.17	7.33	7.17	8.03	7.00	7.67	7.67	7.67	6.67	7.33
Pusa Vidushi	8.67	8.17	8.33	7.67	8.33	8.23	8.00	8.00	8.00	7.67	6.67	7.67
Swarnima	9.67	9.67	9.00	8.67	7.67	8.93	8.33	8.33	8.67	7.67	6.33	7.87
Pusa Shubham	9.00	9.00	9.33	8.67	9.67	9.13	8.00	8.00	7.33	7.00	6.67	7.40
Urvashi	9.33	8.67	9.00	8.33	7.33	8.53	8.33	7.33	7.67	8.00	6.00	7.47
Mean	9.04	9.06	8.76	8.17	7.72		8.33	8.17	8.28	7.91	6.74	
C.D. (5%)												
T	0.47						0.42					
V	0.63						0.57					
T×V	NS						NS					

year. However, during 2nd year interaction of 20 Gy with cv. Urvashi resulted in maximum length of spike on 3rd day while minimum was recorded with interaction of 40 Gy with cv. Pusa Srijana in vase solution. Lower gamma doses induce growth of cells, resulting increase in antioxidant capacity of cells that assist in overcoming physiological, environmental temperature and light fluctuations or any stress factors during growth condition. Whereas, higher gamma doses arrest cell cycle at G2 or M phase during cell division, causing progressive oxidative damage to the entire genome (Preussa and Britta 2003). Sisodia *et al*. (2015) and Singh and Sisodia (2015) in gladiolus were also reported similar findings using gamma irradiation.

Days to withering of 5th floret

The result for days to withering of 5th floret in vase as influenced significantly by various gamma doses and varieties is presented in Table 3. Late withering of 5th floret was recorded with 20 Gy treatment during 1st year. However, during 2nd year early withering of 5th floret was recorded with 50 Gy during 2nd year. High gamma doses affect the cell division process causing structural and physiological changes in cells. This sudden change might cause stress factor inside the cells that fasten the senescence process resulting early withering of flowers (Li *et al*. 2022). Among varieties, cv. Jyotsna exhibited late opening of 5th floret which was significantly higher than other varieties during 1st year. Similar result was also obtained during 2nd year and cv. Jyotsna resulted in maximum days taken to withering of 5th floret and it was statistically higher than other varieties. Carbohydrate, soluble sugars and respiratory substances might have accumulated in stems/spikes or in petals help in quality retention in flowers and extending the longevity of flower (Vehniwal and Abbey 2019). The findings are in close conformity with the results obtained by Buanong and Kanlayanarat (2010) in *Dendrobium* orchid cv. Sonia 'Bom 17', Fjeld *et al*. (1994) in Cardinal and Madelon varieties of cut roses and Sisodia and Singh (2014) in different cultivars of gladiolus.

Days to withering of last floret

Days to withering of last floret in vase was influenced significantly due to various doses of gamma and gladiolus varieties. However, there was no significant difference due to interaction of gamma doses and varieties during both years of observation (Table 4). Gamma dose at 20 Gy resulted in late withering of last floret during 1st year and 2nd year. Maximum days to taken to withering of last floret were recorded with cv. Jyotsna which was statistically higher than other varieties during 1st year. The same cv. Jyotsna also resulted in late withering of last floret in vase during 2nd year which was at par with cvs. Pusa Vidushi and Swarnima and significant to other varieties. Increase in amount of carbohydrate production encouraged by gamma doses (Patil 2014), causing delay in ethylene production leading to delay in senescence process. Lower gamma doses exert some beneficial effect on flowering parameters subjected to keep flowers blooming for longer duration. The present findings were also in line with the results obtained by Patil (2014), Sisodia and Singh (2015) in gladiolus.

Water uptake on 3rd day

The findings with water uptake on 3rd day in vase are mentioned in Fig. 2. Maximum water uptake on 3rd day was recorded with 20 Gy treatment which was significantly higher than all the treatments during 1st year. However, during 2nd year maximum water uptake was recorded with 20 Gy followed by 30 Gy gamma dose. Among varieties, maximum water uptake on 3rd day in vase was obtained with cv. Pusa Shubham which was statistically at par

Table 4: Effect of gamma irradiation on days to withering of last floret in different Indian gladiolus varieties during post harvest studies

