Indian Journal of Agricultural Sciences **85** (1): 79–86, January 2015/Article
https://doi.org/10.56093/ijas.v85i1.46003

Studies on gamma ray induced mutants in gladiolus

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Received: 21 March 2014; Revised accepted: 4 July 2014

ABSTRACT

An experiment was conducted for 2 years (2011-12 to 2012-13) at Varanasi to find out the influence of various gamma rays doses, i e 1.5, 2.5, 3.5, 4.5 and 5.5 kr along with untreated (control) in different varieties of gladiolus, *viz*. Aldebaran, Jyotsna, Legend, Praha, Punjab Dawn, Pusa Kiran and Tiger Flame. Higher dose of gamma irradiation (5.5 kr) resulted in minimum sprouting. Maximum sprouting percentage was recorded with control followed by 1.5 kr, 2.5 kr, 3.5 kr, 4.5 kr and 5.5 kr. Gamma ray doses at 3.5 kr, 4.5 kr and 5.5 kr found were lethal in case of three varieties, i e Aldebaran, Legend and Praha and failed to produce any spike during 1st year. Early spike emergence (74.37 days) was recorded with 1.5 kr dose of gamma irradiation. Late opening of 1st floret (94.00 days) was observed with 2.5 kr of gamma dose. Flower opening was not observed at higher doses, i e 3.5 kr, 4.5 kr and 5.5 kr in cv. Pusa Kiran during 2nd year. Maximum number of flowers/spike was recorded with control which was at par with lower dose of gamma irradiation (1.5 kr). Gamma dose at 2.5 kr exhibited maximum durability of 2nd and 3rd florets. Maximum length of spike at the last floret opening was noticed in control (74.48 cm) followed by 1.5 kr, 2.5 kr, 3.5 kr, 4.5 kr and 5.5 kr. During both years 2.5 kr resulted in maximum duration of flowering. Treatment 4.5 kr resulted in abnormal plant growth, bunched spike in some plants of cv. Pusa Kiran. A mutant having creamish white colour was found at 2.5 kr in one plant of cv. Jyotsna. A colour mutant was observed in cv. Tiger Flame. This colour mutant produced yellow coloured florets at 3.5 kr treatment. One mutant had been found in cv. Punjab Dawn at 2.5 kr treatment. Flowers were white in colour, whereas, flower colour of parent variety Punjab Dawn is pink. Colour of the flowers was white during VM_1 and it was found stable in VM_2.

Key words: Chimeras, Flowering, Gamma irradiation, Gladiolus

Gladiolus occupies a pristine place in the garden for its magnificent inflorescence, colours, shapes and sizes. In India, gladiolus has become the most popular commercial cut flower crop and the demand for multicoloured varieties are increasing day by day. For many years, new varieties of ornamental plants have been produced by hybridization and mutation breeding methods, separately or in combination. Ornamental plants are ideal for the application of mutation breeding because many flowering characters of economic interest (novelty, doubleness, petaloids, dwarfness, vase life) can be easily monitored after the mutagenic treatment. Mutation breeding has become a routine technique in many vegetatively propagated ornamental plants. Flower colour chimeras can arise by mutagenic treatment and depend on the type of material used and the regeneration process. In contrast to other traits, flower colour mutants can readily be recognized even if very small sectors are affected. Datta (1989) stated that the size of mutant sectors varied from narrow streaks on single petals to whole flowers after the irradiation.

Different treatments like recurrent irradiation, combined treatment, split dosage, colchicine treatment, ion beam technology, etc., have been precisely determined for successful development of new varieties (Datta 2012). The main advantage of mutation induction is that the changes can be retained through vegetative propagation. In induced mutation gamma rays have been most successfully used and many new varieties have been developed and released in different ornamentals. Therefore, present experiment was carried out to apply various gamma ray doses on different varieties of gladiolus.

