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Effect of gamma rays on vegetative and floral parameters of gladiolus

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ABSTRACT

The present experiment was carried out during 2014-15 and 2015-2016 with the objective to study the morphological and floral variability in gladiolus variety 'Punjab Glance'. The experiment was conducted in Factorial Randomized complete Block Design (FRCBD) with three replications comprising 50 corms per replication. The corms of gladiolus variety 'Punjab Glance' treated with ^{60}Co gamma rays at 0, 50, 100, 125 and 150 Gy were planted in the field in Factorial Randomized Complete Block Design. The data revealed that with the increase in dose from 50 to 150 Gy, vegetative characters like survival rate, days taken to sprouting of corms, plant height, number of leaves, leaf area, corm and production were decreased. The floral characters like spike length, number of florets per spike, floret size were also reduced. The maximum survival rate (84.52 %), number of leaves (7.01) and leaf area (100.43 cm^2) were recorded in control. Minimum time taken to sprouting of corms (15.29 days) was recorded at 50 Gy, while the maximum (23.15 days) was observed with 150 Gy. The maximum plant height (95.90 cm), corms (2.11) and cormels/ plant (21.07), weight of corms (45.21 g) and cormels/ plant (8.72 g) were recorded at 50 Gy which were reduced at 150 Gy. Leaf abnormalities were recorded in terms of leaf margin and apex bud.

Keywords: *Gladiolus hybridus*, survival rate, height, leaf abnormalities.

INTRODUCTION

Gladiolus (*Gladiolus hybridus* L.) is one of the important bulbous crop, cultivated in various parts of the country. It is an important bulbous crop which occupies important position among cut flowers in domestic as well as international market. It belongs to Family Iridaceae and sub-family Ixioideae is one of the most popular ornamental bulbous plants. The genus *Gladiolus* contain more than 180 species, out of these 20 of them were used for ornamentals purpose. More than 10,000 cultivars have been developed and commercially grown all over the world. Since garden varieties of today has emerged from diverse genetic parentage that are heteroploids with chromosome number ranging from 2n = 30 to 180. The heterozygous mixture of this crop makes it a promising test material for inducing physical or chemical mutagenesis.

In the quest for diversification in agriculture production system, floriculture has emerged as a prominent and an attractive sector in view of high returns per unit area. With continuous introduction of new cultivars and even new crops, cultural techniques are changing and hence new varieties are being developed. Development of new cultivars through conventional or modern techniques has been a prime objective in commercial floriculture. The prequisite for development of variability for novel colour, earliness in flowering, number of flowers, plant architecture, productivity, keeping quality and resistance to abiotic and biotic stresses are the main attributes. Mutation breeding has become a routine technique in many vegetative propagated ornamental plants. It offers great potentialities as the mutated part can be conveniently perpetuated by vegetative means resulting in the development of new forms. Mutation is induced by using radiations and other mutagens like EMS, acridine dyes has successfully commercialized a large number of new varieties in different crops including ornamentals plants Datta (1). Flower colour chimeras can arise by mutagenic treatment and depend on the type of material used and the regeneration process. 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. In general higher doses were found to be lethal and doses from 0.5 to 5.0 krad are advisable for the gamma irradiation in gladiolus (Singh, 11). Thus the present study was conducted to ascertain the effect of different doses of gamma rays on vegetative, floral and corm production and to induce mutants for vegetative and ornamental traits.

MATERIALS AND METHODS

The present investigation was carried out in two successive years during 2014-15 and 2015-16

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at experimental farm Punjab Agricultural University Ludhiana, Punjab. The geographical location of PAU is at 30º 54' North (latitude) and 75 º 48 East (longitude) at the height of 247 m above the sea level. Uniform size (4cm) and healthy corms of gladiolus variety 'Punjab Glance' were irradiated with different doses (0,50,100,125, 150 Gy) of gamma rays at College Orchard, Department of Fruit Science, Punjab Agricultural University, Ludhiana using gamma rays Low Dose Irradiator 2000 ANSI-N 433.1. These corms were planted in the field with in 24 hrs of treatment with spacing 30 × 20 cm. The experiment was laid out in Randomized Block Design with three replications. Observations were recorded on survival rate (%), plant height (cm), days taken to sprouting, number of leaves, leaf area (cm^2), spike length, floret size, and number of florets per spike, total days to flowering, corm and cormels per plant and weight of corm and cormels per plant, leaf abnormalities in both years. During 1st and 2nd years pooled data for all the parameters were statistical analysis was performed using SAS and treatment means were compared using Duncan Multiple Range Test, Duncan (3).

