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EFFECT OF GAMMA RAYS ON SOME QUALITATIVE AND QUANTITATIVE CHARACTERS IN *ZINNIA ELEGANS* JACQ.

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ABSTRACT

Mutations were induced in *Zinnia elegans* Jacq. cv. Crimson Red by using gamma irradiation for plant morphology and flower colour. Significant effects were observed as shown by the increased mean value of plant height, branch number, flower number, and flower diameter up to 7.5 kR dose. Among the gamma-ray doses, only 7.5 kR produced significant morphological changes in *Zinnia elegans*, which may be due to additive gene effect. Four types of new flower colour mutations were induced: majenta, yellow, red and red with white spots. The number of petals (ray florets) was significantly higher in the mutants over control. Two types of structural anomalies were also identified.

Key words: *Zinnia elegans*, gamma rays, morphological variations, flower colour, macromutations.

Commercially important traits in horticultural plants have been altered in a positive way by the various physical mutagens. Among the physical mutagens, gamma rays are widely used for inducing mutations in flowering plants. Induced mutations have contributed to the development of new cultivars of crop plants [1].

Zinnia elegans is one of the most popular flowering annual plant, and offers diversity of forms in terms of plant size, habit, and flower colours [2]. The previous reports are on polyploid induction [3–5], and X irradiation work in *Zinnia elegans* [6, 7].

The objective of this study was to determine the effect of gamma irradiation on plant morphology and flower colour of *Zinnia elegans*.

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MATERIALS AND METHODS

The seeds of *Zinnia elegans* Jacq. var. Crimson Red were obtained from M/S Sutton and Sons, Calcutta. Selfed seeds were used for irradiation. Healthy seeds were subjected to gamma rays from ^{60}Co at the Tamil Nadu Agricultural University, Coimbatore in 2.5 kR, 5.0 kR, 7.5 kR, 10.0 kR, and 12.5 kR doses. In each treatment, 300 seeds were irradiated. The effects of radiation were studied in M_1 to M_4 generations.

M_1 generation. Immediately after irrigation, the seeds were sown in the seed beds in October 1988, in randomized complete block (RCB) design with three replications. The seedlings were transplanted in the experimental plots. During flowering season the M_1 plants were selfed, and seeds were harvested separately from individual plants.

M_2 generation. Seeds from each M_1 plants were sown as individual plant progenies. As suggested by [8], chlorophyll mutations were scored in the nursery beds before transplantation. Chlorophyll mutations were screened at the seedling stage and final germination was recorded one month after sowing. Observations on plant morphology were recorded at 5–20 days interval after transplantation, and the abnormalities were recorded for growth habit, plant height, number of branches per plant, number of heads per plant, head diameter, and head colour (Table 1).

M_3 and M_4 generations. The mutagenized generations three and four were used for experimental evaluations of the six macromutants selected in M_2 generation. The RCB design was followed with three replications, 30 seeds per mutant as well as control in June 1990.

In M_3 generation, plant height, number of branches per plant, number of heads per plant, head diameter, leaf size (length x width), and ray floret length (length x width), ray floret colour, number of ray florets per plant, first date of flowering (days) along with abnormality, if any, were recorded. Days to first flowering and maturity were recorded when more than 50% plants expressed these properties. Data on the quantitative characters in M_2 and M_3 generations were analyzed statistically in accordance with Sharma and Sharma [9].

RESULTS

Significant differences in quantitative characters were recorded in M_2 generation for plant height, branch number, flower number, and flower diameter. The mean, SE, and CV were calculated.

The plant height increased in the 2.5 kR to 7.5 kR treatments over the control (Table 1). The increase in mean value was not linear to dose. The highest mean value of 18.3 cm was

recorded in the 7.5 kR dose, whereas the lowest mean value of 14.6 cm was observed in 10 kR dose.

The branch number increased and decreased depending on the mutagenic dose (Table 1). The mean values increased at 2.5 kR and 5.0 kR, and decreased with 7.5 to 12.5 kR doses. The increase or decrease in mean values were not linear to dose level. The maximum mean number of 19.6 branches per plant was observed with 5.0 kR dose, while the minimum value was 8.6 in 10 kR dose.

Table 1. Effect of gamma irradiation on plant height, branch number, flower number and flower diameter (mean ± SE) in M_2 generation (after 45 days) of *Zinnia elegans*

Gamma-ray treatment	Plant height		Branch No. plant		Flower No. plant		Flower diameter	
	cm	CV	No.	CV	No.	CV	cm	CV
Control	15.3 ± 0.96	19.9	14.6 ± 0.40	27.6	10.5 ± 0.85	25.6	6.7 ± 0.40	18.6
2.5 kR	15.9 ± 1.14	22.6	15.2 ± 1.37	28.6	11.1 ± 0.93	26.6	6.7 ± 0.40	18.8
5.0 kR	15.2 ± 1.51	31.4	19.6 ± 2.39	38.6	14.2 ± 2.04	45.4	6.8 ± 0.49	22.5
7.5 kR	18.3 ± 1.73	29.8	18.8 ± 1.67	28.1	13.5 ± 1.14	26.8	7.0 ± 0.23	10.6
10.0 kR	14.6 ± 1.52	32.8	8.6 ± 1.46	53.6	6.6 ± 1.15	55.1	5.2 ± 0.35	21.3
12.5 kR	17.4 ± 1.47	26.8	8.9 ± 1.47	52.3	7.8 ± 1.16	47.2	5.4 ± 0.40	23.8

The flower number increased or decreased with different doses (Table 1). The flower number increased in the treatments from 2.5 kR to 5.0 kR, and decreased thereafter at higher dose levels (7.5 kR to 12.5 kR). However, the increase and decrease in the mean flower number was not linear to dose. The highest mean value of 14.2 flowers per plant was observed with 5.0 kR, whereas the lowest mean value of 6.6 flowers was recorded in the 10 kR treatment.

