The Pharma Innovation Journal 2021; 10(3): 717-721

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(3): 717-721

www.thepharmajournal.com
Received: 10-01-2021
Accepted: 27-02-2021

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Effect of different doses of gamma rays on mutational characters in dahlia (*Dahlia variabilis* L.)

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Abstract
Rooted cuttings of dahlia cultivars Kenya Blue, Kenya Yellow and Kenya Original were exposed to 0, 10, 15 and 20 Gy gamma rays and planted in earthen pots (8"). Each treatment consists of four replications with 12 treated rooted cuttings each. Among the irradiated population, the highest mortality percentage (38.81%) and abnormal plants percentage (15.88%) was recorded at 20 Gy dose. However, highest survival percentage (100%) observed at untreated plants. As regards to the cultivars, Kenya Yellow had maximum mortality percentage (30.80%) as well as abnormal plant percentage (10.06%). Meanwhile, significantly higher survival percentage was noted in Kenya Original (83.30%). The probit analysis indicated the extrapolated LD_{50} dose was found beyond 20 Gy for survival of cultivars, Kenya yellow had low LD_{50}.

Keywords: Dahlia, gamma irradiation, survival, mortality, abnormal, LD_{50}

Introduction
Dahlia (*Dahlia variabilis* L.) is an herbaceous perennial flowering plant belongs to the family Asteraceae and has originated in mountainous areas of Mexico and Central America. They are extensively grown all over the world for its beautiful charming flowers, but in India, commercial cultivation of dahlia is limited to the hills and plains of eastern India including Jammu and Kashmir. Dahlias are highly attractive facultative short day plant with great variations in shape, size, colour, prolific growing habit and easy to cultivate. It is used for garden display, exhibition, cut flower production, flower arrangement for borders, beds or mixed borders, growing in containers and making garlands. (Giannasi, 1998) [5].
Dahlia spp. has a high occurrence of polyploidy and thus, exhibits various colours, sizes and flower shapes. By using hybridization many new cultivars have been developed already. In general, crosses may be restricted by incompatibility or variations in ploid level and a high degree of heterozygosity, resulting in a complex genetic factor inheritance. In conventional breeding, this causes some significant problems. Here, mutation breeding gives an advantage as a large variation can be realized for the improvement of one or few characters of outstanding cultivar, without altering the remaining genotype within a short span of time. The present study aimed to study the different mutational characters such as mortality percentage, survival percentage, abnormal plant percentage associated with gamma ray irradiation.

Material and Methods
The present experiment was conducted at the Horticultural Research cum Instructional Farm, Department of Floriculture and Landscape Architecture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during the winter season of 2018-19 and 2019-20. Rooted cuttings of three dahlia cultivars *viz.* Kenya Blue, Kenya Yellow and Kenya Original were irradiated with 0, 10, 15 and 0 Gy of gamma rays and immediately planted in the pots under open field condition. The experiment was laid out in FCRD (Factorial Completely Randomized Design) with four replications for each treatment. Data were recorded on different mutational characters in the field.
To determine the mortality percentage (%), the number of rooted cuttings in each treatment in vM_1 was counted after 15 days of planting in open field condition and expressed in percentage but for survival percentage (%), the number of plants that survived out of the total number of rooted cuttings was counted after 30 days of planting and it was also expressed as a percentage. The abnormal plant percentage was recorded by counting the number of abnormal plants in each treatment at the flowering stage and it was expressed as a percentage of the total number of rooted cuttings planted.

The LD_{50} dose of irradiation was calculated by probit analysis method using observations on mortality percentage as described by Sharma (1998) [12]. The data was statistically analyzed by using the procedure of (Gomez and Gomez, 1984) [6] to evaluate the mutational potential of different cultivars with various doses of gamma rays.

Result and Discussion

Mortality percentage

There was a significant difference in the mortality percentage of plant in different cultivars as well as in different gamma radiation doses (Table 1 and Fig. 1). It is clear from the data that mortality percentage increased as the dose of gamma rays increased, as respect to different gamma radiation doses, significantly higher mortality percentage (38.81%) was recorded at 20 Gy as compared to rest of the treatments. Among the cultivars of dahlia, cultivar Kenya Yellow recorded significantly higher mortality percentage (30.80%), whereas, minimum mortality percentage (16.44%) was observed in cultivar Kenya Original. Interaction between cultivar Kenya Yellow and 20 Gy gamma radiation recorded significantly higher mortality percentage (47.82%) as compared to rest of the interactions. The results are in agreement with the work of Tiwari and Kumar (2011) [13], who recorded maximum mortality at higher gamma radiation doses. The death of plants is attributed to the interaction of molecules with other molecules in the cell which produce free radicals of H and OH. The free radicals could combine to form toxic substances such as hydrogen peroxide which contribute to destruction of cells. These results corroborate with the findings of Lamseejan *et al.* (2000) [9] in chrysanthemum and Devi *et al.* (2019) [3] in gladiolus.