RESULTS AND DISCUSSION

It is evident from the data presented in Table 1 that gamma irradiation significantly reduced the survival rate and sprouting percent. The results showed that survival rate was maximum in control (84.52 %) followed by 50 Gy (81.93 %) and 100 Gy (62.61%). The value was recorded to be the minimum under 48.17 % at 125 Gy and decreased as the doses were increased up to 150 Gy (42.10 %). Maximum survival per cent was noticed in second year (68.43 %) and in first year (59.44 %). As per the results of interaction between gamma rays treatment and year it has been recorded that maximum survival per cent was found under control (86.74 %) in second year followed by 83.66 % at 50 Gy. As the doses were increased from 50 to 150 Gy, the survival per cent also decreased. Minimum survival rate was at 150 Gy 37.47 % in first year and (43.94 %) in second year. This revealed that higher doses of gamma rays are detrimental for irradiation of gladiolus corms. Survival rate at higher doses might attribute to genetic loss due to chromosomal aberrations and gene mutation. The lower levels of mutagens are themselves not responsible for stimulating sprouting but the substances such as enzymes that are set free by irradiation and low doses causes stimulations as the enzymes play pivotal role in plant metabolism. Srivastava and Singh (14) and Dobanda (2) noted similar results in different cultivars of gladiolus when treated with gamma radiation at very low level like 20 Gy to very high level of 1250 Gy.

Table 1. Effect of gamma irradiation on different vegetative characters of 'Punjab Glance' variety of gladiolus.

Doses of gamma rays (Gy)	Survival Rate (%)			Days taken to sprouting			Plant height (cm)			Number of leaves			Leaf area (cm^2)			Leaf abnormalities
	2014-15	2015-16	Mean	2014-15	2015-16	Mean	2014-15	2015-16	Mean	2014-15	2015-16	Mean	2014-15	2015-16	Mean	Leaf margin and apex
0 (Control)	98.09 (82.29)	99.75 (86.74)	98.92 (84.52)^{a}	15.35	15.97	15.66^{d}	93.04	94.48	93.76^{b}	7.00	7.02	7.01^{a}	92.10	109.16	100.43^{a}	Straight, pointed
50	96.88 (80.19)	98.41 (83.66)	97.64 (81.93)^{a}	15.11	15.48	15.29^{e}	95.31	96.50	95.90^{a}	6.51	6.80	6.65^{a}	94.86	101.32	98.09^{b}	Straight, pointed
100	63.90 (54.19)	91.08 (73.68)	77.49 (62.61)^{b}	19.72	20.21	19.96^{c}	83.05	86.22	84.63^{b}	6.57	6.70	6.63^{ab}	40.85	54.04	47.45^{c}	Slightly curved
125	46.86 (43.10)	65.62 (54.18)	56.24 (48.17)^{c}	20.51	20.79	20.65^{b}	41.86	43.12	42.49^{c}	6.27	6.62	6.44^{b}	28.08	32.73	30.41^{d}	Curved
150	37.20 (37.47)	48.20 (43.94)	42.70 (42.10)^{d}	20.89	25.42	23.15^{a}	31.39	33.05	32.22^{d}	5.33	5.41	5.36^{c}	14.51	17.50	16.00^{e}	Fully curved
Mean	68.58 (59.44)^{b}	80.61 (68.43)^{a}	74.59 (63.93)	18.31^{b}	19.57^{a}	18.94	69.17^{b}	70.43^{a}	69.80	6.33^{b}	6.51^{a}	6.42	54.08^{b}	62.95^{a}	66.67	
LSD $^{(p=0.05)}$	A = 2.33; B =1.47; A × B = 3.30			A = 1.05; B = 0.66; A × B = 1.49			A = 2.67; B = 1.69; A × B= 3.78			A = 0.28; B = 0.20; A × B= NS			A = 2.70; B = 1.90; A × B= 3.67			

*Figures in parenthesis are arc sine transformed value A = Treatments, B = Year.

