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Effect of gamma rays on growth parameters of bougainvillea varieties in vM_1 generation

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Abstract
An investigation was carried out to study the effect of gamma rays on growth parameters of bougainvillea varieties in vM_1 generation. The experiment was laid out in Factorial Completely Randomized Design with four replications with two factors *viz*., Factor A consist of six levels of gamma rays' treatments i.e., control (No irradiation), 0.25 kR, 0.75 kR, 1.25 kR, 1.75 kR and 2.0 kR. Factor B consist of three varieties i.e., Shubhra (White colour flowers), Partha (Pink colour flowers) and Lady Mary Baring (Orange colour flowers). The irradiation treatment of gamma rays to cuttings of different varieties showed reduction in growth parameters like sprouting and survival percentage, plant height, branches per plant, length of main branch and length of sub-branch. The findings also showed that gradual reduction in values of growth parameters with each increased gamma-irradiation dose.

Keywords: Gamma rays, growth parameters, bougainvillea varieties, vM_1 generation

Introduction
Bougainvillea is one of the most popular ornamental shrub, sometimes climber having versatile nature of growth and flowering pattern. Due to their wonderful blossoms, that bloom several times throughout the whole year, bougainvillea species are considered as attractive plant. Bougainvillea was first collected by Commerson, a French Botanist, from Rio -de-Janeiro, Brazil, and was named after the famous French naviogator Louis Antoine de Bougainville. It has originate in the tropical and sub-tropical South America. It is the tree brightly coloured petels like bracts which give beauty to bougainvillea.
It belongs to the family Nyctaginaceae have arisen from pure base species *Bougainvillea spectaville*, *Bougainvillea glabra*, *Bougainvillea choisy* and *Bougainvillea peruviana*. The colour of bracts are innumertable, ranging from magenta to red, pink, purple, yellow and white. In India the Bougainvillea grows best in Bangalore, Mysore, Pune, Nagpur, Jabalpur, Gwalior, Madras, Hyderabad, Calcutta, Lucknow, Kanpur, Allahabad, Aligarh, Agra, Chandigarh, Patiala, Jaipur, Udaipur and Delhi. It is found growing both as a wild as well as a cultivated garden plant in south America, in places like Brazil, Colombia, Ecuador and Peru etc.
Bougainvillea is now comes in a wide range of beautiful patterns. There is a constant need for unique varieties in today's industrialized horticulture. There are several plant breeding methods used in bougainvillea, such as hybridization, polyploidy, mutation, and bud sports, for producing novel varieties by genetic modification.
Mutation breeding, one key technique for increasing variability in flower crops, which also shortens the duration taken for creating a new variety (Kannan *et al*., 2002) [12]. In view of the above the present investigation have been conducted to assess the effect of gamma rays on growth parameters of bougainvillea varieties in vM_1 generation.

Materials and Methods
The experiment was conducted at Maharaj bagh nursery, Horticulture Section, College of Agriculture, Nagpur, Maharashtra during July, 2020-2021. The experimental materials consist of 13-15 centimetres long stem cuttings collected from middle portion of one-year-old shoots. While preparing the cuttings a smooth slanting cut in each cutting was given one centimetre above the upper node (distal end) and another smooth straight cut was given one centimetre below the lower node (proximal end). The cuttings were treated with the different doses of gamma rays (Cobalt-60) at the Bhaba Atomic Research Centre, Trombay, Mumbai, Maharashtra, India, using gamma rays machine Blood irradiator-2000 during July 2020.

In this experiment cuttings of three varieties (Shubhra, Partha, Lady Mary Baring) were taken to expose the gamma doses (0.25 kR, 0.75 kR, 1.25 kR, 1.75 kR, 2.0 kR gamma rays). Untreated cuttings of bougainvillea were taken as control. The gamma rays treated cuttings along with the control were planted in polybags (6" x 8") containing media i.e., soil + FYM + sand (2:1:1) by making a hole at the centre then cuttings were buried in the media in such a way that two third basal part of all the cuttings was kept under the soil while planting and the soil around cuttings were pressed firmly and kept under shade for rooting. Different morphological parameters observations were recorded during the experiment.

