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GAMMA RADIOSENSITIVITY STUDIES ON *ZINNIA ELEGANS* VAR DREAMLAND

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ABSTRACT

The success of induced mutagenesis technique using gamma rays in any crop or ornamental plants lies in the determination of optimum dose (LD_{50}). The study aims to determine the optimum dose of gamma rays in *Zinnia elegans* var Dreamland and the effect of different doses of gamma radiation on the germination and survival rate, plant height and root length. The seeds were treated with 10Gy, 20Gy, 50Gy, 75Gy, 100Gy, 125Gy, 300Gy, 400Gy and 500Gy at Bhabha Atomic Research Centre, Mumbai using ^{60}CO source. The results revealed that there was significant decline in the germination rate after 50Gy gamma radiation dose and no significant variation in the survival rate until 300Gy as compared to the control. The LD50 for % germination and %survival was found to be 155.98 and 250.78. The higher gamma ray doses significantly decreased the plant height and root length. 40% reduction in shoot length and root length was found to be 250 to 260 and 210 to 220.

Keywords: *Zinnia elegans,* gamma radiation, induced mutagenesis, radiosensitivity, LD_{50}.

Ornamental plants are grown for decoration and aesthetic appeal. Novel flower colours, flower shapes and flower sizes, dwarfed plants, modified growth, fragrance are the traits to look for improvement in an ornamental plant to increase the commercial value in ornamental industry. Economically important traits mainly the flower characteristics and growth habits make the ornamental plants the ideal candidates for the application of induced mutagenesis techniques (Raina *et al*., 2016). Flower colour and morphology are of the greatest importance in directing the market of flower industry, as characteristics that are judged by the consumer. Ever changing preferences and fashion increase the demand for rapid production of new characteristics in ornamental plants (Elomaa *et al*., 1994). The low cost of the technique and the advantage of seed production in *Zinnia elegans* makes it the ideal plant for obtaining new and novel flower colours through induced mutagenesis. The *Zinnia* plants are highly useful in ornamental industry and offers diversity of forms in terms of plant size, habit and flower colours (Venkatachalam and Jayabalan, 1997) and there is always a need for new and novel varieties with improved flower colour and morphology. Mutation refers to the process of revising the genes that comprise the building blocks and foundation of plant development (Adamu *et al*., 2004; Kadhimi *et al*., 2016). Mutations occur naturally in double stranded DNA molecule, most of them are repaired and some of them pass onto the offspring (Kangarasu *et al*., 2014). Mutations are induced by exposure of seeds, tissues and organs to physical or chemical mutagens (Mba *et al*., 2010; Horn and Shimelis, 2013) and affect the survival percentage, germination percentage and other morphological characteristics. Consequently, these properties have been exploited for developing new and novel varieties which are of high commercial value. Plant architecture, yield, flowering and maturity duration, quality and tolerance to biotic and abiotic stresses are some of the characters which have been improved through induced mutagenesis techniques. Production of mutants through ionising radiations is most cost effective (Bhat *et al.*, 2007; Bhosale and Hallale, 2011; Kangarasu *et al.*, 2014).

Gamma rays have been proved to be highly potent in inducing variations in ornamental plants (Venkatachalam and Jayabalan, 1997) that account for the development of 60% of the mutant varieties out of 89% developed using physical mutagens (Kharkwal, 2000; Ellyfa Kon *et al.*, 2007). Radiosensitivity or determination of the optimum dose of radiations describes the relative measure of the quantity of recognisable effects of a radiation exposure on the irradiated material (Owoseni 2007; Horn and Shimelis, 2013). The basic requirement for an effective use of mutation induction in plant breeding programmes is the analysis of radio sensitivity of the explant material and LD_{50} (Walther and Sauer, 1986; Datta S.K, 1997). One of the first steps in mutagenic treatments is the estimation of the most appropriate dose to apply (Predieri and Gatti, 2000; Barakat and El-Sammak, 2011). The morphological, structural and the functional changes depend on the strength and the duration of the gamma-irradiation stress (Hameed *et al.*, 2008). Earlier reports showed that higher exposures of gamma rays were usually inhibitory (Radhadevi and Nayar, 1996; Kumari and Singh, 1996) whereas, lower exposures were sometimes stimulatory (Sparrow, 1996; Taylor, 1968; Raghava and Raghava 1989; Thapa, 1999). The aim of the study is to determine the gamma radiosensitivity in *Zinnia elegans* var Dreamland.