	I Year						II Year					
Gamma dose / Variety	**Control**	**20 Gy**	**30 Gy**	**40 Gy**	**50 Gy**	**Mean**	**Control**	**20 Gy**	**30 Gy**	**40 Gy**	**50 Gy**	**Mean**
Gulal	9.83	10.17	9.67	8.83	7.67	9.23	11.00	11.67	11.33	9.33	8.33	10.33
Jyotsna	12.50	12.50	12.67	12.17	9.50	11.87	13.50	14.50	13.33	12.83	10.17	12.87
Mohini	11.17	11.33	9.67	7.83	8.50	9.70	11.50	14.00	13.50	9.17	9.17	11.47
Pusa Kiran	11.00	10.17	9.50	8.33	8.00	9.40	12.67	10.17	11.17	9.33	8.67	10.40
Pusa Srijana	10.17	10.17	8.50	7.67	7.17	8.73	11.83	11.17	10.17	9.00	9.17	10.27
Pusa Vidushi	10.33	10.17	10.67	8.67	10.00	9.97	11.67	12.67	13.00	12.67	11.67	12.33
Swarnima	8.33	11.00	10.33	10.33	9.00	9.80	13.00	13.00	12.00	12.33	11.00	12.27
Pusa Shubham	10.33	9.67	11.00	9.33	10.00	10.07	11.00	10.67	11.33	10.00	11.00	10.80
Urvashi	10.67	9.33	10.17	10.00	8.33	9.70	12.67	11.67	10.83	10.17	9.33	10.93
Mean	10.48	10.50	10.24	9.24	8.69		12.09	12.17	11.85	10.54	9.83	
C.D. (5%)												
T	0.66						0.71					
V	0.89						0.95					
T×V	NS						NS					

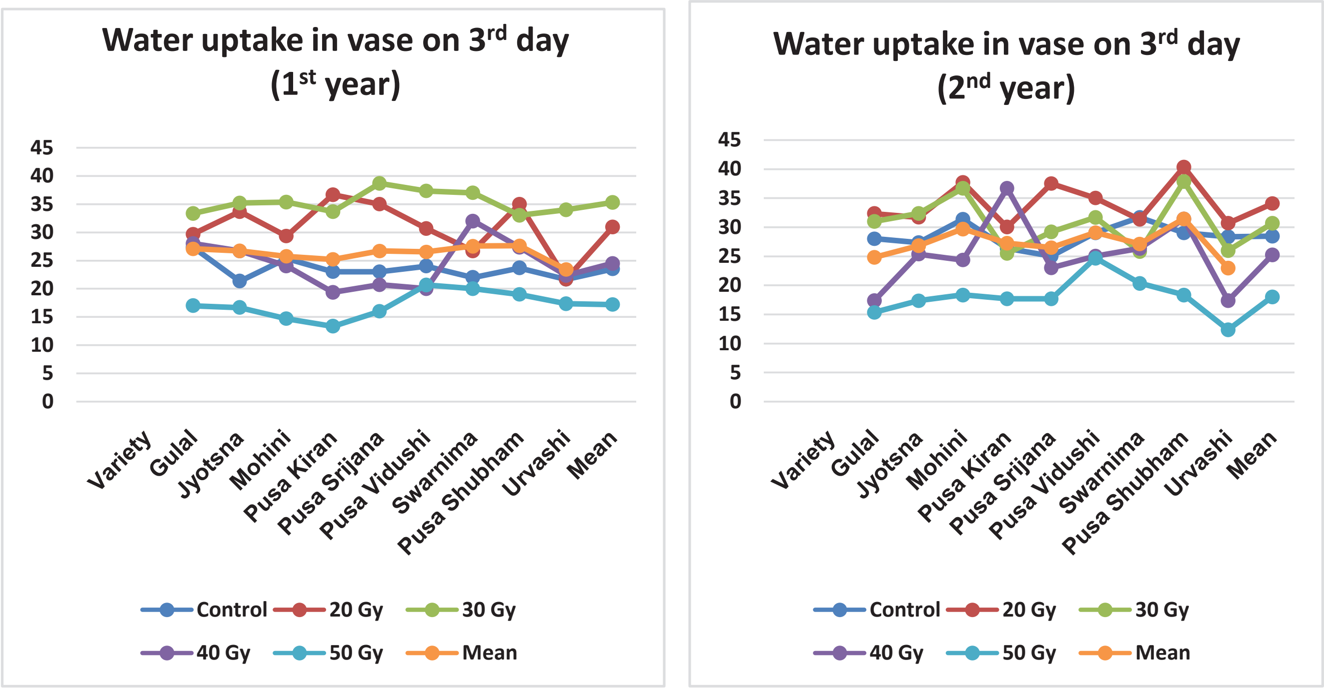

Fig. 2: Effect of gamma irradiation on water uptake on 3rd day in different gladiolus varieties during post-harvest studies