Results and Discussion

Effect of irradiation doses

Sprouting percentage

Data presentd in the Table 1 revealed that, increase in the dose of gamma irradiation from 0 to 2.0 kR gamma rays resulted reduction in the sprouting percentage. At 30 days after planting irradiation doses recorded significant differences. The highest sprouting percentage (84.17%) was recorded in treatment T_1 (Control). Among the irradiated treatments, the maximum sprouting percentage (78.50%) was recorded in the treatment T_2 (0.25 kR). However, the minimum of sprouting percentage (30.83%) was recorded in the treatment T_6 (2.00 kR). Higher doses of gamma radiation can lead to a decrease in sprouting, either because of a drop in auxin levels or because of an increase in chromosome aberrations (Sparrow, 1961) [15]. This has been seen in chrysanthemum Patil (2015) [14], Swaroop *et al*., (2015) [16] and Anitha *et al*., (2017) [1] in bougainvillea and Ghosh *et al*., (2018) [9] in Jasmine.

Survival percentage

Data regarding survival percentage as influenced by different irradiation doses are presented in Table 1 and showed the significant differences in vM_1 generation. At 120 DAP, maximum survival percentage (89.60%) was recorded in the treatment T_1 (Control). Among the irradiated treatments, maximum survival percentage (74.13%) was recorded in the treatment T_2 (0.25 kR) which was at par with (72.21%) treatment T_3 (0.75 kR). Whereas, minimum survival percentage (38.50%) was recorded in the treatment T_6 (2.00 kR).

Gamma rays have been shown to have a negative effect on survival after being exposed to them. This is because gamma rays can inactivate and/or reduce the amount of a hormone called auxin that helps cells divide. This can lead to poor growth and survival (Mahure *et al*., 2010) [13]. Gamma rays can also have a lethal effect if they cause chromosomal aberrations (Banerji and Datta, 1990, Dilta *et al*., 2003) [2, 6].

Plant height

The height of the plant is very important in terms of growth characteristics as well as flowering quality. The data on the height of the plant (cm) was recorded at 60 days, 90 days and 120 days after planting in the vM_1 generation according to Table 2.

Irradiation doses were observed at 60, 90, and 120 DAP. The maximum plant height (38.72 cm) was recorded in the treatment T_2 (0.25 kR) which was at par with the treatment T_1, Control (37.64 cm) and the minimum plant height (14.07 cm) was recorded in the treatment T_6 (2.00 kR). At 60 DAP, maximum plant height (51.27 cm) was recorded in treatment T_2 (0.25 kR) which was at par with the treatment T_1, Control (51.18 cm) and the minimum plant height (18.33 cm) was recorded in the treatment T_6 (2.00 kR). At 120 DAP, highest plant height (65.94 cm) was recorded in the treatment T_1 (Control). Among the irradiated treatments, the maximum plant height (65.04 cm) was recorded in the treatment T_2 (0.25 kR). However, minimum plant height (25.61 cm) was recorded in the treatment T_6 (2.00 kR).

This study looked at the height of plants at different growth stages and found that the height decreased as the gamma rays dose increased. Higher doses of gamma rays cause more harm to the plant's genetic structure, so the higher the dose, the lower the height. A similar research work had been documented by Jayanthi *et al.*, (1999) [11], Swaroop *et al*., (2015) [16] in bougainvillea. Dwivedi *et al*., (2009) [8] in perennial chrysanthemum.

Branches per plant

The data regarding branches per plant as influenced by different irradiation doses was recorded at 60, 90 and 120 days after planting in vM_1 generation and presented in Table 3. At 60 90 and 120 days after planting irradiation doses recorded significant differences. The maximum branches per plant (1.53) was recorded in the treatment T_1 (Control) and T_2 (0.25 kR) which was at par with (1.48) the treatment T_3, (0.75 kR). The minimum branches per plant (1.13) were recorded in the treatment T_6 (2.00 kR). At 90 days after planting, highest branches per plant (2.51) was recorded in the treatment T_1 (Control). Among the irradiated treatments the maximum branches per plant (2.28) was recorded in the treatment T_2 (0.25 kR). The minimum branches per plant (1.32) were recorded in the treatment T_6 (2.00 kR). At 120 days after planting irradiation doses recorded significant differences. The highest branches per plant (3.25) was recorded in the treatment T_1 (Control). Among the irradiated treatments the maximum branches per plant (3.00) was recorded in the treatment T_2 (0.25 kR). The minimum branches per plant (1.97) were recorded in the treatment T_6 (2.00 kR).

