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Effect of Gamma Radiation and Oryzalin Treatment on the Survival and Growth of Balsam (*Impatiens balsamina*)

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ABSTRACT: The present study was conducted at Horticulture Research Farm, Banaras Hindu University, Varanasi with a view to evaluate the effect of doses of gamma radiation (35 kR and 40 kR from ^{60}Co source) and oryzalin (50 µmol, 100 µmol and 150 µmol) on the survival and growth of balsam (*Impatiens balsamina*). The experiment was conducted on 29 selected genotypes of balsam. Experiment was laid out in a Randomized Block Design with three replications. It was observed that survival of BDR-2 and BSV-11 was significantly increased over untreated control among all other genotypes. The maximum survival percentage of genotypes was observed with genotypes treated with low dose of gamma *i.e.* 35 kR (50.92 and 55.75 during M_1 and M_2 generation) while low survival was observed with high dose of oryzalin *i.e.* 150 µmol (41.86 and 53.01 during M_1 and M_2 generation). Five parameters were taken into the consideration to estimate the overall growth of balsam *i.e.* number of primary branches per plant, fresh weight of leaves (g), number of leaves per plant, diameter of stem (mm) and height of plant (cm). It was noted that genotypes *viz.*, BDR-1, BDV-1, BS-39, BS-14, BS-23, BSW-7 etc. showed positive response to the treatments in terms of number of primary branches per plant during both consecutive years of experiment. Similarly, BSW-7 along with few other also showed positive correlation with the treatments in terms of plant height (cm) and fresh weight of leaves (g). The genotype BDR-4 had also represented the results in equal manner in terms of stem diameter (mm). The maximum growth during M_1 and M_2 generation observed with treatment of 50 µmol (13.01 and 13.60 in terms of number of primary branches), 50 µmol and 40kR (0.54 and 0.96 in terms of fresh weight (g) of leaf), 35kR and 50 µmol (503.42 and 476.72 in terms of number of leaves), 50 µmol (23.17 and 23.32 in terms of diameter (mm) of stem), 50 µmol and 35kR (74.18 and 97.22 in terms of height (cm) of plant). Moreover, it was observed that all the genotypes showed positive response to the treatments except in terms of survival where the decreasing trend was observed with increasing doses of the treatments.

Keywords: Gamma Radiation, oryzalin treatment, *Impatiens balsamina.*

INTRODUCTION

Balsam (*Impatiens balsamina*) popularly known as *Gulmehdhi* is a annul flowering plant that belongs to the family Balsaminaceae. It is commonly known as touch me not, Balsam, Jewel Weed and Rose Balsam. It is profusely found in tropical and subtropical Southern and Southeast Asia in India, Malaysia and China and is also introduced into Southern Europe and Turkey. Balsam is a short duration, free flowering, and half hardy and compact plant. Balsam is also having medicinal or aromatic properties. This plant is ideal for beds and also grown in mixed borders along walks. The dwarf varieties are suitable for pot plants. Commonly used method for the propagation of garden balsam is seeds. The edible parts of balsam plant are namely young shoot and leaves, seeds (Kunkel, 1984) and the flowers (Paul, 2011). Balsam seed oil can be used as anti-parasitic drugs to expel *Pheretima posthuma* vitro (Jalapure *et al*. 2007). Seed oil can be used in surface-coating industry, burning lamps and for cooling purpose. There are various methods which are widely used in varietal developmental program. Other than hybridization, mutation also creates variation in internal and external traits of genotype. Mutation is a natural process which creates changes in DNA sequences. The genetic variation created by the mutants is useful because it helps population to survive positively by coping up with the changing climatic conditions. Induced mutation with gamma irradiation and chemical mutagens in ornamental plants have been used for genetic changes (Cantor *et al*., 2002). Gamma rays are known to influence plant growth and development by inducing cytological, genetic, biochemical, physiological and morphogenetic changes in cells and tissues (Abdullah *et al*., 2009). The rate of spontaneous mutations in nature is very low. Both physical and chemical mutagens can be used to induce mutations in crop plants. Various workers adopted various doses of gamma for improvement of gladiolus and found beneficial effect of gamma doses and solid mutants were also found (Singh and Sisodia, 2015; Sisodia and Singh 2015; Padhi and Singh 2022). Among physical mutagens, gamma rays directly penetrate the plant tissue and are partially ionizing. Depending upon the radiation level, they can damage or modify important components of plant cells and affect the morphology, anatomy, biochemistry and physiology of plants. Chemical mutagens generally produce induced mutations that lead to substitution of base pairs especially GC to AT resulting in amino acid changes which change the function of proteins. Therefore, the combination of gamma radiation and oryzalin were used in experiment to evaluate its effect on the survival and growth of balsam (*Impatiens balsamina*).

MATERIALS AND METHODS

The experiment was conducted during year 2017 and 2018 in Randomized Block Design with three replications on 29 selected genotypes of balsam (*Impatiens balsamina*), collected from different parts of India and maintained in the Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The healthy, dry and uniform seeds of balsam were irradiated with two gamma doses *viz.*, 35 kR and 40 kR from a low dose irradiator ^{60}Co source at CSIR, National Botanical Research Institute, Lucknow to induced physical mutagenesis in them. Similarly, the pre-soaked seeds were treated with oryzalin solution for 12 hours with concentrations of 0 µmol (Control), 50 µmol, 100 µmol and 150 µmol. The soaked seeds were washed under running water continuously for 2 hours in order to remove the excess mutagen. The seeds were dried with filter paper and immediately sown after treatment, in order to study the effect of different doses/concentrations of mutagens on germination, survival and growth parameters. The balsam planted in first year (2017) set up the M_1 generation while those planted in second year (2018) constituted M_2 generation. Uniform cultural practices were adapted to grow the crop of balsam for all the experimental plots. The observations were recorded on the survival percentage of treated plants in comparison with untreated control. Five factors were taken into the consideration to estimate the overall growth of balsam *i.e.* number of primary branches per plant, fresh weight of leaves (g), number of leaves per plant, diameter of stem (mm) and height of plant (cm). The analysis of variance of data was done as per design of the experiment as suggested by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