with cvs. Mohini and Pusa Vidushi during 2nd year only. Interaction of 20 Gy with cv. Pusa Shubham gave pronounced effect on water uptake on 3rd day in vase which was statistically at par with interactions of 30 Gy with cv. Pusa Shubham and 20 Gy with cv. Mohini. Lower gamma doses are found less destructive to plant cells that may not tissue collapsed or cell shrank, resulting in maximum absorption of vase water. While higher doses of gamma affect the tissues as well as optimum uptake of water (Buanong and Kanlayanarat 2010). The results are in congruence with the observations of Hayashi and Todoriki (1996) in chrysanthemum and Sisodia and Singh (2014) in gladiolus cultivars.

Morphological changes in cultivars Jyotsna, Pusa Kiran, Pusa Srijana and Pusa Vidushi due to gamma dose effect

The influence of gamma irradiation on different Indian gladiolus varieties has been manifested by investigating several morphological changes and abnormalities of the irradiated plants. Abnormalities were observed, studied and compared with parents in each gladiolus varieties in VM_1 and VM_2 generations. The effect of higher gamma doses was persistent in VM_3 and various changes were observed in growth, flowering and morphological characteristics in few cultivars of gladiolus (Plate 1). Abnormal, malformed and stunted growth of pale coloured spike with undistinguished number of florets was observed in cv. Pusa Kiran at 40 Gy gamma dose (Fig. 1). Double florets in another spike of cv. Pusa Kiran originated from a single node was observed at 50 Gy gamma dose (Fig. 1). Missing green colour and yellowing leaves were also observed in chrysanthemum cv. Donglinruixue (Wang *et al*. 2020) and in gladiolus (Mishra 1986). In treated plant of Pusa Srijana, stunted with impaired, spindle growth and sickle shape leaves were appeared at of 40 Gy gamma dose. Leaves were narrow, bent down and intermingling with each other (Fig. 2). In another plant of cv. Pusa Srijana, number of florets/spike was observed very less (only 3) when compared to untreated plants at 50 Gy gamma dose. Spike and unopened floret colour was also changed to some brown colour and lack of chlorophyll content was also observed within it (Fig. 3). In cv. Pusa Vidushi, a change in macule colour from dark purplish red to light reddish purple in cv. at same gamma treatment (Fig. 4). Similar findings were also observed by Wang *et al*. (2020) in chrysanthemum, Singh and Sisodia (2015) in gladiolus. Cultivar Jyotsna irradiated with higher gamma dose (50 Gy) detected with change in

Fig. 1: Malformed, stunted and pale coloured spike growth in cv. Pusa Kiran at 40 Gy and double florets at 50 Gy

Fig. 2: Sickle shape leaf growth at 40 Gy in cv. Pusa Srijana

Fig. 3: Malformed and pale coloured spike at 50 Gy in cv. Pusa Srijana

Fig. 4: Macule of lighter shade in cv. Pusa Vidushi at 50 Gy

Fig. 5: Irregular flower arrangment and partial opening of florets in cv. Jyotsna at 50 Gy

Fig. 6: Colour change and irregular macule in cv. Jyotsna at 50 Gy

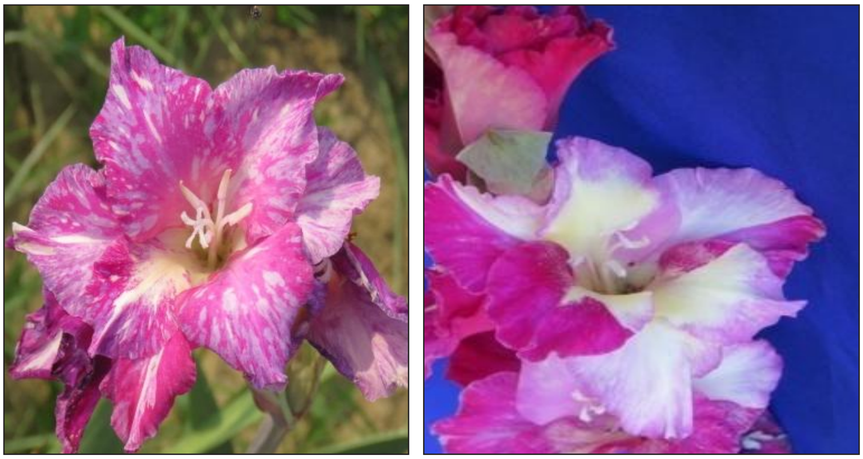

Fig. 7: Lighter colour tepals with irregular shape of floret at 50 Gy, and white coloured chimera in cv. Pusa Srijana at 40 Gy

