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Research Article

EFFECT OF GAMMA IRRADIATION ON GROWTH AND CORM PRODUCTION OF *Gladiolus hybridus* L.

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Abstract- The demand of gladiolus is increasing day by day; therefore, it needs attention towards genetic improvement of gladiolus. It is known that frequency and spectrum of mutations differ somewhat depending upon the mutagen used and the dose applied. The corms of gladiolus variety 'Punjab Glance' were irradiated with different doses (0, 50,100,125,150 Gy) of gamma rays. The experiment was laid out in Randomized Block Design with 3 replications and data were pooled for statistical analysis. Plant height and number of leaves were reduced after irradiation as compared to untreated plants and was recorded minimum at highest dose (150 Gy). The corm treated with lowest dose at 50 Gy sprouted after 13.72 days and more time was taken by highest dose 20.67 days. The corm multiplication in terms of corm number per corm and cormels per corm was recorded that it was reduce with increased dose of gamma rays. Corms per corm (1.09) and 16.39 cormel per corm at 150 Gy. The leaf abnormalities in terms of changes in leaf shape, leaf size, leaf margin and leaf apex were observed.

Keywords- Gladiolus, gamma rays, Plant height, leaf abnormalities, leaf length and survival rate.

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Introduction

Floriculture has been identified as the fast-emerging sector and is now branded as an industry in domestic as well as export market. 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. Mutation is a method by which novelty can be created in an already well-established cultivar. The use of induced mutations through irradiation and chemical agents has played a major role in the development of superior crop varieties Datta, [6]. There is no visual difference between artificially produced or induced mutants and spontaneous mutants found in nature Broertjes, [5]. *Gladiolus* belonging 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. But the frequency and spectrum of mutations differ somewhat depending upon mutagen used and dose applied. The physical mutagens are widely used and have the advantage of good penetration and precise dosimetry in ornamentals Micke and Donini, [15]. Ornamental plants are ideal for the application of mutation induction techniques because many characters of economic interest, i.e. flower traits novelty, doubleness, dwarfness, vase life, leaf variegation, biotic and abiotic resistance) are easily monitored after the mutagenic treatment.

Mutation breeding has a unqiue 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. 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, [25]. Thus, the present study was conducted to ascertain the effect of different doses of gamma rays on vegetative and corm production in gladiolus variety 'Punjab Glance'.

Materials and Methods

The present investigation was carried out in two successive years during 2014-15 and 2015-16 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 x 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), 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 [7].

Result and Discussion

Growth parameters:

To study the effect of different gamma rays treatments on growth of plants, observations on different parameters like survival rate (%), days taken to sprouting of corms, plant height, number of leaves, leaf length and leaf width were recorded. Results pertaining to these parameters are presented in [Table-1] and discussed

as under:

Survival rate [%]

It is evident from the data presented in [Table-1] that gamma irradiation significantly reduced the survival rate. The results showed that survival rate (%) was maximum in control (86.31 %) followed by 50 Gy (82.41 %). The per cent survival was 54.69 % at 125 Gy and 43.94 % at 150 Gy. Significant variation in the growth rate was observed in both the varieties under experiment. The maximum survival rate was 71.54 % in Second year. It was 64.92 % in first year. The result of interaction between gamma rays treatment and years indicate that maximum survival was recorded in second year (89.96 %) under control which was followed by 50 Gy (83.79 %) in the second year. The results indicate that the percent survival decrease with the increase in doses of gamma rays. It was recorded as minimum 41.76 % at 150 Gy in first year.

This indicates 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. Growth stimulation due to the changes in auxin level was probably due to inactivation of auxin or distruction of enzymes system reported by Datta and Datta [6] and Bairagi, [2] or inhibition of mitotic activities and chromosome damage associated with secondary physical damage Gunckel [11]. 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. These results are in parallel line of work reported by Misra [16] who stated that higher doses of gamma radiations adversely affect sprouting in *cv.* 'Oscar'.

Table-1 *Effect of gamma irradiation on different growth parameters of gladiolus variety 'Punjab Glance'*