All the treatments under study *i.e.* gamma radiation (35 kR and 40 kR) and oryzalin (50 µmol, 100 µmol and 150 µmol) showed the significant effects on the survival and growth of the balsam (Table 1). The good survival percentage of genotypes was observed with genotypes treated with low dose of gamma *i.e.* 35 kR (50.92 and 55.75 during M_1 and M_2 generation) while low survival was observed with high dose of oryzalin *i.e.* 150 µmol (41.86 and 53.01 during M_1 and M_2 generation). The relative high survival among the oryzalin treated plants was observed with the low dose *i.e.* 50 µmol (54.97 and 59.31 during M_1 and M_2 generation), whereas the relative low survival among the plants treated with gamma radiations was observed with 40 kR (44.66 and 49.75 during M_1 and M_2 generation).

All the treatments under study *i.e.* gamma radiations (35 kR and 40 kR) and oryzalin (50 µmol, 100 µmol and 150 µmol) shows the significant effects on the various growth parameters of the balsam.

It was observed that the maximum growth in terms of number of primary branches / plants was found with treatment of 50 µmol (13.01 and 13.60 during M_1 and M_2 generation) while the least number of primary branches / plants was observed with 35 kR during M_1 (10.87) and 40 kR during M_2 (12.83) generation (Table 2). The number of primary branches were relatively higher with gamma dose of 40 kR (10.95) during M_1 generation and 35 kR (12.86) during M_2 generation. Similarly, the number of primary branches / plants was low in the plants treated with 150 µmol (12.56 and 12.93 during M_1 and M_2 generation).

It was observed that the maximum growth in terms of high weight (g) of fresh leaves was recorded with 50 µmol and 40kR (0.54 and 0.96 during M_1 and M_2 generation) followed by 100 µmol (0.53) during M_2 generation and 35 kR (0.42) during M_1 generation (Table 3). The relative low weight (g) for the treatment of gamma radiations was recorded with 40 kR and 35 kR (0.41 and 0.95) while in terms of oryzalin treatments it was observed with 150 and 50 µmol (0.51 and 0.49) during M_1 and M_2 generation, respectively.

The results obtain for the overall highest growth for gamma and oryzalin treatments *i.e.* 35 kR and 50 µmol was 503.42 and 476.72 in terms of number of leaves during M_1 and M_2 generation, respectively (Table 4). The other treatment which performs better in terms of number of leaves were 100 µmol and 35 kR (494.73 and 465.89) during M_1 and M_2 generation, respectively. The relative lower number of leaves were observed with the 40 kR gamma radiations (467.339 and 456.01) and 150 µmol of oryzalin treatment (461.40 and 441.55) during M_1 and M_2 generation, respectively.

The results obtain for the overall highest growth in terms of diameter (mm) of stem was for chemical mutagen oryzalin dose of 50 µmol and gamma radiation of 35 kR *i.e.* 23.17 and 27.21 during M_1 and M_2 generation, respectively (Table 5). The gamma radiation (35 kR) treated plant sample shows the average stem diameter of 21.68 mm while the oryzalin dose of 50 µmol shows the growth in average diameter of 23.32 mm, respectively. The lower growth in the diameter of the stem recorded with the gamma radiation dose of 40 kR *i.e.* 21.65 and 27.11 while the 150 µmol dose of oryzalin recorded the similar lower growth in the diameter of the plant *i.e.* 22.71 and 22.86 during M_1 and M_2 generation, respectively.

Table 1: Effect of mutagens on plant survival (%) in different genotype of balsam.