Basically, the framework of a plant is made up of how many shoots the plant develops, and this directly affects the leaves of the plant. Consequently, the decreased number of branches associated with a higher dosage of gamma rays may be due to the inhibitory effects of a higher dose of the mutagen on the plant's growth. These results on number of branches per plant are in close conformity with the results reported by Datta and Gupta (1980) [5] in chrysanthemum.

Length of main branch

The data regarding length of main branch as influenced by different irradiation doses and was recorded at 60, 90 and 120 days after planting in vM_1 generation and presented in Table 4.

At 60, 90 and 120 DAP, irradiation doses recorded significant differences. The maximum length of main branch (25.13 cm) was recorded in the treatment T_2 (0.25 kR) which was at par with the treatment T_1, Control (24.17 cm). The minimum length of main branch (3.40 cm) was recorded in the treatment T_6 (2.00 kR). At 90 DAP, maximum length of main branch (40.00 cm) was recorded in the treatment T_2 (0.25 kR) which was at par with the treatment T_1, Control (39.77 cm) and minimum length of main branch (6.87 cm) was recorded in the treatment T_6 (2.00 kR). At 120 DAP, maximum length

of main branch (55.41 cm) was recorded in the treatment T_2 (0.25 kR) which was at par with the treatment T_1, Control (55.39 cm) and minimum length of main branch (11.07 cm) was recorded in the treatment T_6 (2.00 kR). The same trend in length of main branch was reported by Swaroop *et al.* (2015) [16]

Length of sub-branch

The data regarding length of sub-branch as influenced by different irradiation doses was recorded at 120 days after planting in vM_1 generation and presented in Table 4.

The highest length of sub-branch (37.01 cm) was recorded in the treatment T_2 (0.25 kR) which was at par with the treatment T_1, Control (36.33 cm) and minimum length of sub-branch (6.77 cm) was recorded in the treatment T_6 (2.00 kR).

Effect of varieties

Sprouting percentage

Data regarding sprouting percentage as influenced by varieties are presented in Table 1 and showed the significant differences in vM_1 generation.

The observation recorded at 30 DAP; variety Lady Mary Baring (V_3) recorded significantly maximum sprouting percentage (58.00%). However, minimum sprouting percentage (55.17%) was recorded in the variety Shubhra (V_1). The similar results were also found by Datta and Banerji (1997) in four double bracted bougainvillea cultivars and Gupta and Shukla (1974) in nine cultivars of bougainvillea.

Survival percentage

Data regarding survival percentage as influenced by varieties are presented in Table 1 and showed the significant differences in vM_1 generation.

The results revealed that, varieties had a significant influence on survival percentage**.** The observation recorded at 120 DAP, variety Lady Mary Baring (V_3) recorded significantly maximum survival percentage (66.31%). However, minimum survival percentage (60.21%) was recorded in the variety Shubhra (V_1).

This may be attributed to the fact that higher doses of mutagens cause more cellular damage and generate more adverse reactions at higher doses.Similar findings were also reported in bougainvillea by Swaroop *et al*., (2015) [16] and K. Anitha *et al*., (2017) [1].

Plant height

Data regarding plant height as influenced by varieties are presented in Table 2 and showed the significant differences among the various growth stages in vM_1 generation.

The observation recorded at 60 days after planting, variety Lady Mary Baring (V_3) recorded significantly maximum plant height (28.23 cm), whereas, minimum plant height (23.46 cm) was recorded in the variety Shubhra (V_1). At 90 days after planting, variety Lady Mary Baring (V_3) recorded significantly maximum plant height (38.25 cm), whereas, minimum plant height (32.41 cm) was recorded in the variety Shubhra (V_1). At 120 days after planting, variety Lady Mary Baring (V_3) recorded significantly maximum plant height (50.08 cm), whereas, minimum plant height (43.57 cm) was recorded in the variety Shubhra (V_1).