Doses of gamma rays (Gy)	Survival Rate (%)			Days taken to sprouting			Plant height (cm)			Number of leaves			Leaf length (cm)			Leaf width (cm)		
	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	2014-15	2015-16	Mean
0	98.16 (82.67)	100.00 (89.96)	99.08 [a] (86.31)	13.85	14.17	14.01 [d]	96.43	98.00	97.21 [b]	7.00	7.05	7.02 [a]	73.00	75.00	73.50 [a]	2.07	2.48	2.27 [a]
50	97.33 (81.03)	98.83 (83.79)	98.08 [b] (82.41)	13.48	13.97	13.72 [e]	98.02	99.50	98.76 [a]	6.66	6.95	6.78 [b]	71.52	74.89	73.20 [b]	2.22	2.27	2.24 [b]
100	85.81 (68.01)	96.66 (79.62)	91.23 [c] (73.81)	15.67	16.30	15.98 [c]	85.50	85.81	85.65 [c]	6.60	6.90	6.77 [c]	54.49	57.78	56.13 [c]	1.26	1.70	1.48 [c]
125	60.66 (51.13)	72.23 (58.25)	66.49 [d] (54.69)	15.89	16.35	16.12 [b]	58.91	60.66	59.78 [d]	6.50	6.81	6.65 [d]	41.47	42.51	41.99 [d]	1.23	1.30	1.26 [d]
150	44.41 (41.76)	52.00 (46.12)	48.20 [e] (43.94)	16.45	24.89	20.67 [a]	42.00	44.41	43.20 [e]	5.33	5.34	5.33 [e]	23.77	26.14	24.95 [e]	1.03	1.24	1.13 [e]
Mean	77.27 (64.92)	83.96 (71.54)	80.61 (68.23)	15.06	17.13	16.10	76.65	77.19	76.92	6.41	6.61	6.51	52.85	55.26	53.95	1.56	1.79	1.68
F-test	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Figures in parenthesis are arc sine transformed values

*Mean values in each column with the same letter are not significantly different at $p < 0.05$ according to DMRT

Days to sprouting of corms (Days)

It is evident from the results of gamma rays treatment on corms resulted in earlier sprouting of corms. The minimum time taken for sprouting of corms was 13.72 days at 50 Gy followed by control 14.01 days. The days were increased as the doses were increased up to 150 Gy 20.67 days. Out of two years minimum time were taken for sprouting of corms was noticed in first year (15.06 days). The results of interaction between gamma rays treatment and years indicates that the minimum days taken to sprouting 13.48 days in 50 Gy which is followed by (13.85 days) control during the first year. More days were taken by 150 Gy (17.13 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 is responsible for stimulating sprouting substances such as enzymes which are set free by irradiation and play an important role in plant metabolic activities resulting in stimulated plant growth. At lower doses certain plant chemical substances are produced Sax, [24] which enhanced sprouting and germination and above the optimum level these chemicals may form certain toxic substances Grabowska and Mynett, [10] which may cause death of the cells, ultimately forcing the plant to die. These results are in parallel line of work reported by Pandey and Gaur [18] recorded that cormels of *cv.* 'Scarlet' irradiated with the low dose generally exhibited slight earliness in sprouting because of increase in O_2 uptake, stimulation of alpha-amylase enzyme prior to sprouting and a rise in sugar content. The higher doses delayed sprouting, by decreased O_2 uptake and inhibited alpha-amylase activity although it induced a slight rise in sugar content. The enzymes that are set free by irradiations at low doses causes stimulation of sprouting which play pivotal role in plant metabolism as reported by Srivastava *et al*, [26] in gladiolus

Plant height (cm)

The results showed significant effect of gamma rays treatment on plant height. The highest plant height was assumed in corms treated with 50 Gy (98.76 cm) which was at par with untreated corms (97.21 cm). The lowest plant height was found at 150 Gy (43.20 cm). Out of two years maximum plant height was noticed in second year (77.19 cm). The data of interaction among gamma rays treatment and years reveals that maximum plant height was found in second year (99.50 cm) in 50 Gy which was followed by (98.02 cm) in first year at 50 Gy. Plant height was decreased as the dose of gamma rays treatment was increased to 150 Gy. Minimum plant height was observed (42.00 cm) in first year.

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 (8] and chromosomal aberration Gunkel and Sparrow [12].These results are also in accordance with the findings of Patil and Dhaduk [23] who recorded reduction in plant height at higher gamma rays doses. Tiwari *et al* [28] irradiated four cultivars of gladiolus using gamma rays and observed significant increase in plant height at lower doses.

Number of leaves

The results showed that number of leaves was maximum in control (7.02) followed by 50 Gy (6.78) and 100 Gy (6.77) and decreased as the doses were increased up to 150 Gy (5.33). Out of two years maximum number of leaves was noticed in second year (6.61). The data of interaction reveals that among gamma rays treatment and years, maximum leaf number was found in second year in control (7.05) which was at par with 7.00. Number of leaves decreased as the dose of gamma rays was increased to 150 Gy. Minimum leaf number was observed in '(5.33) in first year.

This significant reduction might be due to poor growth of plant due to radiation damage which could be due to physiological, morphological and cytological disturbance caused by ionizing radiations. 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 Gorden [9]. Raghava *et al* [22] also reported reduction in leaf number in gladiolus varieties after 5, 10 and 15 Krad gamma rays treatment.