	2017							2018						
	Gamma rays			Oryzalin				Gamma rays			Oryzalin			
Treatment / Genotype	0	35 kR	40 kR	50 µmol	100 µmol	150 µmol	Mean	0 kR	35 kR	40 kR	50 µmol	100 µmol	150 µmol	Mean
BDR-22	93.63	77.54	32.87	50.15	45.18	46.25	57.60	88.09	42.14	43.33	80.91	48.77	50.93	59.03
BDR-1	86.32	55.11	42.35	61.18	45.04	58.24	58.04	87.04	39.32	50.32	63.33	48.67	88.68	62.89
BDV-1	85.11	55.09	73.44	68.49	57.01	49.10	64.70	92.48	70.24	38.97	77.56	68.42	70.73	69.73
BS-39	82.28	36.02	51.53	65.51	39.42	51.07	54.30	83.55	86.12	76.70	62.55	69.01	68.26	74.36
BS-14	84.90	50.11	51.42	75.83	41.46	56.36	60.51	86.15	69.07	82.27	57.14	53.53	83.76	71.99
BS-20	66.16	64.43	52.11	50.43	37.04	61.36	55.25	80.95	42.14	78.90	75.40	75.04	81.22	72.27
BS-39	93.72	45.27	56.08	71.01	66.63	52.09	64.13	88.09	60.28	31.92	80.58	66.26	52.29	63.24
BS23	79.14	44.38	52.24	78.15	59.32	56.18	61.57	84.50	33.19	36.38	90.88	66.96	54.52	61.07
BSW-7	97.53	40.88	56.32	46.07	18.15	36.40	54.23	92.03	54.76	51.22	65.69	55.20	85.37	67.38
BSP-32	94.06	32.43	18.95	64.09	54.05	60.36	53.99	66.66	48.50	42.04	58.39	63.34	61.42	56.72
BDR-2	42.32	39.51	43.46	72.61	58.57	40.91	49.56	86.22	46.28	40.17	75.06	77.88	48.48	62.35
BSW-6	70.83	36.89	20.75	61.36	75.27	58.63	53.95	89.41	51.47	32.06	69.85	85.74	50.84	63.23
BDP-13	82.62	50.09	24.02	57.19	31.51	38.30	47.29	93.76	57.42	33.20	71.47	34.37	46.15	56.06
BDR-3	70.77	73.75	40.66	59.26	58.19	40.56	57.20	84.04	62.39	70.60	62.05	46.27	46.09	61.91
BDV-17	84.27	61.27	41.49	52.57	61.47	38.77	56.64	87.97	38.71	32.42	44.36	51.96	41.63	49.51
BD- Rosi	92.54	40.92	55.21	36.19	41.12	31.04	49.50	85.46	67.28	74.51	38.88	41.55	42.54	58.37
BDR-4	80.41	50.29	40.48	64.05	44.52	30.04	51.63	84.75	51.51	50.52	79.48	50.54	37.54	59.06
BDR-5	88.61	37.17	26.29	69.42	52.49	21.42	49.23	69.55	52.62	48.38	86.39	34.68	17.28	51.48
BDR-6	90.95	53.37	60.62	45.04	42.25	34.26	54.41	86.10	57.70	33.06	50.55	45.33	62.02	55.79
BSV-11	36.52	23.13	27.83	51.10	46.38	38.41	37.23	76.20	72.52	40.12	61.41	70.26	50.38	61.81
BS-28	80.35	42.35	48.70	54.19	32.15	20.01	46.29	87.98	58.06	75.79	39.93	40.91	24.94	54.60
BSP-9	95.18	80.77	59.36	68.34	65.01	45.07	68.95	73.29	69.65	35.56	40.50	41.17	50.22	51.73
BSP-1	83.43	20.65	17.80	32.47	20.54	35.42	35.05	88.73	76.16	50.96	40.38	23.50	37.57	52.88
BSW-27	89.75	42.39	39.27	30.29	37.55	34.99	45.71	85.53	40.55	36.24	40.35	50.04	80.14	55.47
BSR-16	77.34	81.82	56.27	26.18	39.23	23.22	50.67	90.84	66.37	65.83	31.67	41.22	18.71	52.44
BDV-2	90.91	53.31	36.15	48.47	56.67	41.36	54.48	73.64	44.88	57.95	55.95	68.19	62.52	60.52
BDP-1	83.48	34.28	45.13	59.07	40.89	32.48	49.22	89.39	48.41	32.83	37.70	40.36	38.22	47.82
BDP-2	82.78	81.56	64.07	45.21	59.33	42.35	62.55	66.36	46.21	44.53	48.15	47.57	53.17	51.00
BDR-7	51.26	68.89	60.29	30.37	35.34	39.43	47.60	68.63	62.98	56.03	33.39	28.66	31.69	46.89
Mean	80.59	50.92	44.66	54.97	47.99	41.86		83.36	55.75	49.75	59.31	52.94	53.01	

Factors	2017		2018	
	C.D.	SE(m)	C.D.	SE(m)
Genotype	1.81	0.65	1.70	0.61
Treatment	0.82	0.29	0.77	0.27
Genotype ×Treatment	4.45	1.59	4.17	1.49

Table 2: Effect of mutagens on number of primary branches per plant in different genotypes of balsam.

	2017							2018						
	Gamma rays			Oryzalin				Gamma rays			Oryzalin			
Treatment / Genotype	0 kR	35 kR	40 kR	50 µmol	100 µmol	150 µmol	Mean	0 kR	35 kR	40 kR	50 µmol	100 µmol	150 µmol	Mean
BDR-22	15.33	14.11	13.33	13.35	13.33	12.71	13.69	12.66	14.11	14.12	16.50	16.16	14.66	14.70
BDR-1	10.44	9.88	10.00	12.11	13.00	11.86	11.21	12.00	13.44	13.09	13.33	13.00	13.66	13.09
BDV-1	11.00	11.44	15.77	13.74	12.66	13.00	12.93	11.89	12.66	12.80	12.16	16.33	18.83	14.11
BS-39	10.33	9.00	9.443	14.16	13.66	12.00	11.43	13.11	11.11	11.82	18.66	15.83	20.50	15.17
BS-14	11.88	13.11	13.55	10.19	14.00	10.94	12.28	12.89	12.89	13.84	13.66	13.66	12.50	13.24
BS-20	10.66	8.55	7.88	9.69	11.76	9.30	9.64	12.77	12.89	12.87	13.83	13.33	15.16	13.47
BS-39	11.33	10.22	10.55	12.50	12.88	11.62	11.52	11.77	12.67	12.36	13.50	11.66	8.83	11.80
BS23	10.66	10.22	10.22	11.83	10.65	12.24	10.97	11.00	13.00	12.03	11.83	13.66	12.66	12.36
BSW-7	12.11	10.44	11.00	13.50	14.00	12.66	12.28	11.11	12.22	11.48	13.50	11.83	11.66	11.96
BSP-32	14.44	10.89	10.44	12.63	12.96	14.66	12.67	14.11	12.66	12.43	11.83	14.00	13.00	13.00
BDR-2	14.44	11.44	11.00	10.26	17.00	15.33	13.24	13.55	14.11	14.57	12.00	13.00	13.83	13.51
BSW-6	12.89	11.44	10.66	14.66	15.66	15.66	13.50	13.00	12.22	12.51	12.50	14.83	14.16	13.20
BDP-13	11.55	11.89	12.22	13.08	14.00	17.33	13.34	13.33	12.44	12.68	14.00	12.00	15.33	13.29
BDR-3	15.00	10.77	11.44	14.00	13.00	15.00	13.20	14.66	12.22	13.62	16.00	15.00	11.5	13.83
BDV-17	12.22	10.00	10.88	14.68	12.26	13.66	12.28	11.33	12.88	12.65	16.00	14.83	17.83	14.25
BD- Rosi	11.33	9.11	9.557	15.00	10.66	11.33	11.16	12.89	11.88	12.72	12.33	10.66	14.33	12.47
BDR-4	12.33	10.33	9.67	11.00	11.87	13.00	11.36	10.22	13.00	11.31	17.00	14.16	14.00	13.28
BDR-5	13.33	11.44	11.33	14.79	13.16	12.16	12.70	11.33	13.33	12.71	16.66	13.16	14.16	13.56
BDR-6	15.77	14.66	12.55	15.06	14.01	13.66	14.29	13.55	14.11	14.24	18.00	16.50	14.00	15.06
BSV-11	11.22	10.66	8.33	11.96	10.86	12.01	10.84	12.11	13.00	12.81	14.16	14.00	14.16	13.37
BS-28	13.22	10.78	10.55	14.27	12.16	12.00	12.16	12.44	12.66	12.96	11.66	10.50	10.50	11.78
BSP-9	13.22	11.66	11.22	11.77	9.00	11.66	11.42	11.89	11.11	11.97	10.83	9.00	8.66	10.57
BSP-1	10.77	10.33	10.44	14.28	10.66	11.50	11.33	12.00	13.22	12.61	8.66	10.66	10.33	11.25