Plate 1: Effect of gamma doses on changes in growth and flowering pattern in Indian gladiolus varieties

tepal colour from strong red (parent) to light pink. Florets were partially opened and some were not opened and withered at a time. Higher dose caused deformity in florets including floral spiralization (Fig. 5). Similar abnormalities in flowers and plant growth of chrysanthemum was also noticed by Wang *et al*. (2020). Another plant of cv. Jyotsna with deformed floret shape along with irregular, larger and broaden macule was observed at 50 Gy gamma dose (Fig. 6). In cv. Pusa Srijana, a lighter pink purplish coloured tepal with light purple streaks and irregular floret shape was observed at 50 Gy. Apart from these colour change in tepals, there was appearance of white colour chimera at same treatment in other spike of cv. Pusa Srijana. This chimeric mutant was observed with irregular shape and its one lower outer tepal and two inner tepals were of white colour which was significantly different from the parent tepal colour (Fig. 7). The abnormalities in floral organ might be due to fusion and fasciation in floral organ. Sometimes higher doses affect the cell division process, damaging the DNA and genome of plants resulting abnormalities and morphological changes in plants (Preussa and Britta 2003). Present findings are lent credence with the observation made by earlier workers. Misra (1986) irradiated gladiolus corms of cvs. Wind Song, Rose Momento, Mayur and Green Finch and observed colour variation at 1.5 kR such as colour changes in petals, chlorophyll variation in leaf and spikes. In a comprehensive study, Sisodia and Singh (2014) observed various qualitative changes floral parameters in cv. Pusa Kiran. Anomalous changes in spike growth, colour change i.e., yellow colour mutant in cv. Pusa Kiran were observed at 2.5 kR. Singh and Sisodia (2015) observed various morphological changes in the gladiolus varieties *i.e.*, Pusa Kiran, Jyotsna and Praha. In cv. Pusa Kiran, abnormal spike growth was observed at 4.5 kR dose of gamma irradiation. White colour on the tepal and pink colour stripes were developed in cv. Jyotsna at 2.5 kR. Gamma doses at 2.5 kR resulted in orientation of florets in both side of spike in cv. Praha. In Bougainvillea cv. Mahatma Gandhi, different floral and morphological abnormalities were also observed as a result of increased gamma doses (Swaroop *et al*. 2015). Desirable changes in gladiolus cv. Wild Rose was observed by Raghava *et al*. (1988). Pink colour florets was observed in VM_2 as chimera at 1 krad treatment of gamma dose while a roseine purple floret was also observed in VM_4. Various morphological changes have also been observed in rose (Arnold *et al*. 1998), chrysanthemum (Matsumura *et al*. 2010 and Wang *et al*. 2020) and lilium (Hajizadeh *et al*. 2022).

REFERENCES

Arnold, N.P., Barthakur, N.N. and Tanguay, M. 1998. Mutagenic effects of acute gamma irradiation on miniature roses: target theory approach. *Hort. Sci.*, **33**(1): 127-129.

Aslam, F., Naz, S. and Javed, S. 2016. Effect of radiation on morphological characters of different cultivars of Lilium and genetic analysis of mutants through molecular markers. *J. Anim. & Plant Sci.*, **26**(6): 1819-1827.

Buanong, M. and Kanlayanarat, S. 2010. Gamma Irradiation Causes Deterioration of Inflorescences of Dendrobium Sonia 'Bom 17'. *In*: *I International Orchid Symposium 878.* M.G. Blanchard, E.S. Runkle and Y.I. Lee (eds.). Taichung, Taiwan. Pp. 411-416.

Donà, M., Lorenzo, V., Anca, M., Massimo, C., Monica, S., Annalisa, G., Daniela, C. and Alma, B. 2013. Gamma irradiation with different dose rates induces different DNA damage responses in *Petunia* × *hybrida* cells. *J. Plant Physiology*, **170**(8): 780-787.

Fjeld, T., Gislerød, H.R., Revhaug, V. and Mortensen, L.M. 1994. Keeping quality of cut roses as affected by high supplementary irradiation. *Scientia Horticulturae* **57**(1-2): 157-164.