MATERIALS AND METHODS

The present investigation was carried out at the Horticulture Research Farm and at the Post-harvest Laboratory of Department of Horticulture, Banaras Hindu University, Varanasi, Uttar Pradesh during 2011-2012 and 2012-2013. The experimental site lies approximately in the centre of North-Gangetic alluvial plain, on the left bank of river Ganga which is homogeneously fertile with uniform texture. Varanasi city is situated at 25^0 10' North latitude and 83^0 03' East longitudes. The site is at an altitude of 123.23 meter above the mean sea level. The climate of Varanasi is humid subtropical with large variation between summer and winter temperatures. During the experiment duration maximum temperature ranged from 14.2^0C to

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43.0^{0}C in summer and minimum temperature ranged from 7.1^{0}C to 28.1^{0}C in winter. Gladiolus corms of 7 varieties *viz*., Aldebaran, Jyotsna, Legend, Praha, Punjab Dawn, Pusa Kiran and Tiger Flame were exposed to gamma doses at 1.5 kr, 2.5 kr, 3.5 kr, 4.5 kr and 5.5 kr at National Botanical Research Institute, Lucknow. These treated corms were planted in the beds with a spacing of row to row 30 cm and corm to corm 20 cm during November 2011. The experiment was laid out in randomized block design with 5 replications. All the parameters were observed on flowering and morphological changes, i e sprouting percentage, days to spike emergence, days to opening of 1st floret, number of flowers/spike, length of spike (at last floret opening) durability of 2nd and 3rd floret (in field condition) and duration of flowering.

RESULTS AND DISCUSSION

Sprouting percentage

Sprouting percentage of corms varied due to various gamma ray doses during 1st year and 2nd year. Higher dose of gamma irradiation (5.5 kr) resulted in minimum sprouting. Sprouting improved as doses decreased. It is interesting to note that lower percentage of sprouting was recorded in all the varieties at higher doses (5.5 kr) during 1st year. Maximum sprouting percentage was recorded with control followed by 1.5 kr, 2.5 kr, 3.5 kr, 4.5 kr and 5.5 kr. Similar to 1st year maximum sprouting percentage was observed in control followed by 2.5 kr, 1.5 kr, 3.5 kr, 4.5 kr and 5.5 kr treatments during 2nd year (Fig 1). Less sprouting percentage was observed at higher dose of gamma irradiation (5.5 kr). In some varieties corms could not sprout due to lethal effect of higher dose of gamma irradiation (5.5 kr). Interaction of control with cv. Tiger Flame exhibited maximum sprouting percentage followed by control with cv. Punjab Dawn, 2.5 kr with cv. Aldebaran, control with cv. Praha and control with cv. Pusa Kiran. Whereas, 5.5 kr gamma doses with cv. Praha and 5.5 kr with cv. Punjab Dawn recorded minimum sprouting percentage during 1st year. However, during 2nd year maximum sprouting percentage was obtained in the interaction of 2.5 kr gamma dose with cv. Tiger Flame followed by 1.5 kr and cv. Jyotsna, 2.5 kr with cv. Jyotsna, 1.5 kr with cv. Tiger Flame and control with cv. Tiger Flame (Fig 1). Various levels of mutagens did not show any effect on early sprGladiolus,

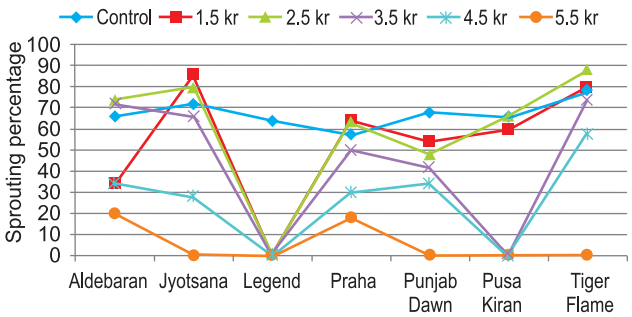

Fig 1 Sprouting percentage of gladiolus varieties as influenced by gamma doses (2nd year)

outing but physical mutagens influence the activity of enzymes. Dutta and Dutta (1953) reported that growth stimulation due to the changes in auxin level was probably due to inactivation of auxin or distruction of enzyme system (Bairagi 1969) or inhibition of mitotic activities and chromosome damage associated with secondary physical damage (Gunckel 1957). Various growth parameters increased at lower doses of gamma irradiation, whereas, they decreased as doses of gamma irradiation increased. It might be due to some enzyme activities and related to the increased activity of gibberellins and auxins and disappearance of the inhibitors.