Minimum days to sprouting were taken by 15.29 days at 50 Gy and it was statistically at par with control (15.66 days). Days were increased as the doses were increased up to 150 Gy (23.15 days). Out of two years minimum days were taken to sprouting of corms was noticed in first year (18.31 days). It was (19.57 days) in second year. The effect of interaction between gamma rays treatment and years on days taken to sprouting of corms was also significant. The minimum time was taken to sprouting of corms by 50 Gy 15.11 days in first year followed by 15.35 days under control in first year. As the doses were increased from 50 to 150 Gy, the time of sprouting of corms also increased. The more number of days was taken to sprouting at 150 Gy (25.42 days) in second year. The significant decrease in time to sprouting at higher level of gamma rays may be due to low level of mutagens which might responsible for stimulating sprouting substances such as enzymes those were set free by irradiation and played an important role in plant metabolic activities resulting in stimulated plant growth. The enzymes those were set free by irradiations at low doses caused stimulation of sprouting which played pivotal role in plant metabolism as reported by (Srivastava *et al.*, 15) in gladiolus

Maximum plant height was observed in 50 Gy (95.90 cm) followed by control (93.76 cm) and 100 Gy (84.63 cm) and decreased as the doses were increased up to 150 Gy (32.22 cm). Out of two years maximum plant height was noticed in second year (70.43 cm). It was 69.17 cm in first year. The effect of interaction between gamma rays treatment and years indicate that maximum plant height (96.50 cm) was found at 50 Gy in second year which is followed by 95.31 cm in first year at 50 Gy. It was decreased as the doses of gamma rays increased and recorded at 150 Gy (31.39 cm). It was observed from present trial that plant growth in terms of plant height was effected significantly due to to gamma ray treatments. The plants treated at higher dose resulted in poor growth due to physiological, morphological and cytological disturbance caused by ionizing radiations. Reduction in growth following mutagenic treatments was explained due to auxin destruction and inhibition of auxin synthesis (Gorden, 4). Gamma irradiation are ionizing radiation and interact with atoms and molecules to produce free radicals in cell and these radicals damage or modify important components of cells and affect the morphology, physiology of plants depending upon irradiation levels (Wi *et al.*, 17). Tiwari *et al.* (16) irradiated four cultivars of gladiolus using gamma rays and observed significant increase in plant height at lower doses.

Number of leaves was maximum in control (7.01) followed by 50 Gy (6.65) and 100 Gy (6.63) and decreased as the doses were increased up to 150 Gy (5.36). Out of two years maximum number of leaves was noticed in second year (6.51). It was 6.33 in first year but it also exhibited non-significant effect on number of leaves. The results of interaction between gamma rays and years are presented in reveals that maximum number of leaves was observed (7.02) in control followed by 7.00 in first year. As the doses were increased from 50 to 150 Gy, number of leaves was also decreased. It exhibited non-significant effect on leaf number. Reduction in vegetative growth due to changes in auxin level or due to inactivation of auxin was hypothesized by (Tiwari *et al.*, 16) in gladiolus. These results are in conformity with the work of (Misra and Bajpai, 7; Patil and Dhaduk, 10) in gladiolus.