Hajizadeh, H.S., Mortazavi, S.N., Tohidi, F., Helvaci, H.Y.M., Alas, T. and Okatan, V. 2022. Effect of mutation induced by gamma-irradiation in ornamental plant lilium (*Lilium Longiflorum* Cv. Tresor). *Pak. J. Bot.* **54**(1): 223-230.

Hayashi, T. and Todoriki, S. 1996. Sugars prevent the detrimental effects of gamma irradiation on cut chrysanthemums. *Hort. Sci.*, **31**(1): 117-119.

Li, Y., Li C., Xiaodie Z., Liang L., Feihong F., Zihua G., Dan W. and Hao, C. 2022. Biological effects of gamma-ray radiation on tulip (*Tulipa gesneriana* L.). *Peer J.* **10***:* e12792.

Matsumura, A., Nomizu, T., Furutani, N., Hayashi, K., Minamiyama, Y. and Hase, Y. 2010. Ray florets color and shape mutants induced by 12C5+ ion beam irradiation in chrysanthemum. *Scientia Horticulturae*, **123**(4): 558-561.

Misra, R.L. 1986. Mutational studies in gladioli (*Gladiolus* L.) III. New forms as somatic mutants obtained by means of 60Co gamma rays. *South Indian Horti.*, **34**(5): 360-361.

Patil, S.D. 2014. Induction of mutation in commercial varieties of gladiolus using physical mutagen CO-60 gamma rays. *Int. J. Adv. Res. and Biolog. Sci.*, **1**(6):15-20.

Preuss, S.B. and Britta, A.B. 2003. A DNA-damage-induced cell cycle checkpoint in Arabidopsis. *Genetics* **164**(1): 323-334.

Raghava, S.P.S., Negi, S.S., Sharma, T.V.R.S. and Balkrishna, K.A.1988. Gamma ray induced mutants in gladiolus. *J. Nuclear and Agric. Biolo.*, **17**(1): 5-10.

Roychoudhury, N. 1980. Flower biology of gladiolus. *Mysore Hort. Sci.*, **20**(4): 36-38.

Schum A. 2003. Mutation breeding in ornamentals and efficient breeding method. *ActaHorticulture* 612: 47- 60.

Singh, A.K. and Sisodia, A. 2015. Effect of gamma irradiation on morphological changes, flowering and induced mutants in gladiolus. *Indian J. Horti.*, **72**(1): 84-87.

Singh, A.K. and Sisodia, A. 2017. Textbook of Floriculture and Landscaping. New India Publishing Agency, New Delhi, pp. 432.

Singh, A.K. 2014. Breeding and Biotechnology of Flowers: Vol 1, Commercial flowers. New India Publishing Agency, Pitam Pura, New Delhi, pp. 698.

Singh, A.K. 2006. Flower Crops: Cultivation and Management. New India Publishing Agency, Pitam Pura, New Delhi, pp. 147.

Sisodia, A. and Singh, A.K. 2015. Studies on gamma ray induced mutants in gladiolus. *The Indian J. Agric. Sci.*, **85**(1): 79-86.

Sisodia, A. and Singh, A.K. 2014. Influence gamma irradiation on morphological changes, post harvest life and mutagenesis in gladiolus. *Int. J. Agriculture, Environ. and Biotech.*, **7**(3): 535.

Sisodia, A., Singh, A.K. and Sisodia, V. 2015. Morphological changes and induced mutagenesis in gladiolus varieties through gamma irradiation. *Indian J. Agric. Sci.*, **85**(8): 1059-1064.

Swaroop, K. Jain, R. and Janakiram, T. 2015. Effect of different doses of gamma rays for induction of mutation in Bougainvillea cv. Mahatma Gandhi. *Indian J. Agric. Sci.*, **85**(9): 1245-1247.

Vehniwal, S.S. and Abbey, L. 2019. Cut flower vase life-influential factors, metabolism and organic formulation. *Horti. Int. J.*, **3**(6): 275-281.

Wang, L., Wu, J., Lan, F. and Gao, P. 2020. Morphological, cytological and molecular variations induced by gamma rays in 'Donglinruixue'. *Folia Horticulturae,* **32**(1): 87-96.

Wi, S.G., Chung, B.Y., Kim, J.S., Kim, J.H., Baek, M.H., Lee, J.W. and Kim, Y.S. 2007. Effects of gamma irradiation on morphological changes and biological responses in plants. *Micron.*, **38**(6): 553-564.