Days to spike emergence

Days to spike emergence was influenced significantly due to gamma irradiation treatment and varieties during both the years of investigation. Gamma doses at 3.5 kr, 4.5 kr and 5.5 kr were found lethal in case of three varieties, i e Aldebaran, Legend and Praha and failed to produce any spike during 1st year. During 2nd year spike emergence was not observed in variety Legend with all the gamma doses (1.5. 2.5, 3.5 4.5 and 5.5 kr), whereas, control plant produced spike (Table 1). Similar observations were also made in the cv. Pusa Kiran at higher doses, i e 3.5 kr, 4.5 kr and 5.5 kr which failed to exert spikes. LD_{50} was noticed at higher dose of gamma irradiation (5.5 kr) in most of the varieties (Jyotsna, Legend, Punjab Dawn, Pusa Kiran and Tiger Flame) except two varieties (Aldebaran and Praha) during 2nd year. Early spike emergence (74.37 days) was recorded with 1.5 kr dose of gamma irradiation which was statistically on par with control and significant to all other treatments. At higher doses spike emergence was not observed in some varieties during 1st year. Treatment 2.5 kr resulted in late spike emergence (77.83 days). Significant effect of gamma irradiation was also observed in 2nd year. Various doses of gamma irradiation resulted in early spike emergence than control. Among the varieties cv. Tiger Flame exhibited late spike emergence which was statistically higher to all other varieties during 1st year of observation. However, during 2nd year cv. Aldebaran registered late spike emergence followed by cv. Praha, Tiger Flame, Jyotsna, Punjab Dawn, Pusa Kiran and Legend. Interaction of 4.5 kr with cv. Pusa Kiran resulted in early spike emergence which was statistically on par with the combination of 3.5 kr and cv. Pusa Kiran and significant to all other treatment combinations. In 2nd year, interaction of control with cv. Legend produced early spike emergence which was significantly earlier than all other treatment combinations. Present results were also in accordance with Cantor *et al*. (2002) who observed that gamma doses increased root and shoot length, which probably absorb more nutrient and improved photosynthesis and ultimately resulted in early spike emergence and flowering. Rather and John (2000) also studied days to floret emergence in Dutch iris. Some doses of gamma rays resulted in early floret emergence; however, difference was not significant to the control.

Table 1 Effect of gamma irradiation on days to spike emergence, days to 1st floret opening and number of flowers/spike

Variety	Year	Days to spike emergence							Days to 1st floret opening							No. of flowers/spike						
		Gamma doses (Treatment)							Gamma doses (Treatment)							Gamma doses (Treatment)						
		Control	1.5 kr	2.5 kr	3.5 kr	4.5 kr	5.5 kr	Mean	Control	1.5 kr	2.5 kr	3.5 kr	4.5 kr	5.5 kr	Mean	Control	1.5 kr	2.5 kr	3.5 kr	4.5 kr	5.5 kr	Mean
Aldebaran	I	82.20	83.60	83.20				41.50	107.20	104.00	106.00				52.87	7.60	9.20	8.00	0.00	0.00	0.00	4.13
	II	86.00	89.20	85.80	85.20	86.80	86.00	86.50	98.60	103.60	99.40	99.80	99.80	102.00	100.53	8.40	9.40	10.60	9.60	10.80	8.80	9.60
Jyotsna	I	73.80	63.60	66.20	66.00	64.20	68.00	66.97	88.40	84.80	81.40	85.60	85.40	86.40	85.33	10.60	12.20	13.60	10.20	12.20	10.40	11.53
	II	86.20	77.40	83.00	90.20	82.60		69.90	97.80	89.40	85.40	96.40	96.20		77.53	10.40	19.00	19.40	18.60	19.20	0.00	14.43
Legend	I	63.60	68.80	68.60				33.50	85.00	82.60	90.60				43.03	10.60	7.00	3.60	0.00	0.00	0.00	3.53
	II	59.20						09.87	74.80						12.46	6.60	0.00	0.00	0.00	0.00	0.00	1.10
Praha	I	86.00	85.40	99.40				45.13	97.60	103.40	108.60				51.60	8.00	8.20	11.60	0.00	0.00	0.00	4.63
	II	67.40	79.20	81.00	78.40	77.00	76.40	76.57	85.60	88.00	91.00	90.00	90.20	89.20	89.00	10.00	9.80	9.60	10.80	8.60	9.20	9.66
Punjab	I	70.60	69.80	72.00	66.00	66.20	69.20	68.97	88.20	87.60	88.00	88.60	84.80	85.60	87.13	13.20	11.00	8.60	9.00	8.20	10.40	10.06
Dawn	II	76.40	80.00	77.60	78.60	85.40		66.33	90.80	94.20	91.60	91.20	91.60		76.56	17.80	15.20	16.60	14.80	9.80	0.00	12.36
Pusa	I	66.00	65.40	72.40	64.40	59.80	66.80	65.80	84.00	83.80	84.20	85.80	79.80	86.80	84.07	10.00	9.60	9.80	9.60	9.40	5.00	8.90
Kiran	II	76.00	71.60	69.60				36.20	90.20	84.20	82.40				42.80	10.00	13.20	16.00	0.00	0.00	0.00	6.53
Tiger	I	81.00	84.00	83.00	82.20	87.00	81.80	83.17	100.80	104.60	99.20	97.60	102.80	99.00	100.67	12.80	10.80	12.20	9.80	9.00	6.40	10.16
Flame	II	92.00	90.40	87.60	93.40	86.60		75.00	104.40	102.00	98.40	104.80	99.60		84.86	17.60	15.80	15.60	12.80	10.20	0.00	12.00
Mean	I	74.74	74.37	77.83	39.80	39.60	40.82		93.03	92.97	94.00	89.40	50.40	51.11		10.40	9.71	9.62	5.51	5.54	4.60	
	II	77.60	69.68	69.22	60.83	59.77	23.20		91.74	80.20	64.26	68.88	68.20	27.31		11.54	11.77	12.54	9.51	8.37	3.14	