Maximum (100.43 cm²) leaf area was recorded in untreated corms which were at par with treated corms (98.09 cm²) at 50 Gy. The minimum area was observed 16.00 cm² at 150 Gy. Out of two years maximum leaf area was noticed in second year (62.95 cm²). It was 54.08 cm^2 in first year. The results of interaction between gamma rays treatment and years reveal that maximum (109.16 cm²) leaf area was observed in untreated corms in second year. The leaf area was decreased as the dose of gamma rays increased to 150 Gy (14.51 cm²) in first year. The reduction in leaf area in terms of length and width of plants treated with higher doses of gamma rays may be due to inactivation or decrease in auxin content or disturbances in auxin synthesis. Similar results of reduction in leaf area were also reported in gladiolus by Kumari *et al.* (6).

The effect of different doses of gamma rays treatment and years are presented in Table 2. Minimum days to flowering were assumed in corms treated at 0 Gy (89.62 days) which was followed by 95.37 days at 50 Gy. The maximum days to flowering 119.54 days was observed at higher doses of gamma rays i.e. 150 Gy. Out of two years, minimum time to flowering was noticed in first year (103.62 days). It was 105.38 days in second year. The results of interaction between gamma rays treatment and years indicated that earlier flowering (88.93 days) was observed in untreated corms during first year which were followed by 0 Gy (90.32 days) in second year. The days for flowering were increased as the dose of gamma rays increased to 150 Gy (119.98 days) in second year. In general there was decrease in days to flowering with increased dose of gamma rays. Delay in flowering might be due to disturbances in biochemical pathway, which assists in synthesis of flower significantly at 5 KR treatment in various varieties used in their rays on zinnia. These

Table 2. Effect of gamma irradiation on different floral characters of 'Punjab Glance' variety of gladiolus.

Doses of gamma rays (Gy)	Total days to flowering (days)			Spike Length (cm)			Floret size (cm)			Number of florets/ spike		
	2014-15	2015-16	Mean	2014-15	2015-16	Mean	2014-15	2015-16	Mean	2014-15	2015-16	Mean
0 (Control)	88.93	90.32	89.62^{c}	74.82	77.24	76.03^{b}	9.03	9.12	9.07^{ab}	11.13	13.05	12.09^{b}
50	94.23	96.51	95.37^{c}	77.80	81.23	79.52^{a}	10.84	10.97	10.90^{a}	12.33	14.98	13.65^{a}
100	100.81	102.01	101.41^{bc}	65.40	65.68	65.54^{c}	8.67	8.75	8.71^{b}	9.49	11.43	10.46^{c}
125	115.01	118.09	116.55^{ab}	31.33	32.10	31.71^{d}	4.00	4.07	4.03^{b}	4.58	4.93	4.76^{d}
150	119.11	119.98	119.54^{a}	20.95	22.12	21.53^{e}	3.02	3.34	3.18^{b}	3.31	3.44	3.37^{e}
Mean	103.62^{b}	105.38^{a}	104.50	54.12^{b}	55.62^{a}	54.86	7.11^{b}	7.24^{a}	7.17	8.28^{b}	9.44^{a}	8.86
LSD $^{(p=0.05)}$	A = 12.73; B = 8.05; A × B= NS			A = 1.95; B = 1.23; A × C= 2.90			A = 2.83; B = 1.79; A × B = NS			A = 0.69; B = 0.48; A × B=1.09		

A = Treatments, B = Year.

results are in conformity with the observations made by (Singh and Kumar, 15) who reported beneficial effect of lower doses of gamma rays.

The longest (79.52 cm) spikes were assumed in corms treated with 50 Gy which was at par with untreated corms (76.03 cm) and 100 Gy (65.54 cm). The shortest spike length was observed (21.53 cm) at 150 Gy. Out of two years, longest spike was noticed in second year (55.62 cm). It was 54.12 cm in first year. The results of interaction between gamma rays treatment and years indicated that Longest spike length (81.23 cm) was observed in corms treated with 50 Gy in second year which were at par with (77.80 cm).The length of spike was decreased as the dose of gamma rays increased to 150 Gy (20.95 cm) in second year. Higher doses effect of gamma irradiation was more pronounced which resulted in smaller spike length and reduced flower size. This might be due to reduction in plant growth. These results are in close conformity with the findings of Misra and Bajpai (7) and Patil and Dhaduk (10).