BSW-27	8.33	9.88	9.78	11.23	10.75	11.66	10.27	10.55	15.11	14.02	10.66	11.50	9.33	11.86
BSR-16	12.88	11.11	11.66	12.62	13.42	11.16	12.14	11.55	13.55	12.52	12.16	12.83	10.16	12.13
BDV-2	11.89	9.88	10.44	13.49	13.20	12.66	11.92	12.44	12.66	12.24	14.33	12.00	8.33	12.00
BDP-1	12.44	10.55	11.77	14.00	12.66	10.63	12.01	12.78	13.11	13.07	12.16	9.66	9.83	11.77
BDP-2	12.44	10.33	10.00	13.22	12.61	11.66	11.71	13.66	12.22	13.06	13.50	11.16	11.66	12.54
BDR-7	14.22	11.11	11.78	14.37	13.22	11.33	12.67	13.00	12.55	12.91	13.00	11.83	11.33	12.44
Mean	12.33	10.87	10.95	13.01	12.72	12.56		12.40	12.86	12.83	13.60	12.99	12.93	

Factors	**2017**		**2018**	
	C.D.	**SE(m)**	**C.D.**	**SE(m)**
Genotype	1.21	0.43	1.18	0.42
Treatment	0.55	0.19	0.54	0.19
Genotype ×Treatment	2.97	1.07	2.90	1.04

Table 3: Effect of mutagens on fresh weight of leaf (g) in different genotypes of balsam.

	2017							**2018**						
	Gamma rays			**Oryzalin**				**Gamma rays**			**Oryzalin**			
Treatment / Genotype	**0 kR**	**35 kR**	**40 kR**	**50 µmol**	**100 µmol**	**150 µmol**	**Mean**	**0 kR**	**35 kR**	**40 kR**	**50 µmol**	**100 µmol**	**150 µmol**	**Mean**
BDR-22	0.46	0.55	0.49	0.56	0.50	0.37	0.49	0.63	0.95	1.01	0.35	0.54	0.39	0.64
BDR-1	0.56	0.67	0.60	0.43	0.47	0.48	0.53	0.81	0.98	1.03	0.26	0.56	0.50	0.69
BDV-1	0.37	0.54	0.37	0.43	0.48	0.41	0.43	0.98	0.96	1.02	0.40	0.50	0.40	0.71
BS-39	0.45	0.63	0.47	0.75	0.52	0.61	0.57	0.90	1.04	1.12	0.79	0.46	0.64	0.82
BS-14	0.44	0.45	0.49	0.47	0.54	0.55	0.49	1.01	0.91	0.99	0.45	0.56	0.527	0.74
BS-20	0.42	0.50	0.40	0.53	0.52	0.50	0.48	1.11	1.04	1.01	0.50	0.56	0.51	0.79
BS-39	0.39	0.32	0.30	0.69	0.64	0.58	0.49	1.00	0.75	1.10	0.61	0.52	0.48	0.74
BS23	0.40	0.38	0.44	0.49	0.45	0.42	0.43	1.10	1.17	1.03	0.50	0.54	0.35	0.78
BSW-7	0.43	0.47	0.47	0.77	0.78	0.77	0.61	0.80	0.87	0.92	0.95	0.96	1.15	0.94
BSP-32	0.65	0.50	0.54	0.62	0.44	0.45	0.53	0.73	0.83	0.81	0.30	0.48	0.49	0.61
BDR-2	0.52	0.51	0.55	0.34	0.49	0.50	0.48	1.07	0.96	0.95	0.33	0.52	0.51	0.72
BSW-6	0.37	0.39	0.36	0.42	0.43	0.49	0.41	0.71	0.82	0.90	0.42	0.47	0.53	0.64
BDP-13	0.41	0.51	0.45	0.47	0.52	0.49	0.47	0.87	0.94	0.75	0.45	0.52	0.48	0.67
BDR-3	0.49	0.48	0.41	0.59	0.49	0.42	0.48	0.64	0.74	0.87	0.59	0.48	0.45	0.63
BDV-17	0.50	0.44	0.38	0.68	0.55	0.52	0.51	0.96	0.83	0.80	0.70	0.51	0.51	0.72
BD- Rosi	0.36	0.31	0.35	0.50	0.49	0.45	0.41	1.10	0.98	0.93	0.49	0.50	0.41	0.73
BDR-4	0.29	0.31	0.33	0.45	0.43	0.55	0.39	0.97	0.92	0.82	0.45	0.4	0.55	0.69
BDR-5	0.24	0.27	0.31	0.39	0.46	0.46	0.35	0.99	0.83	0.82	0.40	0.48	0.49	0.67
BDR-6	0.25	0.33	0.37	0.37	0.47	0.47	0.38	1.15	0.85	0.86	0.38	0.46	0.47	0.69
BSV-11	0.32	0.38	0.38	0.53	0.51	0.56	0.44	1.17	1.08	1.12	0.51	0.50	0.59	0.83
BS-28	0.35	0.35	0.34	0.62	0.54	0.45	0.44	1.07	1.08	1.17	0.45	0.54	0.49	0.79
BSP-9	0.37	0.38	0.39	0.52	0.51	0.51	0.45	1.32	1.14	1.01	0.50	0.54	0.53	0.84
BSP-1	0.28	0.31	0.31	0.60	0.54	0.44	0.41	1.06	1.017	1.00	0.60	0.54	0.44	0.77
BSW-27	0.33	0.33	0.40	0.82	0.73	0.73	0.56	1.12	1.06	1.02	0.46	0.57	0.51	0.79
BSR-16	0.29	0.36	0.38	0.35	0.48	0.39	0.37	1.06	0.96	1.02	0.34	0.60	0.56	0.75
BDV-2	0.26	0.35	0.36	0.44	0.50	0.57	0.41	0.94	0.97	0.91	0.47	0.50	0.60	0.73
BDP-1	0.35	0.39	0.41	0.69	0.54	0.61	0.50	1.18	0.93	0.98	0.47	0.48	0.49	0.75
BDP-2	0.45	0.38	0.37	0.54	0.57	0.52	0.47	1.04	0.85	1.02	0.54	0.58	0.57	0.76
BDR-7	0.32	0.38	0.41	0.55	0.42	0.48	0.42	1.02	1.02	0.99	0.47	0.41	0.51	0.73
Mean	0.39	0.42	0.41	0.54	0.52	0.51		0.98	0.95	0.96	0.49	0.53	0.52	