CD (P=0.05)	I Year	II Year	I Year	II Year	I Year	II Year
Treatments	1.74	1.53	1.44	1.50	0.76	0.96
Varieties	1.88	1.66	1.56	1.62	0.82	1.04
Treatments × Varieties	4.61	4.07	3.81	3.96	2.01	2.54

Days to opening of 1st floret

Late opening of 1st floret (94.00 days) was observed with 2.5 kr of gamma dose which was statistically on par with control and 1.5 kr of gamma dose and significant to 5.5 kr, 3.5 kr and 4.5 kr of gamma doses during 1st year. Floret opening was not observed at higher doses, i e 3.5 kr, 4.5 kr and 5.5 kr in cv. Pusa Kiran during 2nd year. Late opening of 1st floret was observed with control (91.74 days) which was statistically higher than other treatments. Various gamma doses showed significantly early opening of 1st floret than control. Significant difference on opening of 1st floret was not observed between 3.5 kr and 4.5 kr of gamma doses. Late opening of 1st floret was recorded with cv. Tiger Flame (100.66 days) followed by cv. Punjab Dawn, Jyotsna, Pusa Kiran, Aldebaran, Praha and Legend during 1st year. During 2nd year late opening of 1st floret was recorded with cv. Aldebaran (100.53 days) followed by cv. Praha, Tiger Flame, Jyotsna, Punjab Dawn, Pusa Kiran and Legend during 2nd year. Interaction among gamma irradiation treatment and varieties was found significant for both the years of investigation on days of opening of 1st floret. Earliest opening of 1st floret (79.80 days) was recorded with cv. Pusa Kiran when treated with 4.5 kr followed by cv. Pusa Kiran with 1.5 kr treatment combination. During 2nd year, interaction of gamma dose at 3.5 kr with cv. Tiger Flame resulted in late opening of 1st floret (104.80 days) followed by control with cv. Tiger Flame (104.40 days). Present findings were in agreement with that of Seilleur (1975), who irradiated corms of gladiolus and observed that corms treated with lower doses resulted in early flowering. Similar observation has also been made by Misra *et al*. (2009) who got early bud initiation in chrysanthemum when various gamma doses were applied. The present findings were also in line for days to flowering in gladiolus cv. Sylvia and Eurovision (Srivastava *et al*. 2007). They recorded early flowering with 20 Gy and 40 Gy in comparison to control on days to flowering.