Maximum floret size (10.90 cm) was assumed at 50 Gy which was at par with untreated corms (9.07 cm) and 100 Gy (8.71 cm). Minimum floret size was observed (3.18 cm) at 150 Gy. Out of two years, maximum floret size was noticed in second year (7.24 cm). It was 7.11 cm in first year. The results of interaction between gamma ray and years indicates that maximum floret size (10.97 cm) was observed in 50 Gy during second year which were followed by (10.84 cm) at 50 Gy in first year. Floret size was decreased as the dose of gamma rays increased to 150 Gy (3.02 cm). There is no significant difference between floret size and gamma rays. In general, higher doses of gamma rays decrease floret size drastically. Decrease in flower size at higher doses of gamma rays treated was also reported by Singh *et al.* (12) in African marigold.

Maximum (13.65) number of floret was recorded in corms treated with 50 Gy which was at par with untreated corms (12.09) and 100 Gy (10.46). The number of florets per spike was decreased (3.37) as the doses of gamma ray increased up to 150 Gy. Out of two years, maximum number of florets per spike was observed in second year (9.44) which was at par with first year (8.28). The effect of interaction between gamma rays treatment and years revelas that maximum number of florets (14.98) at 50 Gy followed by 13.05 in corms treated with 0 Gy in second year. Number of florets was decreased as the dose of gamma rays increased to 150 Gy (3.31) in first year. In general, there was drastic reduction in floret number at highest dose of gamma rays as compared to control. The radiation reduced floret number and affected adversely may be because of auxin destruction, irregular auxin synthesis, failure of assimilation, mechanisms or inhibition of mitotic and chromosomal changes or damage with association of secondary physiological damage. Patil (8) noticed that lower dose of gamma irradiation found beneficial in improving some floral parameters and higher dose found injurious for most of the flowering parameters in gladiolus.

The effect of different doses of gamma rays treatment and years on corm production is presented in Table 3. Maximum number of corms (2.11) was found at 50 Gy which was at par with control (1.88) and 100 Gy (1.70). Minimum number of corms was observed at 150 Gy (1.07) per plant. Out of two years, maximum number of corms was noticed in second year (1.63) and it was 1.54 in first year. The results of interaction between gamma rays treatment and years reveals that maximum number of corms (2.15) was observed at 50 Gy during second year which was at par with (2.07) in first year. The corm number decreased as the dose of gamma rays

Table 3. Effect of gamma irradiation on corm and cormels production in 'Punjab Glance' variety of gladiolus.

Doses of gamma rays (Gy)	Corms/plant			Cormels/plant			Weight of Corm/plant (g)			Weight of cormels/plant (g)		
	2014-15	2015-16	Mean	2014-15	2015-16	Mean	2014-15	2015-16	Mean	2014-15	2015-16	Mean
0 (Control)	1.86	1.90	1.88[b]	18.76	18.81	18.78[b]	42.43	42.80	42.61[b]	8.28	8.56	8.42[b]
50	2.07	2.15	2.11[a]	21.01	21.12	21.07[a]	44.65	45.77	45.21[a]	8.67	8.78	8.72[a]
100	1.61	1.79	1.70[c]	17.6	17.92	17.76[b]	39.30	40.16	39.73[c]	7.16	7.07	7.11[c]
125	1.15	1.22	1.18[d]	13.83	14.33	14.08[c]	35.27	36.14	35.70[d]	6.50	6.73	6.61[d]
150	1.05	1.09	1.07[d]	11.64	12.10	11.87[d]	25.11	25.74	25.43[e]	6.00	6.13	6.06[e]
Mean	1.54 [b]	1.63 [a]	1.58	16.57 [b]	16.85 [a]	16.71	37.35 [b]	38.12 [a]	37.73	7.27 [b]	7.50 [a]	7.38
LSD [(p=0.05)]	A = 0.13; B = 0.09; A × B = NS			A = 0.79 ;B = 0.56; A × B = 1.25			A = 1.10; B = 0.77; A × B = 1.74			A = 0.23;B = 0.14; A × B = 0.33		

A = Treatments, B = Year.

increased to 150 Gy (1.05) during first year. It is evident that at higher doses of gamma rays number of corms reduced significantly. The changes in number of corms per plant may be attributed to the fact that due to irradiation treatment at higher dose and physiology of the plant was disturbed which affected photosynthesis and root system resulting in the improper growth of the plants by hampering root system thus adversely affected corm number. Tiwari *et al*. (16) reported that decrease in corm number in gladiolus plant after irradiation.