Factors	**2017**		**2018**	
	C.D.	**SE(m)**	**C.D.**	**SE(m)**
Genotype	0.05	0.02	0.09	0.03
Treatment	0.02	0.009	0.04	0.01
Genotype ×Treatment	0.1 3	0.04	0.02	0.08

Table 4: Effect of mutagens on number of leaves in different genotypes of balsam.

	2017							**2018**						
	Gamma rays			**Oryzalin**				**Gamma rays**			**Oryzalin**			
Treatment / Genotype	**0 kR**	**35 kR**	**40 kR**	**50 µmol**	**100 µmol**	**150 µmol**	**Mean**	**0 kR**	**35 kR**	**40 kR**	**50 µmol**	**100 µmol**	**150 µmol**	**Mean**
BDR-22	871.66	636.33	683.00	510.33	529.00	471.00	616.88	693.33	467.66	678.33	462.33	414.66	366.33	513.77
BDR-1	550.00	460.33	521.66	513.66	553.00	537.00	522.61	611.33	474.00	581.00	568.33	404.00	425.66	510.72
BDV-1	670.66	482.00	480.33	488.33	603.00	477.00	533.55	517.33	430.66	522.66	400.33	448.66	444.66	460.72
BS-39	506.00	543.33	366.00	635.00	587.33	523.66	526.88	536.66	409.00	352.00	517.00	490.33	410.00	452.50
BS-14	549.66	826.33	453.66	462.33	491.00	340.00	520.50	382.66	613.66	668.00	454.66	471.33	418.33	501.44
BS-20	566.33	363.33	365.66	494.00	426.66	427.00	440.50	440.33	301.66	286.00	348.66	458.66	482.66	386.33
BS-39	495.33	512.66	572.00	409.00	471.33	456.00	486.05	377.66	468.33	378.00	377.66	351.00	464.00	402.77
BS23	513.66	448.00	336.00	509.33	545.00	479.00	471.83	530.00	308.66	334.33	427.66	401.00	428.00	404.94
BSW-7	640.00	388.66	577.00	593.66	502.33	480.66	530.38	541.00	378.66	318.33	477.66	499.33	519.33	455.72
BSP-32	557.33	376.33	366.66	543.33	555.33	516.33	485.88	547.33	383.33	351.00	481.66	342.66	332.00	406.33
BDR-2	833.00	713.33	624.66	570.66	501.66	515.66	626.50	767.00	682.33	408.00	593.00	526.33	518.66	582.55