The flower diameter also increased or decreased under the various gamma-rays dose levels (Table 1). The mean increased in dosages from 2.5 kR to 7.5 kR, whereas the mean decreased in higher doses, i.e. from 10 kR to 12.5 kR. However, the increase or decrease in the head diameter was not linear to the mutagenic dose. The highest mean diameter of 7.0 cm was observed at 7.5 kR, and the lowest 5.2 cm at 10 kR. In the present study, the coefficient of variation also increased due to mutagenic treatment in all the morphological characters, viz., plant height, branch number, flower number, and flower diameter over the control.

The plant leaves were crinkled and puckered (Fig. 1) in the treatments with higher doses of gamma rays. The leaf deformities were directly proportional to the dose level. Flower

colour changes were noticed as the effect of dose level. Individually observed M_2 plants that exhibited morphologically desirable and discernible variability were selected. Four most interesting new flower colours, namely, majenta, yellow, red, red with white spots (mosaic) were obtained in the var. Crimson Red. Two morphological mutations in flowers, i.e. many whorls and puckered flowers, were also isolated. The number of whorls was 7–8 in the multiwhorled mutant as compared to 2–3 whorls in control. The above six flower mutants were advanced for further studies in M_3 and M_4 generations.

The true breeding macromutants isolated in M_2 generation were grown in M_3 generation. The quantitative and qualitative characters, i.e., plant height, branch number, leaf size (length x width), number of flowers per plant, flower diameter, number of ray florets, and size of ray floret (length x width) in the mutants were studied in M_3 generation (Table 2). The mean values of the various morphological and floral characters significantly increased in the majenta, red, red with white spot, and multiwhorled mutants over the control at 5% level, but significantly decreased in the yellow and puckered flower mutants.

In M_3 generation, some structural and morphological abnormalities like three leaves on a node instead of the normal two leaves (Fig. 1), indicated the type of altered phyllotaxy, which was evident in 10% of the treated plants. This mutant was selected from the yellow flowered mutant (2.5 kR). Dichotomous branching was also induced by 7.5 kR dose in the seeds from the red coloured mutant.

The macromutants were advanced to M_4 generation by selfing. Observation of M_4 generation was identical to those in the M_3 generation. The mutant character were further confirmed in M_4 generation.

Table 2. Morphological and floral characters of six macromutations in M_3 generation (after 90 days) of *Zinnia elegans*

Mutant	Plant height (cm)	Branch number	Leaf size (cm^2)	No. of heads	Head diameter (cm)	Ray floret length (cm)	Ray floret number per flower
Control	46.6	21.4	37.9	13.8	8.1	4.4	99.6
Majenta	54.5	25.4	45.0	15.8	8.5	5.1	76.9
Yellow	38.5*	16.6	38.1	11.4	5.0*	2.5*	48.7*
Multiwhorled	49.7	34.2*	57.5*	21.8*	9.1	5.0	209.1*
Red	48.5	32.0*	49.7*	20.0*	9.2	4.6	164.4*
Red with white spots	42.5	16.0	40.2	11.0	8.7	2.8	174.7*
Puckered	36.9*	15.6	43.5	12.0	8.0	2.4	103.6

*Significantly different from the parent variety at 5% level (t- test).

Fig. 1. Crinkled and puckered leaves of *Zinnia elegans* plant treated with gamma rays (left) and control (right).

DISCUSSION

Based on these results, considerable variation in the mean values of plant height, branch number, flower number and flower diameter was observed up to 7.5 kR gamma-ray treatment. Above this dose level, the mean value decreased. Among the gamma-rays doses applied, 7.5 kR dose produced maximum number of morphological variations in *Zinnia elegans*. In the present investigation, the mean plant height, branch number, flower number, and flower diameter increased with 7.5 kR dose. Buiatti and Ragazzini [10] reported that the mean values of morphological characters were significantly depressed due to the treatment, roughly increasing with the dose above 7500 rads of gamma rays.

Four types of new flower colour mutants and two mutations for flower structure, i.e. multiwhorled (7–8 whorls) and puckered flowers, were isolated. Four types of induced colour changes were recorded in *Dianthus caryophyllus* after gamma rays treatment [10].

In the present investigation, the multiwhorled flowers were completely devoid of the disc florets. Such double flowers were very attractive than the flowers of the parent variety.

Flower characters are said to be controlled by polygenic system which can be changed in mutation experiments [10, 11]. The number of petals in flowers (heads) is controlled by a polygenic system. Buiatti and Ragazzini [10] ascribed to a more complex inheritance

mechanism the character "number of petals" in *Dianthus caryophyllus*. The possible cause for change in the petal number may be pleiotropic effect of the mutant genes. In the present investigation, early flowering (13 days) was realized under the influence of a mutated gene.

Two types of anomalies observed, viz., altered phyllotaxy and dichotomous branching in yellow and red flower mutants, respectively, may be due to recessive mutant genes. Similar anomalies in *Zinnia elegans* have been described earlier by Johnson [6] using X radiation.

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