Number of flowers per spike

Various doses of gamma irradiation and varieties of gladiolus gave pronounced effect on number of flowers/spike in both the years. Maximum number of flowers/spike was recorded with control which was on par with lower dose of gamma irradiation (1.5 kr). Treatments 1.5 kr and 2.5 kr were also on par during 1st year. Higher doses of gamma irradiation in general produced lesser number of flowers/spike. During 2nd year maximum number of flowers/spike was registered with 2.5 kr which was on par with 1.5 kr and significant to other gamma irradiation doses including control, whereas, these treatments were significant to the higher doses of gamma irradiation (3.5 kr, 4.5 kr and 5.5 kr). Among the cultivars, cv. Jyotsna recorded maximum number of flowers/spike (11.53), followed by cv. Tiger Flame, Punjab Dawn, Pusa Kiran, Praha, Aldebaran and Legend during 1st year. Similar to the 1st year, cultivar Jyotsna recorded maximum number of flowers/spike during 2nd year which was statistically higher than other varieties. Due to interaction of gamma doses and different varieties number of flowers/spike found significant. Interaction of 2.5 kr with cv. Jyotsna resulted in maximum number of flowers/spike during both years of investigation. In a study Venkatchalan and Jayabalan (1992) observed that the number of flowers in zinnia increased with the lower dose of gamma irradiation from 2.5 to 5 kr and decreased thereafter at higher doses of 7.5 kr to 12.5 kr. Kole and Meher (2005) observed increase in the flower number at lower doses of gamma irradiation, whereas, number of flower reduced drastically at higher dose of gamma rays in zinnia. They further observed that due to application of gamma doses percentage of double flowers increased significantly compared to control. Arnold *et al*. (1998) stated that number of petals increased with application of gamma doses in two varieties, i e Potluck and Dark Red Mountie, whereas, it decreases in other two varieties Blood Red and Mountie due to gamma doses at 50, 100 and 200 Gy. They further stated that dose response relationship often showed erratic results because gamma rays photons may miss the targets necessary to generate mutation and radio sensitivity depends on the variety.

Durability of 2nd and 3rd floret in field

Gamma dose at 2.5 kr exhibited maximum durability of 2nd floret (6.14 days) which was on par with 1.5 kr dose of gamma irradiation and significant to other treatments. Similar to the 1st year, in 2nd year, treatment 2.5 kr registered maximum durability of 2nd floret which was at par with control and significant to other treatments. During 1st year maximum durability of 3rd floret was noticed with 2.5 kr treatment (6.31 days) which was on par with 1.5 kr treatment and significant to all other treatments. In 2nd year maximum durability of 3rd floret was registered with control, however, it was statistically on par with 2.5 kr and 1.5 kr treatments. Spike emergence in variety Aldebaran was observed at 1.5 and 2.5 kr, however, their 2nd and 3rd florets were failed to open. Cultivar Punjab Dawn exhibited maximum durability of 2nd and 3rd floret which was significant to all other varieties during 1st year. However during 2nd year maximum durability of 2nd and 3rd floret was recorded with cultivar Jyotsna. Interaction of 2.5 kr with cv. Legend resulted in maximum durability of 2nd floret which was on par with treatment combinations of 5.5 kr with cv. Punjab Dawn and significant to other treatment combinations. During 2nd year interaction of 1.5 kr with cv. Jyotsna recorded maximum durability of 3rd floret which was on par with the interaction of 2.5 kr with cv. Jyotsna and statistically higher to other treatment combinations. These results were incongruence with the observations made by Singh and Kumar (2013) who reported beneficial effect on various flowering parameters due to lower dose of gamma irradiation, whereas, from 3 kr to 7 kr decreased different flowering parameters in gladiolus.

Length of spike

Significant effect was found on length of spike at last

Table 2 Effect of gamma irradiation on durability of 2nd and 3rd floret and length of spike at last floret opening