Leaf Length (cm)

The results showed significant effect of gamma rays treatment on leaf length. The maximum (73.50 cm) leaf length was recorded in untreated corms which were followed by treated corms (73.20 cm) at 50 Gy. The minimum length of leaf was observed 24.95 cm at 150 Gy. Out of two years maximum leaf length was noticed in second year 55.26 cm. The effect of interaction reveals that among gamma rays treatment and years maximum leaf length was found (75.00 cm) during the second year in control which was at par with 50 Gy (74.89 cm) in second year. Leaf length was decreased as the dose of gamma rays were increased to 150 Gy (23.77 cm) in first year.

There was greater reduction in leaf length with increasing dosage of gamma rays. This significant reduction might be due to poor growth of plant due to irradiation. Banerji *et al* [4] had also reported reduction in leaf length after irradiation of gladiolus corms with higher doses of gamma rays.

Leaf width (cm)

The results showed significant effect of gamma rays treatment on leaf width. The maximum (2.27 cm) leaf width was assumed in untreated corms which were at par with treated corms (2.24 cm) at 50 Gy. The minimum width of leaf was observed 1.13 cm at 150 Gy. Out of two years, maximum leaf width was noticed in second year 1.79cm. The results of interaction reveals that among gamma rays treatment and years maximum leaf width was found (2.48 cm) during the second year in control. Leaf width was decreased as the dose of gamma rays were increased to 150 Gy (1.03 cm) in first year.

The reduction in leaf width is due to radiation damage which could be due to physiological, morphological and cytological disturbances caused by ionizing radiations. Raghava *et al* [22] also reported reduction in leaf width in gladiolus varieties after 5, 10 and 15 Krad gamma rays treatment.

Leaf and floral abnormalities:

The leaf abnormalities and leaf size also increased with the increase dose. In gladiolus different types of leaf abnormalities like change in leaf shape and size, margins, apex, fission and fusion were recorded after irradiation with gamma rays. The leaf abnormalities in irradiated corms may be due to chromosomal aberrations, disturbance in the production and/or distribution of growth substances, breakdown of phosphate metabolism and accumulation of free amino acids Gunckel and Sparrow, [12].

Corm production parameters

Effect of different doses of gamma rays treatment on various parameters of corms viz. corms per plant, cormels per plant, weight of corms per plant, weight of cormels per plant and corm size. The results obtained in respect of these factors are presented in [Table-2] and discussed as under:

Table-2 *Effect of gamma irradiation on corm and cormels production in gladiolus variety 'Punjab Glance'*

Doses of gamma rays (Gy)	Corms/ plant			Cormels/ plant			Weight of Corm / plant (g)			Weight of cormels/ plant (g)			Corm Size (cm)		
	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
0	1.88	1.96	1.92^{b}	28.76	28.83	28.79^{b}	51.12	51.49	51.30^{b}	9.37	9.81	9.59^{a}	4.93	4.95	4.94^{b}
50	2.12	2.27	2.19^{a}	33.12	33.30	33.21^{a}	55.04	56.36	55.70^{a}	9.78	9.93	9.85^{a}	5.26	5.37	5.31^{a}
100	1.62	1.88	1.75^{b}	27.31	27.81	27.56^{c}	47.24	48.24	47.74^{c}	7.74	7.20	7.47^{b}	4.65	4.71	4.68^{c}
125	1.19	1.25	1.22^{c}	20.15	21.07	20.61^{d}	39.70	41.08	40.39^{d}	6.95	6.58	6.76^{c}	4.59	4.64	4.61^{d}
150	1.07	1.11	1.09^{c}	15.96	16.82	16.39^{e}	25.55	26.25	25.90^{e}	6.42	6.51	6.46^{c}	4.25	4.36	4.30^{e}
Mean	1.57	1.69	1.63	25.06	25.56	25.31	43.73	44.68	44.20	7.87	8.18	8.02	4.73	4.80	4.76
F-test	*	*	*	*	*	*	*	*	*	*	*	*			

`Mean values in each column with the same letter are not significantly different at p < 0.05 according to DMRT

Corm per plant

The results showed significant effect of gamma rays treatment on number of corms. Maximum number of corms (2.19) was found at 50 Gy which was at par with control (1.92) and 100 Gy (1.75). However, the corm number was minimum (1.09) at 150 Gy treatment. Out of two Year, maximum number of corms was noticed 1.69 in second year. The effect of interaction reveals that among gamma rays treatment and years maximum corms per plant (2.27) was found in second year at 50 Gy which was followed by (2.12) in first year at 50 Gy. Corm number decreased as the dose of gamma rays was increased to 150 Gy that is minimum number of corms was observed in (1.07) 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 (Grabowska and Mynett [10]. Tiwari *et al* [28] and Misra and Mahesh, [17] reported that decrease in corm number in gladiolus plant after irradiation.