Maximum number of cormel (21.07) was found at 50 Gy which was at par with control (18.78) and 100Gy (17.76). Minimum number of cormels were observed (11.87) at 150 Gy. Out of two years, maximum number of cormels was noticed in second year (16.85) as compared to first year (16.57).The results of interaction between gamma rays treatment and years indicate that maximum number of cormels (21.12) was observed at 50 Gy in second year which were at par with (21.01) at 50 Gy during first year. Cormel number was decreased as the dose of gamma rays increased to 150 Gy (11.64). In the present investigation the reduction in number of cormels may be attributed due to the fact that due to treatment damage, physiology of the plant in higher doses was disturbed which affected photosynthesis and root system resulting in the improper growth of plant. Similar results were found by Kumari and Kumar (5) who reported that within increase in dose the cormels per plant were reduced.

Maximum weight of corm (45.21 g) was found at 50 Gy which was at par with control (42.61 g) and 100 Gy (39.73 g). Minimum weight was observed (25.43 g) at 150 Gy. Out of two years, maximum weight of corm was noticed in second year (38.12 g). It was 37.35 g in first year. The results of interaction between gamma rays treatment and years indicate that maximum weight of corms (45.77 g) was observed at 50 Gy in the second year which was at par with (44.65g) in first year. Corm weight was decreased as the dose of gamma rays increased to 150 Gy (25.11 g). In general there was decrease in weight of corms per plant which is related with decrease in number of corms. The reduction in vegetative growth at higher dose failed in translocation of photosynthates to the storage oragan. These results were also substantiating the findings of Patil (9).

Maximum weight of cormels (8.72 g) was found at 50 Gy which was at par with control (8.42 g) and 100 Gy (7.11 g). Minimum weight was observed (6.06 g) at 150 Gy. Out of two years, maximum weight of cormels was noticed in second year (7.50 g). It was 7.27g in first year. The results of interaction between gamma rays treatment and years reveals that maximum weight of cormels (8.78 g) was observed at 50 Gy in second year which were at par with (8.67g) in first year. As the doses were increased from 50 to 150 Gy, weight of cormels was decreased it was assumed as (6.00 g) at 150 Gy. Weight of cormels per plant decreased with higher radiation dose. The decrease in cormel weight might be due to the reduction in leaf number and size as well as hampered growth of roots due to pronounced effect of higher dose. These results substantiate the findings of Patil (9) and Tiwari *et al.* (16) who reported that increase the dose, weight of cormels per plant was decreased.

The results showed that higher doses leaf apex and margins become fully curved in 'Punjab Glance' variety. As per the results of the Table 1 in variety 'Punjab Glance' the leaf margin and apex was straight and pointed at 0 and 50 Gy. However, at 100 Gy it was slightly curved and highly curved at 125 Gy. As the doses of gamma rays increased to 150 Gy leathery leaves, wavy and stunted growth of leaves were observed which thickened and bending towards soil at

150 Gy. Different types of morphological abnormalities like changes in apex and margin, fusion were detected at higher doses of gamma rays. It is clear that abnormal leaves at lower doses were bigger in size as compared with those produced at higher dose.

On the basis of findings, it may be concluded that considerable mutation was noted through gamma radiation in vegetative and floral characters of gladiolus and the characters like leaf shape and leaf apex showed high variability and best results were obtained at 50 and 100 Gy doses and higher doses were lethal for the vegetative and floral variability in gladiolus.

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