BSW-6	560.66	455.66	526.33	490.00	546.33	482.66	510.27	560.33	246.66	244.66	496.66	401.00	426.00	395.88
BDP-13	612.33	513.00	457.66	415.00	413.66	439.33	475.16	504.66	536.00	359.33	461.00	464.00	364.00	448.16
BDR-3	846.33	637.66	517.00	579.66	600.66	547.00	621.38	827.33	597.33	670.66	594.00	519.00	516.33	620.77
BDV-17	641.33	490.000	383.33	509.66	511.00	513.00	508.05	559.33	417.33	462.33	499.00	464.66	361.66	460.72
BD- Rosi	587.00	591.66	575.00	506.66	479.66	463.00	533.83	411.33	638.00	568.33	390.00	489.66	406.66	484.00
BDR-4	637.00	494.66	580.33	453.33	430.66	378.66	495.77	561.00	652.00	480.33	454.33	540.00	456.66	524.05
BDR-5	729.66	530.66	500.33	513.33	459.33	458.00	531.88	726.33	509.33	495.33	514.33	525.66	459.33	538.38
BDR-6	760.66	592.33	476.66	432.00	468.33	461.00	531.83	524.33	529.00	464.33	480.33	429.00	431.66	476.44
BSV-11	626.00	557.66	449.66	416.00	413.00	444.66	484.50	600.00	471.00	449.00	585.66	453.33	549.00	518.00
BS-28	577.33	432.33	417.00	434.66	470.00	449.00	463.38	596.66	397.00	574.33	556.33	435.33	495.33	509.16
BSP-9	468.00	478.33	545.33	490.00	482.33	434.66	483.11	465.66	424.66	432.33	482.66	425.00	410.66	440.16
BSP-1	416.33	510.00	523.33	459.66	564.00	500.33	495.61	432.33	493.00	428.66	366.33	459.00	409.00	431.38
BSW-27	328.33	376.33	442.33	385.66	397.33	390.33	386.72	395.00	308.66	301.33	418.33	418.66	449.00	381.83
BSR-16	484.00	505.00	292.66	505.33	508.66	444.33	456.66	400.33	490.00	529.33	435.33	452.66	437.66	457.55
BDV-2	523.00	461.33	440.00	538.00	489.66	479.66	488.61	509.66	443.66	525.33	474.66	517.00	490.33	493.44
BDP-1	454.33	334.33	328.66	436.66	428.00	420.00	400.33	446.66	355.66	343.00	446.66	371.00	385.66	391.44
BDP-2	440.66	420.66	328.33	508.33	441.66	430.33	428.33	413.00	462.66	495.33	516.33	539.66	458.66	480.94
BDR-7	696.00	467.00	423.66	452.66	477.33	421.33	489.66	674.66	621.00	522.66	544.00	462.66	487.66	552.11
Mean	591.12	503.42	467.39	491.59	494.73	461.40		536.32	465.89	456.01	476.72	454.32	441.55	

Factors	**2017**		**2018**	
	C.D.	**SE(m)**	**C.D.**	**SE(m)**
Genotype	50.34	18.09	63.64	22.87
Treatment	22.89	8.22	28.95	10.40
Genotype ×Treatment	123.30	44.31	155.90	56.02

Table 5: Effect of mutagens on stem diameter (mm) of plant in different genotypes of balsam.

	2017							**2018**						
	Gamma rays			**Oryzalin**				**Gamma rays**			**Oryzalin**			
Treatment / Genotype	**0 kR**	**35 kR**	**40 kR**	**50 µmol**	**100 µmol**	**150 µmol**	**Mean**	**0 kR**	**35 kR**	**40 kR**	**50 µmol**	**100 µmol**	**150 µmol**	**Mean**
BDR-22	21.15	21.28	20.38	21.45	19.21	20.69	20.69	27.61	28.06	29.47	21.28	19.62	22.31	24.72
BDR-1	24.09	20.68	19.24	22.73	20.43	21.12	21.38	30.44	36.91	39.87	22.57	20.38	20.06	28.37
BDV-1	23.79	20.71	21.02	22.08	20.50	21.33	21.57	35.64	33.55	37.12	22.50	19.76	22.77	28.56
BS-39	27.78	22.72	21.94	21.64	20.91	20.67	22.61	32.92	37.64	34.53	22.43	20.29	20.71	28.09
BS-14	28.10	23.69	23.41	24.65	24.48	23.08	24.57	26.70	33.34	34.57	26.84	27.16	24.22	28.80
BS-20	27.73	20.43	20.72	25.21	25.22	22.57	23.64	23.28	24.18	29.70	25.21	25.22	22.57	25.03
BS-39	27.01	21.95	22.34	27.36	21.89	21.08	23.60	29.17	28.82	27.70	27.36	22.71	22.57	26.39
BS23	24.77	22.70	21.25	21.44	23.06	23.63	22.81	28.91	27.23	26.58	23.31	23.57	24.53	25.69
BSW-7	26.65	19.44	21.07	22.68	21.50	23.25	22.43	26.26	24.90	26.07	23.35	19.88	24.19	24.11
BSP-32	21.30	19.09	21.70	22.20	22.84	21.19	21.39	26.83	24.52	25.60	20.45	20.10	21.34	23.14
BDR-2	23.08	17.84	19.55	23.40	20.74	22.27	21.15	22.81	24.56	25.50	23.87	20.10	22.82	23.28
BSW-6	23.54	20.95	20.71	23.34	22.02	22.07	22.10	26.15	37.34	28.26	23.69	20.14	26.20	26.96
BDP-13	24.82	20.55	21.43	23.07	22.16	22.51	22.42	28.06	31.47	28.37	24.66	21.20	22.05	25.96
BDR-3	19.85	18.19	19.99	20.26	20.51	19.39	19.70	23.81	25.80	22.74	18.99	21.21	20.60	22.19
BDV-17	24.50	24.45	20.10	24.41	22.23	21.77	22.91	33.94	25.85	25.47	23.13	24.39	22.57	25.89
BD- Rosi	23.17	31.38	29.85	24.19	31.03	32.43	28.67	28.68	25.57	27.86	21.83	31.48	32.91	28.05
BDR-4	20.17	27.10	31.50	25.94	33.89	32.35	28.49	25.34	23.21	21.89	21.06	33.65	32.17	26.22
BDR-5	20.48	20.58	20.27	22.34	21.30	21.93	21.15	23.19	20.72	21.37	21.08	22.44	23.59	22.06
BDR-6	22.91	21.89	21.77	21.62	21.66	21.59	21.90	26.71	23.45	21.06	22.94	30.36	22.31	24.47
BSV-11	23.26	20.22	20.95	22.29	23.36	21.98	22.01	32.95	22.65	20.41	23.48	20.59	20.64	23.45
BS-28	24.29	22.20	21.37	23.81	22.23	22.37	22.71	34.93	21.75	22.78	22.96	21.78	22.57	24.46
BSP-9	26.13	21.90	22.82	25.88	23.36	25.40	24.25	36.09	27.03	23.41	26.76	22.95	26.39	27.10
BSP-1	26.31	23.93	24.06	26.08	24.82	24.19	24.90	36.32	23.69	22.15	26.86	25.22	24.54	26.46
BSW-27	22.51	21.78	22.88	23.77	25.34	23.79	23.34	28.04	25.64	26.32	23.24	24.85	23.09	25.20
BSR-16	21.47	22.27	18.19	22.67	23.52	20.19	21.38	31.54	26.94	27.42	22.12	22.15	17.34	24.58
BDV-2	23.66	20.99	21.69	21.80	21.37	21.90	21.90	32.39	28.20	27.15	23.07	21.92	21.84	25.76
BDP-1	23.52	20.67	19.49	21.02	22.06	21.76	21.42	38.88	24.27	26.58	25.15	22.37	19.78	26.17
BDP-2	24.62	20.78	20.48	24.21	22.77	21.84	22.45	36.85	28.51	28.95	25.16	20.56	19.56	26.60
BDR-7	20.02	18.31	17.63	20.40	19.62	20.28	19.37	36.91	23.41	27.28	20.95	19.23	16.79	24.09
Mean	23.82	21.68	21.65	23.17	22.90	22.71		30.05	27.21	27.11	23.32	22.94	22.86	