MATERIALS AND METHODS

Theseeds of *Zinnia elegans* var Dreamland pink were procured fromIndo American Hybrid Seeds, Bangalore. The gamma radiosensitivity of *Zinnia elegans* were studies at St Aloysius College, Mangalore. The experimental material was irradiated with 9 doses of gamma rays (10Gy, 20Gy, 50Gy, 75Gy, 100Gy, 125Gy, 300Gy, 400Gy, 500Gy). The non-irradiated seeds were served as control. 0 Gy dose served as a comparative control. The irradiated seeds were sown immediately after the irradiation treatment and planted in soil beds containing soil: sand: vermiculite at a ratio 2:1:1. The planting distance was 5cm within row and 15 cm between rows. The experiment is conducted in three replications. The germination rate of the planted seeds was recorded in the first week of the culture. Meanwhile, % survival, the height of the plantlets, the length of the roots was determined after 15 days of germination. The % reduction in the shoot length and root length were determined utilising the shoot length and root length of the seedlings (Kadhimi *et al.*, 2016). The length of the roots and the shoot length of the seedlings were measured using a ruler. The optimum LD50 doses for *Zinnia* were assessed by performing the linear regression analysis. The optimum dose for mutagenesis was measured based on % germination. The data was analysed using the standard analysis of variance and Tukey's test using IBM SPSS version 20.

% Germination = No. of germinated seeds × 100/No. of irradiated seeds planted

% Survival = No. of survived seedlings × 100/No. of germinated seeds

% reduction of shoot length = Mean of shoot length (control) – mean of shoot length (given treatment) x100/ Mean of shoot length (control)

% reduction of root length = Mean of root length (control) – mean of root length (given treatment) x100/ Mean of root length (control)

RESULTS AND DISCUSSION

% Germination:

The optimum dose of gamma radiation was determined using the LD_{50} of %germination (Fig. 2 and Table 1). In our present study, Fig. 1 shows that the higher gamma radiation reduces the % germination of the seeds. Compared to control, the lower radiation dose (10Gy) was found to increase the germination rate. At 10Gy and 20Gy, the % germination was not significantly different from the control. The similar results were observed by (Minisi *et al*., 2013) in a study on *Moluccella laevis* L. seeds and the results showed that low doses of gamma radiation increased the germination percentage compared to higher doses. Similarly, (Maherchandani, 1975) also observed the increase in the germination rate of *Avena fatua* L. seeds irradiated with lower doses and attributed the effect to the increase in oxygen uptake following irradiation with low doses of gamma rays resulting in the production of organic and inorganic peroxy radicals, leading to the revival of seed dormancy. The stimulating causes of gamma ray on germination may be caused by the activation of RNA or protein synthesis, which occurs during the early stage of germination after the irradiation of seeds (Abdel-Hady *et al*., 2008). The inhibition of seed germination at high doses could be due to the damage in seed tissue, chromosomes and subsequent mitotic retardation and the severity of the damage depending on the doses used (Al-Safadi and Simon, 1990; Datta *et al*., 2009).

Table 1. The LD50 values of % germination and % survival of *Zinnia elegans*

Parameters	Regression equation	LD50 dose (Gy)
% Germination	Y=0.1156x+68.032	176.51

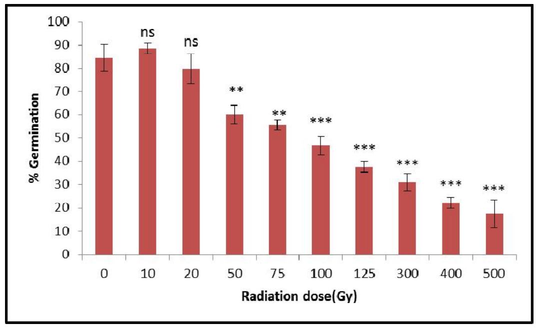

Fig. 1. Effect of gamma radiation on the germination rate of *Zinnia elegans* var Dreamland

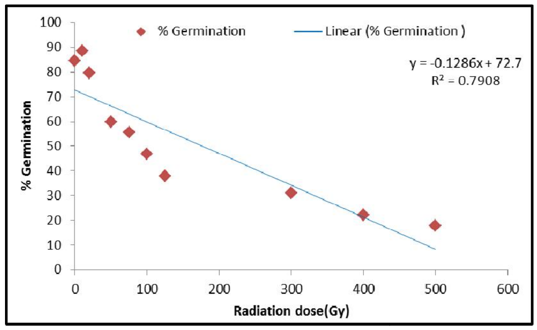

Fig. 2. The linear regression analysis of % germination of *Zinnia elegans* var Dreamland

% Survival:

The statistical analysis of % survival showed that the seedlings treated with 10 Gy to 300Gy were not significantly different from control (Fig. 3). The significant decrease in the % survival was observed in seedlings treated with 400Gy and 500Gy. The seedlings exposed to higher gamma radiation then 125Gy did not survive more than 30days. Similar study has been reported by (Kumari *et al*., 2013) in *Chrysanthemum morifolium* variety 'otome pink'. The result showed that Gamma irradiation significantly reduced the per cent plant survival. The reduction in survival increased with increase in dose. The higher doses significantly reduced final plant height.