Branches per plant

Data regarding branches per plant as influenced by varieties are presented in Table 3 and showed the significant differences among the various growth stages in vM_1 generation.

The observations recorded at 60 DAP, variety Lady Mary Baring (V_3) recorded significantly maximum branches per plant (1.45) which was at par with Partha (V_2) variety (1.37). However, minimum branches per plant (1.34) were recorded in the variety Shubhra (V_1).

At 90 DAP, variety Lady Mary Baring(V_3) recorded significantly maximum branches per plant (1.93) which was at par with Partha (V_2) variety (1.89). However, minimum branches per plant (1.80) were recorded in the variety Shubhra (V_1).

At 120 DAP, variety Lady Mary Baring (V_3) recorded significantly maximum branches per plant (2.70) which was at par with Partha (V_2) variety (2.61). However, minimum branches per plant (2.56) were recorded in variety Shubhra (V_1).

These results on number of branches per plant are in close conformity with the results reported by Banerji and Datta (2002a) [3] and Dilta *et al*., (2006) [7] in chrysanthemum.

Length of main branch

Data regarding length of main branch as influenced by varieties are presented in Table 4 and showed the significant differences among various growth stages in vM_1 generation.

The observations recorded at 30 DAP, variety Shubhra (V_1) noticed significantly maximum length of main branch (4.72 cm). However, minimum length of main branch (3.73 cm) was recorded in the variety Partha (V_2).

At 60 DAP, variety Lady Mary Baring (V_3) recorded significantly maximum length of main branch (16.68 cm). However, minimum length of main branch (11.76 cm) was recorded in the variety Shubhra (V_1).

At 90 DAP, variety Lady Mary Baring (V_3) recorded significantly maximum length of main branch (27.42 cm). However, minimum length of main branch (21.44 cm) was recorded in the variety Shubhra (V_1), whereas at 120 DAP, variety Lady Mary Baring (V_3) recorded significantly maximum length of main branch (37.40 cm). However, minimum length of main branch (31.04 cm) was recorded in the variety Partha (V_2).

Length of sub-branch

Data regarding length of sub-branch as influenced by varieties are presented in Table 4 and showed the significant differences.

The observation recorded at 120 days after planting, variety Lady Mary Baring (V_3) recorded significantly maximum length of sub-branch (24.76 cm). However, minimum length of sub-branch (18.90 cm) was recorded in the variety Shubhra (V_1). The same trend in length of sub-branch was reported by Swaroop *et al*., (2015) [16].

Interaction effect

The data presented in Table 1,2,3 and 4 revealed that, interaction effect of irradiation doses and varieties on growth parameters of bougainvillea was found non- significant at various growth stages in vM_1 generation.

Table 1: Effect of gamma rays on survival and sprouting percentage of bougainvillea varieties in vM_1 generation

Treatments	Sprouting percentage (%)	Survival percentage (%)
	30 DAP	120 DAP
	vM_1 generation	vM_1 generation
A. Irradiation doses		
T_1 - Control (No irradiation)	84.17 (66.78)	89.60 (71.67)
T_2 - 0.25 kR gamma rays	78.50 (62.51)	74.13 (59.53)
T_3 - 0.75 kR gamma rays	61.50 (51.70)	70.21 (57.07)
T_4 - 1.25 kR gamma rays	43.50 (41.24)	56.38 (48.71)
T_5 - 1.75 kR gamma rays	36.83 (37.34)	49.19 (44.53)
T_6 - 2.0 kR gamma rays	30.83 (33.68)	38.50 (38.30)
F test	Sig	Sig
SE(m)±	1.22	1.90
CD at 5%	3.47	5.40
B. Varieties		
V_1 – Shubhra	55.17 (48.33)	60.21(51.47)
V_2 – Partha	54.50 (47.89)	62.49 (52.97)
V_3 – Lady Mary Baring	58.00 (50.40)	66.31 (55.47)
F test	Sig	Sig
SE(m)±	0.86	1.34
CD at 5%	2.45	3.82
Interaction		
F test	NS	NS
SE(m)±	2.12	3.29
CD at 5%	-	-