Factors	**2017**		**2018**	
	C.D.	**SE(m)**	**C.D.**	**SE(m)**
Genotype	1.35	0.48	1.81	0.65
Treatment	0.61	0.22	0.82	0.29
Genotype ×Treatment	3.30	1.18	4.45	1.59

Table 6: Effect of mutagens on plant height (cm) in different genotypes of balsam.

	2017							2018						
	Gamma rays			Oryzalin				Gamma rays			Oryzalin			
Treatment / Genotype	0 kR	35 kR	40 kR	50 µmol	100 µmol	150 µmol	Mean	0 kR	35 kR	40 kR	50 µmol	100 µmol	150 µmol	Mean
BDR-22	37.75	51.59	61.35	87.44	90.66	65.35	65.69	77.45	80.73	77.60	72.83	78.30	76.40	77.21
BDR-1	54.21	81.91	82.86	72.00	67.00	86.00	73.99	104.03	102.16	98.31	105.23	103.93	92.90	101.09
BDV-1	42.75	68.94	85.62	82.66	84.66	77.66	73.72	109.90	103.48	103.81	91.66	104.53	85.16	99.76
BS-39	46.46	79.75	77.93	74.00	66.33	72.00	69.41	90.60	95.71	100.99	77.43	72.33	86.10	87.19
BS-14	49.46	90.62	86.90	86.00	82.66	74.08	78.29	96.63	102.83	102.30	86.46	94.20	97.43	96.65
BS-20	47.84	74.34	70.02	62.78	51.66	68.66	62.55	92.93	91.13	90.85	96.80	92.00	90.76	92.41
BS-39	48.76	74.11	80.03	74.66	58.66	67.78	67.34	95.36	92.10	90.45	95.26	99.63	89.40	93.70
BS23	58.87	85.87	80.09	97.33	60.33	68.09	75.10	95.15	113.38	111.75	108.50	98.60	103.50	105.14
BSW-7	52.47	64.51	67.44	77.33	68.65	67.33	66.29	85.76	96.93	78.40	90.56	89.96	85.36	87.83
BSP-32	54.57	83.90	83.46	70.33	69.41	83.99	74.28	89.85	119.60	101.73	106.23	109.33	114.30	106.84
BDR-2	44.26	67.74	72.56	65.33	64.66	73.90	64.74	74.23	92.91	84.56	78.73	80.13	82.00	82.09
BSW-6	50.23	69.11	70.11	108.66	90.16	64.33	75.43	79.00	86.05	94.90	86.43	70.93	85.36	83.78
BDP-13	51.85	77.72	65.84	90.33	93.53	62.00	73.54	101.73	95.73	89.76	106.93	102.13	98.66	99.16
BDR-3	36.71	64.48	61.07	78.33	69.60	72.33	63.75	69.62	69.13	72.68	67.23	69.93	80.83	71.57
BDV-17	43.15	62.09	67.48	69.66	76.46	73.59	65.40	95.75	107.10	114.51	75.30	85.23	88.40	94.38
BD- Rosi	45.58	72.70	71.66	66.00	62.10	76.16	65.70	100.38	116.03	107.78	93.46	70.16	79.43	94.54
BDR-4	34.19	59.36	62.50	69.00	70.37	65.06	60.08	78.35	89.36	92.05	67.46	66.06	71.90	77.53
BDR-5	37.62	67.84	63.16	70.00	65.33	67.13	61.84	74.45	88.68	90.30	65.53	67.96	64.10	75.17
BDR-6	44.66	50.32	52.92	57.00	56.37	64.80	54.34	81.88	87.71	90.21	70.40	74.30	69.76	79.04
BSV-11	54.50	68.89	63.67	95.66	91.00	74.83	74.76	113.05	109.55	113.31	96.76	91.23	78.16	100.34
BS-28	101.79	62.57	67.96	96.33	93.33	92.46	85.74	104.93	102.46	101.96	82.46	88.66	85.76	94.37
BSP-9	64.17	76.92	79.45	77.67	84.49	83.81	77.75	113.23	110.60	111.08	89.70	86.80	93.86	100.88
BSP-1	56.74	85.36	74.24	75.49	76.50	68.72	72.84	103.20	103.66	106.21	82.10	84.66	79.53	93.23
BSW-27	34.36	59.22	55.57	61.16	66.46	68.97	57.62	86.86	91.60	99.00	77.73	74.30	72.70	83.70
BSR-16	38.02	52.13	45.77	51.18	64.47	58.12	51.61	104.58	93.01	87.13	90.86	98.23	102.50	96.05
BDV-2	36.93	52.04	56.69	65.13	67.61	70.30	58.12	102.45	98.11	91.86	95.90	101.53	89.66	96.58
BDP-1	39.63	49.49	51.79	57.68	62.98	54.91	52.74	101.65	90.01	100.96	100.00	96.23	92.80	96.94
BD P-2	41.65	51.98	44.46	59.68	61.29	57.96	52.83	104.55	106.98	102.56	104.96	105.13	96.66	103.47
BDR-7	35.40	47.40	41.10	52.55	52.07	62.38	48.48	84.48	82.61	82.55	68.66	71.36	66.80	76.08
Mean	47.74	67.34	67.02	74.18	71.34	70.44		93.52	97.22	96.19	87.29	87.16	86.21	