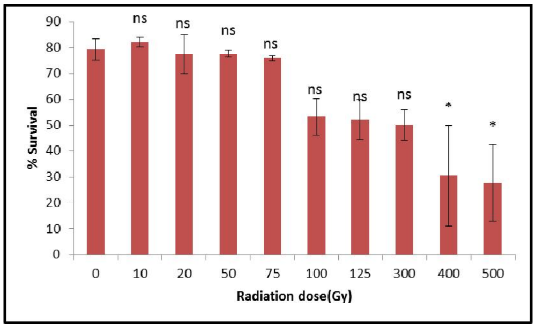

Fig. 3. Effect of gamma radiation on the survival rate of *Zinnia elegans* var Dreamland

Shoot length and root length:

The variation in shoot length was recorded after 15 days of germination. In general, the increase in the gamma radiation dose caused a decrease in the shoot length of the seedlings. However, no significant variation was observed in seedlings treated with 10Gy to 75Gy doses of gamma radiation (Fig. 4). Initial increase in the plant height was observed in 10Gy and 20Gy doses. Similar results of increase in the shoot length in the *Zinnia* seedlings treated with low doses gamma radiation were observed by (Venkatachlam and Jayabalan, 1997). The % reduction in shoot length was consistent in higher doses of gamma radiation. The 40% reduction in shoot length was found to be at 258.38Gy (Fig. 5). Compared to the control, the data in the Fig. 6 shows that increase in the radiation doses reduced the root length of the *Zinnia elegans* seedlings. The significant decrease in the root length was observed in 300Gy, 400Gy and 500Gy as compared to control. The % reduction in root length was consistent in higher gamma radiation doses. The 40% reduction in root length was found to be at 216.66Gy (Fig. 7). The negative effect of gamma Irradiation could seriously affect the cell cycle capture at the G2/M stage throughout the somatic cell division or affect the genome, thereby inhibiting development (Kadhimi *et al*., 2016; Preuss and Britt, 2003).

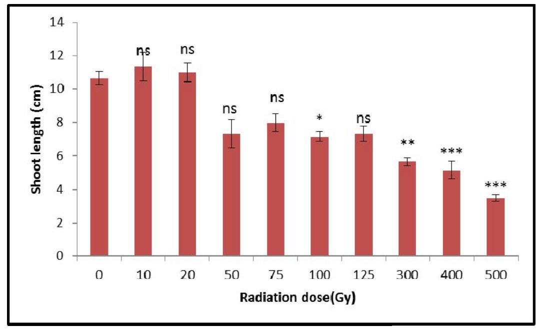

Fig. 4. Effect of gamma radiation on shoot length of the seedlings of *Zinnia elegans* var Dreamland

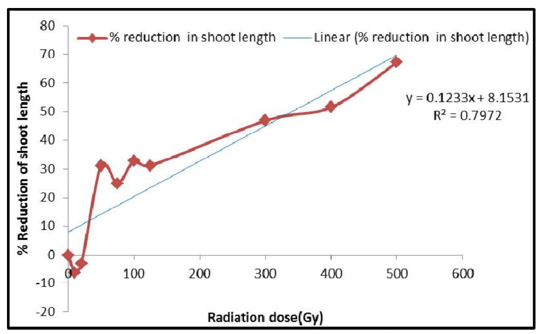

Fig. 5. %reduction in shoot length of the seedlings of *Zinnia elegans* var Dreamland

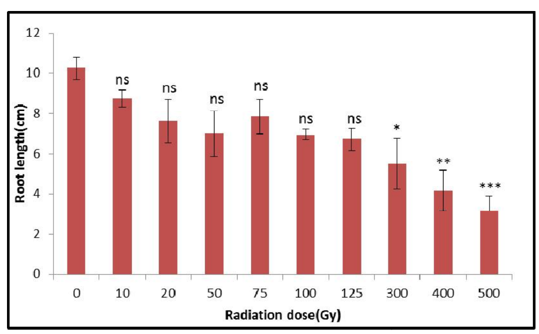

Fig. 6. Effect of gamma radiation on root length of the seedlings of *Zinnia elegans* var Dreamland

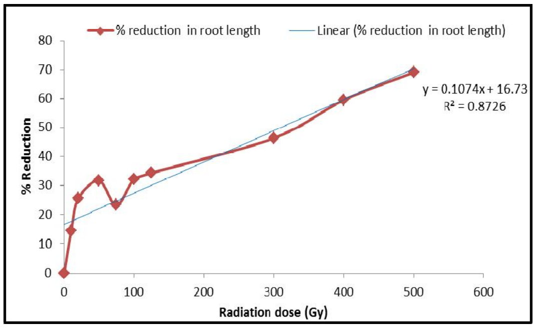

Fig. 7. % reduction in root length of the seedlings of *Zinnia elegans* var Dreamland

Conclusion:

Currently, *Zinnia elegans* is a minor economically important plant compared to the major plants such as roses, chrysanthemums and carnations and the improvement of the flower colour and shelf life will increase the aesthetic and commercial value. Induced mutagenesis through gamma radiation in spite of being an old technique is the most useful approach to obtain genetic variation and diversity. Gamma radiosensitivity studies contribute as a first step to the production of novel flower colour varieties in ornamental plants.

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