Variety	Year	Days to spike emergence							Days to 1st floret opening							No. of flowers/spike						
		Gamma doses (Treatment)							Gamma doses (Treatment)							Gamma doses (Treatment)						
		Control	1.5 kr	2.5 kr	3.5 kr	4.5 kr	5.5 kr	Mean	Control	1.5 kr	2.5 kr	3.5 kr	4.5 kr	5.5 kr	Mean	Control	1.5 kr	2.5 kr	3.5 kr	4.5 kr	5.5 kr	Mean
Aldebaran	I	2.80						0.46	3.07						0.51	64.34	70.00	68.16	0.00	0.00	0.00	33.75
	II	3.80	4.00	4.00	3.80	4.60	4.00	4.03	3.60	3.20	4.00	3.40	3.60	4.00	3.63	63.30	75.04	71.18	64.90	57.90	66.04	66.39
Jyotsna	I	3.60	6.60	5.80	5.80	5.60	4.80	5.36	3.20	6.20	6.20	6.60	5.20	4.60	5.33	100.62	82.56	76.42	80.90	82.08	60.82	80.57
	II	4.20	8.40	8.20	5.80	6.20		5.46	4.00	8.60	8.20	7.00	5.60		5.56	98.10	77.40	77.42	81.84	109.3	0.00	74.02
Legend	I	6.00	5.00	11.40				3.73	5.80	6.60	11.60				4.00	70.28	66.42	79.54	0.00	0.00	0.00	36.04
	II	5.00						0.83	5.40						0.90	62.68	0.00	0.00	0.00	0.00	0.00	10.44
Praha	I	5.00	4.20	3.80				2.16	5.20	4.60	3.60				2.23	66.98	72.10	62.22	0.00	0.00	0.00	33.55
	II	5.20	5.00	5.40	5.60	3.60	3.40	4.70	5.00	5.40	4.80	4.60	3.60	3.80	4.53	48.00	54.62	54.14	65.68	45.32	56.98	54.12
Punjab	I	5.20	8.20	9.80	5.80	6.40	9.80	7.53	5.60	8.20	9.80	5.00	7.40	10.20	7.70	70.66	66.02	58.84	52.32	51.54	52.24	58.60
Dawn	II	4.80	3.00	5.00	6.80	4.80		4.06	5.00	4.00	5.40	5.80	4.20		4.06	82.72	80.18	80.18	65.48	53.02	0.00	60.26
Pusa	I	6.60	8.40	6.00	4.40	5.60	9.00	6.67	6.60	9.00	7.20	5.20	6.60	10.40	7.50	71.90	72.00	71.34	68.42	53.14	48.42	64.20
Kiran	II	4.00	4.40	4.40				2.13	4.40	4.00	4.40	0.00			2.13	71.90	68.84	84.58	0.00	0.00	0.00	37.55
Tiger	I	5.80	7.00	6.20	4.60	4.60	4.80	5.50	6.60	7.00	5.80	4.40	5.20	4.60	5.60	76.60	62.14	70.92	71.06	66.22	34.84	63.63
Flame	II	4.80	5.40	5.60	3.80	4.40		4.00	5.40	5.60	5.20	3.60	3.80		3.93	106.04	89.82	84.80	66.34	79.76	0.00	71.12
Mean	I	5.00	5.62	6.14	2.94	3.17	4.05	5.15	5.94	6.31	3.02	3.48	4.25	5.15		74.48	70.17	69.63	38.95	36.14	28.04	
	II	4.54	4.31	4.65	3.68	3.37	1.05	4.68	4.48	4.57	3.48	2.97	1.11	4.68		76.10	63.70	64.61	49.17	49.33	17.57	
CD (P=0.05)			I Year		II Year					I Year		II Year					I Year		II Year			
Treatments			0.62		0.34					0.62		0.32					3.29		2.29			
Varieties			0.67		0.36					0.67		0.34					3.56		2.47			
Treatments × Varieties			1.65		0.90					1.66		0.84					8.72		6.06			

floret opening due to gamma irradiation. Maximum length of spike at the last floret opening was noticed in control (74.48 cm) followed by 1.5 kr, 2.5 kr, 3.5 kr, 4.5 kr and 5.5 kr. However, significant difference was not observed between control and lower dose of gamma irradiation (1.5 kr). It was found that with the increase in gamma doses there was a decrease in the length of spike. Similarly, in 2nd year, maximum length of spike was registered with control (76.10 cm) followed by 2.5 kr and 1.5 kr, whereas, higher dose (5.5 kr) was found significantly lower to other treatments. Cultivar Jyotsna registered maximum spike length in both the years of investigation. In 1st year interaction of control with cv. Jyotsna resulted in maximum length of spike followed by 1.5 kr with cv. Jyotsna, 4.5 kr with cv. Jyotsna and 3.5 kr with cv. Jyotsna. In 2nd year interaction of 4.5 kr with cv. Jyotsna recorded the maximum length of spike. In the present investigation, reduction in

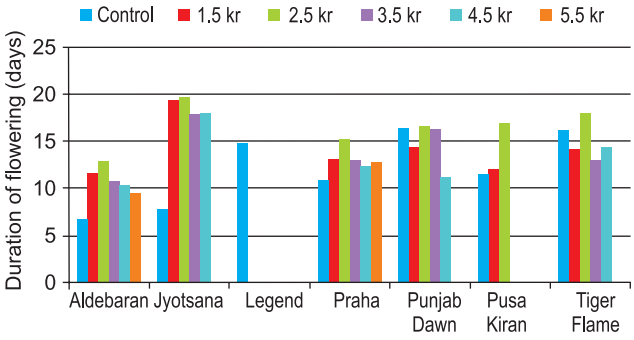

Fig 2 Effect of gamma irradiation on duration of flowering in gladiolus varieties (2nd year)