Table 2: Effect of gamma rays on plant height of bougainvillea varieties in vM_1 generation

Treatments	Plant height (cm)		
	60 DAP	90 DAP	120 DAP
A. Irradiation doses			
T_1 - Control (No irradiation)	37.64	51.18	64.94
T_2 - 0.25 kR gamma rays	38.72	51.27	65.04
T_3 - 0.75 kR gamma rays	29.71	40.10	53.66
T_4 - 1.25 kR gamma rays	19.31	27.91	39.57
T_5 - 1.75 kR gamma rays	16.05	22.57	31.28
T_6 - 2.0 kR gamma rays	14.07	18.33	25.61
F test	Sig	Sig	Sig
SE(m)±	0.42	0.46	0.50
CD at 5%	1.18	1.30	1.41
B. Varieties			
V_1 – Shubhra	23.46	32.41	43.57
V_2 – Partha	26.06	35.02	46.40
V_3 – Lady Mary Baring	28.23	38.25	50.08
F test	Sig	Sig	Sig
SE(m)±	0.29	0.32	0.35
CD at 5%	0.83	0.92	1.00
Interaction			
F test	NS	NS	NS
SE(m)±	0.72	0.79	0.86
CD at 5%	-	-	-

Table 3: Effect of gamma rays on branches per plant of bougainvillea varieties in vM_1 generation

Treatments	Branches per plant		
	60 DAP	90 DAP	120 DAP
A. Irradiation doses			
T_1 - Control (No irradiation)	1.53	2.51	3.25
T_2 - 0.25 kR gamma rays	1.53	2.28	3.00
T_3 - 0.75 kR gamma rays	1.48	1.93	2.71
T_4 - 1.25 kR gamma rays	1.32	1.70	2.53
T_5 - 1.75 kR gamma rays	1.34	1.49	2.28
T_6 - 2.0 kR gamma rays	1.13	1.32	1.97
F test	Sig	Sig	Sig
SE(m)±	0.05	0.05	0.05
CD at 5%	0.13	0.14	0.13
B. Varieties			
V_1 – Shubhra	1.34	1.80	2.56

V_2 – Partha	1.37	1.89	2.61
V_3 – Lady Mary Baring	1.45	1.93	2.70
F test	Sig	Sig	Sig
SE(m)±	0.03	0.04	0.03
CD at 5%	0.09	0.10	0.10
Interaction			
F test	NS	NS	NS
SE(m)±	0.08	0.09	0.08
CD at 5%	-	-	-

Table 4: Effect of gamma rays on length of main branch and length of sub-branch of bougainvillea varieties in vM_1 generation

Treatments	Length of main branch (cm)			Length of sub-branch (cm)
	60 DAP	120 DAP	120 DAP	120 DAP
A. Irradiation doses				
T_1 - Control (No irradiation)	24.17	39.77	55.39	36.33
T_2 - 0.25 kR gamma rays	25.13	40.00	55.41	37.01
T_3 - 0.75 kR gamma rays	16.17	29.73	41.14	26.88
T_4 - 1.25 kR gamma rays	9.67	17.51	24.78	14.46
T_5 - 1.75 kR gamma rays	6.40	12.11	16.73	9.01
T_6 - 2.0 kR gamma rays	3.40	6.87	11.07	6.77
F test	Sig	Sig	Sig	Sig
SE(m)±	0.45	0.74	0.81	0.70
CD at 5%	1.28	2.09	2.30	1.97
B. Varieties				
V_1 – Shubhra	11.76	21.44	31.04	18.90
V_2 – Partha	14.03	24.13	33.82	21.57
V_3 – Lady Mary Baring	16.68	27.42	37.40	24.76
F test	Sig	Sig	Sig	Sig
SE(m)±	0.32	0.52	0.57	0.50
CD at 5%	0.90	1.48	1.62	1.40
Interaction				
F test	NS	NS	NS	NS
SE(m)±	0.78	1.27	1.4	1.20
CD at 5%	-	-	-	-

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