Cormels per plant

The results showed significant effect of gamma rays treatment on number of cormel. Maximum number of cormel (33.21) was found at 50 Gy which was at par with control (28.79) and 100 Gy (27.56). Minimum number of cormel was observed (16.39) at 150 Gy. Out of two years, maximum number of cormels was noticed in second year (25.56).The data of interaction reveals that among gamma rays treatment and years maximum cormel per corm (33.30) was found in second year at 50 Gy which was at par with 33.12 at 50 Gy in first year. And the results indicate that it was followed by (28.83) in second year at 0 Gy. Cormel number was decreased as the dose of gamma rays were increased to 150 Gy that is minimum number of cormels was observed in (15.96) in first year.

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. Kumari and Kumar [14] who reported that within increase in dose the cormels per plant were reduced.

Weight of Corms per plant

The results showed significant effect of gamma rays treatment on weight of corms. Maximum weight of corm (55.70 g) was found at 50 Gy which was at par with control (51.30 g) and 100 Gy (47.74 g). Minimum weight was observed (25.90 g) at 150 Gy. Out of two years, maximum weight of corms was noticed in second year (44.68 g). The data of interaction reveals that among gamma rays treatment and years maximum weight of corms (56.36 g) was found during the second year at 50 Gy which was at par with (55.04 g) at 50 Gy in first year followed by (51.49 g) in second year at 0 Gy. Weight of corms were decreased as the dose of gamma rays were increased to 150 Gy that is minimum weight was observed in (25.55 g) in first year.

The reduction in vegetative growth at higher dose failed in translocation of photosynthates to the storage organ. Reduction in corm weight after irradiation was also reported by Banerji [4]. Talukdar [27] reported that weight of corm varied among different varieties of gladiolus. These results were also substantiating the findings of Patil [20].

Weight of Cormels per plant

The results showed significant effect of gamma rays treatment on weight of cormels. Maximum weight of cormels (9.85 g) was found at 50 Gy which was at par with control (9.59 g) and 100 Gy (7.47 g). Minimum cormels weight was observed (6.46 g) at 150 Gy. Out of two years, maximum weight of cormels was noticed in second year (8.18 g).The data of interaction reveals that among gamma rays treatment and years maximum weight of cormels (9.93 g) was found in the second year at 50 Gy which was at par with (9.81 g) at control followed by (9.78 g)

in first year at 50 Gy. Weight of cormels was decreased as the dose of gamma rays were increased to 150 Gy that is minimum weight was observed in (6.42 g) in first year.

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. Isaev*et al* [13] recorded that decrease in number and size of newly formed cormelets on prolonged irradiation of gladiolus corms. Tiwari *et al* [28] who reported that increase the dose weight of cormels per plant was decreased.

Corm size (cm)

The results showed significant effect of gamma rays treatment on size of corm. Maximum size of corm (5.31 cm) was found at 50 Gy which was at par with control (4.94 cm) and 100 Gy (4.68 cm). Minimum size of corm was observed at 150 Gy (4.30 cm). Out of two years, maximum size of corm was noticed in second year (4.80 cm).

The data of interaction among gamma rays treatment and years reveals that maximum size of corm was found in (5.37 cm) second year followed by (5.26 cm) in first year at 50 Gy. Size of corm decreased as the dose of gamma rays was increased to 150 Gy that is minimum size was observed in (4.25 cm) in first year.

The decrease in yield at higher dose might be due to the reduced vegetative growth as a result of gamma treatments. Reduction in corm diameter after irradiation was also reported by Banerji [4] in gladiolus cultivar 'White Friendship' when the corms are exposed to gamma rays treatment. Enlargement and improvement in size of corm due to application of gamma irradiation was noticed by Jun, [11] in Saffron. Reduction in corm size was also recorded by Banerji *et al* [3] in gladiolus cultivars 'Kajal' and 'Nilofar. At higher doses of gamma rays more production and bigger size of corms were obtained while higher doses resulted in smaller sized corms than control in Tuberose Ali, [1]

Conclusion

On the basis of present observation, it may be concluded that 50 Gy dose of gamma rays are suitable for induction of somatic mutation in gladiolus. The induction of somatic colour mutations in the gamma irradiated plant material may be ascribed to the chromosomal aberrations, breakdown of phosphate metabolities, accumulation of free amino acids and changes in the gene sequences etc. however, the radio-sensitivity of the *cvs.* is dependent upon the genotypes Gordon, [9], Gunckle and Sparrow, [12]. The reduction in production of corm and cormels production could be because of ill-effects of treatments as it hampered root system and cessation of growth of the axillary buds present on the corm by the inactivation of enzymes and hormones. If the doses are too high too many plants will be killed because mutagens can have direct negative effects on plant tissue and many mutations can be lethal. This is due to the fact that primary injuries are retardation or inhibition of cell division, cell death affects the growth rate, habit and changes plant morphology.

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Abbreviations:

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