Fig 3 Abnormal with bunchy growth of spike in cv. Pusa Kiran at 4.5 kr

Fig 4 Chimera with white coloured floret in cv. Jyotsna at 2.5 kr

Fig 5 Colour mutant in cv. Tiger Flame at 3.5 kr

Fig 6 Mutant in cv. Tiger Flame at 4.5 kr

Fig 7 Control plant of cv. Punjab Dawn

Fig 8 White coloured mutant in cv. Punjab Dawn at 2.5 kr

spike length at higher doses of gamma irradiation in some varieties might be due to inactivation of auxin and probably decrease in auxin content with increased irradiation doses is responsible for it at higher doses. Banerji and Datta (2002) stated that survival of plant to maturity and reduction in height depends on the nature and extent of chromosomal damage which might have been observed in this investigation in which higher dose of gamma irradiation was not found beneficial at higher dose (5.5 kr).

Duration of flowering

It is apparent from Fig 2 that duration of flowering was influenced due to gamma irradiation treatments on different varieties of gladiolus during both the years of observations. During 1st year treatment 2.5 kr resulted in maximum duration of flowering followed by 1.5 kr, control, 5.5 kr, 3.5 kr and 4.5 kr. Different varieties showed spectacular effect on duration of flowering in gladiolus during 1st year. Cultivar Punjab Dawn registered maximum duration of flowering. Similar to the 1st year, treatment 2.5 kr gamma irradiation registered maximum duration of flowering during 2nd year (Fig 2) than all other doses of gamma irradiation including control. In 2nd year, cultivar Jyotsna recorded maximum duration of flowering followed by cultivars Praha, Tiger Flame, Punjab Dawn, Aldebaran, Pusa Kiran and Legend. These findings have lent credence to the observation made by Banerji *et al*. (1981). They observed that floret opening and flowering was influenced due to various gamma doses. They further reported that flowering completely ceased at highest doses of gamma doses when conducted a trial on *Gladiolus psittacinus* Barn Hookeri cv. Red and Orange.

Morphological changes in cultivars Pusa Kiran, Jyotsna, Tiger Flame and Punjab Dawn

In gladiolus cv. Pusa Kiran all the doses of gamma irradiation influenced plant growth and spike emergence. Short plant with much wider leaves along with abnormal growth of spike appeared in one plant at 4.5 kr gamma dose. Treatment 4.5 kr also produced lanky growth of plants. Treatment 4.5 kr resulted in abnormal plant growth, bunched spike in some plant of cv. Pusa Kiran which is more apparent in the Fig 3. In some plants of cv. Jyotsna size of florets increased than untreated plants at 2.5 kr. A mutant having creamish white coloured florets (Fig 4) was observed at 2.5 kr dose in one plant of cv. Jyotsna and on same plant one sectoral chimera was observed on the lower portion of the floret which was with two petals. A colour mutant was observed in cv. Tiger Flame. This coloured mutant produced yellow colour florets at 3.5 kr treatment (Fig 5). Another mutant was observed at 4.5 kr treatment which also produced one light yellow coloured floret, whereas, chimera was observed on basal floret (Fig 6). One mutant has been found in cv. Punjab Dawn at 2.5 kr treatment. Flowers were white in colour (Fig 8). No streaks were observed, whereas in parent plant streaks are common and flower colour of parent variety Punjab Dawn is pink (Fig 7). Colour of the flowers was white during VM_1 and it was found stable in VM_2. This mutant was isolated for further studies and its stability in coming generation. Misra (1982) detected coloured mutant in gladiolus cv. Ratna's Butterfly. The mutant has all the segments in the upper half of the floret in violet colour with lighter flakes in between. Very small orange spot was noted between the flakes and this colour mutation persisted in further generation of vegetatively propagated plants. The study was in lines with the observation of Misra (1986) who irradiated gladiolus cv. Green Finch, Mayur, Rose Momento and Wind Song. Colour variations were recorded even from lowest dose of 1.5 krad. Colour changes in petals, fusion and fascition increased floral organ, notching in the petal were recorded in all the varieties. Present findings are also lent credence to the study of Raghav *et al*. (1988) who found a desirable and stable mutant with shell pink colour florets in VM_2 generation as chimera in 1 krad treatment was isolated from the cv. Wild Rose with roseine purple floret colour in VM_4 generation.

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