Factors	2017		2018	
	C.D.	SE(m)	C.D.	SE(m)
Genotype	6.39	2.29	4.69	1.68
Treatment	2.90	1.04	2.13	0.76
Genotype ×Treatment	15.66	5.62	11.50	4.13

The final outcome of data for the overall highest growth in terms of height (cm) of plants is observed with the treatments of 50 µmol and 35kR which was 74.18 and 97.22 during M_1 and M_2 generation, respectively (Table 6). Similarly, plants treated with 35 kR and 50 µmol recorded the diameter growth of 67.34 and 87.29 during M_1 and M_2 generation, respectively. The relatively lower growth in the height of plants was observed with the treatments of 40 kR and 150 µmol *i.e.* 67.02 and 96.19 and 70.44 and 86.21 during M_1 and M_2 generation, respectively.

The present study deals with the evaluation of the effects of gamma radiation and the oryzalin on the periodic survival and the growth of plants of balsam. The results of the present study were elaborated in two parts, among which one dealing with the rate of survival (in terms of percent) of treated balsam plants with that of untreated one and other deals with the effects of physical and chemical mutagens on the different five growth parameters of balsam plant *viz.* number of primary branches per plant, fresh weight of leaves (g), number of leaves per plant, diameter of stem (mm) and height of plant (cm).

Mutagen are the substance that can cause the mutation in the cellular level organization of living material. Many times, it was observed that the mutagens cause adverse effect on the fitness of living organism either flora or fauna (Loewe and Hill 2010). It was observed from the present study that as the dose of treatments (either physical or chemical) increases, the probability of survival of plants decreases (Mullins *et al*., 2021). Hence, in present study data presented in Table 1, reveals that the survival was more in untreated control as compared with mutagen treated plants. The results of present study were supported by the *Bhusari et al*. (2017); Berenschot *et al*. (2008) who reported similar findings in marigold and petunia. Control plots and lower dose of gamma exhibited maximum plant growth and leaf area of gladiolus and tuberose (Sisodia *et al*., 2015; *et al*., 2017; Singh *et al*., 2017).

Similarly, the physical and chemical mutagens taken into account in present experiment shows alike trend in terms of different growth parameters. The data presented for number of primary branches per plant reveals that number of primary branches had significant effect of gamma irradiation and oryzalin in both M_1 and M_2 generations. The interaction effect of gamma rays and oryzalin with different genotyped showed at higher dose of gamma rays (40 kR) and oryzalin (150 µmol), primary branches were increases in M_1 generation but in some genotypes namely BSW-6, BD-Rosi and BDR-6 had found increase in number of primary branches at lower doses (50 µmol) of oryzalin in M_1. During $M_{2,}$ it was observed that various levels of gamma rays were not responded well on all genotypes but in case of oryzalin treatment primary branches were increases in genotype BDR-22, BS-39, BDR-3, BDV-17, BDR-4, BDR-5, BDR-6 at 50 µmol oryzalin and genotype

BDR-22, BDV-1, BS-39 and BDR-3 at 100 µmol oryzalin and genotype BDV-1, BS-39, BDP-13 and BDV-17 at 150 µmol oryzalin. These findings were corroborated with the findings of Defiani *et al*. (2013); Kole and Mehar (2005).

Maximum fresh weight was recorded at lower dose (50 µmol) of oryzalin in genotype BSW-27, BSW-7, BS-40, BDP-1 and BDV-17 in M_1 generation while, in M_2 maximum fresh weight was recorded in untreated plants of genotype BSP-9, BDV-11, BS-23 with 35 kR gamma rays and BS-28 with 40 kR gamma rays treatment. Decrease in fresh weight was found in untreated plants for M_1 generation whereas, in M_2 fresh weight of leaf was decreased at lower dose (50) of oryzalin. Stem diameter was decrease in all genotypes at higher dose except BSP-32, BDR-3, BD-Rosi, BDR-4 and BSW-27 treated with 40 kR gamma rays while, genotype BD-Rosi, BDR-4, BDR-5, BSW-27 and BDR-7 treated with 150 µmol oryzalin in M_1 generation. During M_2, stem diameter decreases at higher dose gamma radiation and oryzalin except genotype BDR-22, BDR-1, BDV-1, BS-39, BS-14, BS-20, BDR-2, BSW-6 and BDP-13 showed increase in stem diameter at higher dose of gamma radiation. Minimum stem diameter was recorded in genotype BSR-16 treated with 150 µmol oryzalin. These findings justified with the findings of Kumari *et al*. (2013) in chrysanthemum, Singh *et al*. (2009) in African marigold, where diameter of stem decreases at higher doses of gamma irradiation.

Plant height was reduced with gamma dose increased during M_2 generation while in M_1 also observed reduction in plant height at higher dose of oryzalin. These findings were also supported by the findings of Defiani *et al*. (2013); Tiwari and Kumar (2011); Wi *et al*. (2007)

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