Table 1: Effect of different doses of gamma radiation on mortality, survival and abnormal plant percentage

Treatment	Cultivars	Mortality percentage		Survival percentage		Abnormal plant percentage	
Control	Kenya Blue	0.00		100		0.00	
	Kenya Yellow	0.00		100		0.00	
	Kenya Original	0.00		100		0.00	
10 Gy	Kenya Blue	15.34		84.66		6.14	
	Kenya Yellow	31.62		68.20		7.92	
15 Gy	Kenya Original	11.70		88.30		4.88	
	Kenya Blue	22.28		77.48		12.15	
	Kenya Yellow	43.75		56.25		14.00	
20 Gy	Kenya Original	24.30		75.95		13.16	
	Kenya Blue	38.86		61.15		15.34	
	Kenya Yellow	47.82		52.18		18.32	
	Kenya Original	29.75		68.96		14.00	
		S.Em (±)	CD (0.05)	S.Em (±)	CD (0.05)	S.Em (±)	CD (0.05)
C		0.162	0.465	0.265	0.759	0.097	0.278
T		0.187	0.537	0.306	0.877	0.112	0.321
C x T		0.325	0.931	0.530	1.519	0.194	0.555

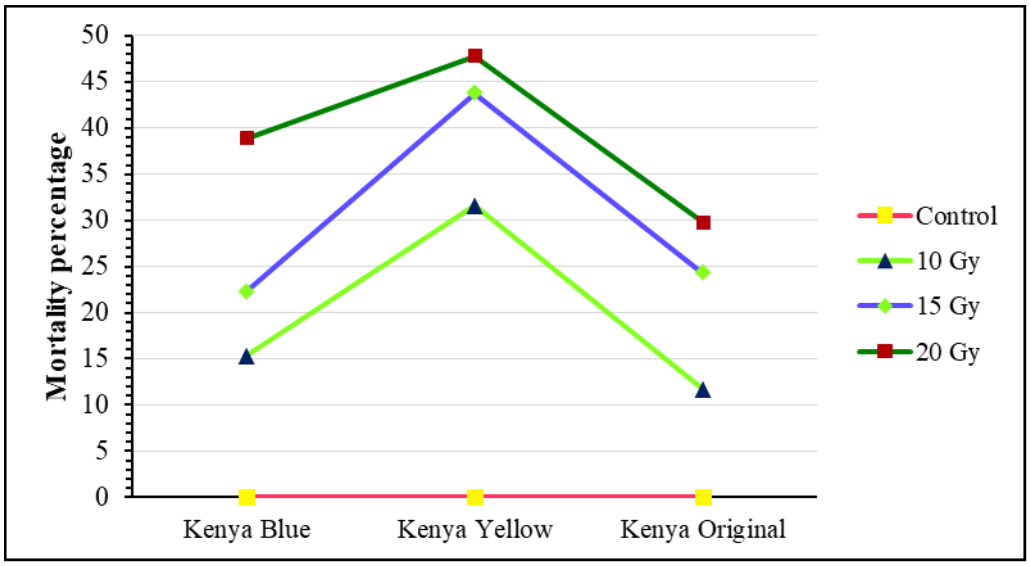

Fig 1: Effect of gamma radiations on mortality percentage in dahlia cultivars

Survival percentage

It is evident from the data (Table 1 and Fig. 2) that survival percentage decreased significantly at increased dose of gamma radiations and hundred percent survival was recorded in untreated plants. Among gamma radiation doses, control plants showed significantly maximum survival percentage (100%) followed by gamma radiation dose 10 Gy (80.39%). As respect to different cultivars, Kenya Yellow was significantly found to be more sensitive to higher exposure (69.16% survival), whereas, Kenya Original (83.30%) cultivars were significantly more tolerant to gamma radiations. The interaction of cultivar Kenya Yellow and 20 Gy gamma rays resulted significantly minimum survival (52.18%) followed by interaction of Kenya Yellow with 15 Gy gamma rays (56.25%). Kaicker (1992) [7] also stated the reduction in survival may be due to the toxic effect at higher

concentration of gamma rays. Differences for radiation sensitivity among cultivar were also reported by Broertjes and Harten (1988) [2]. Survival percent was found to be decreasing with the increasing dose of gamma radiations. Significant reduction in survival after exposure to gamma rays was also observed by Kumari *et al*. (2013) [8] and Banerji and Datta (2005) [1] in chrysanthemum.

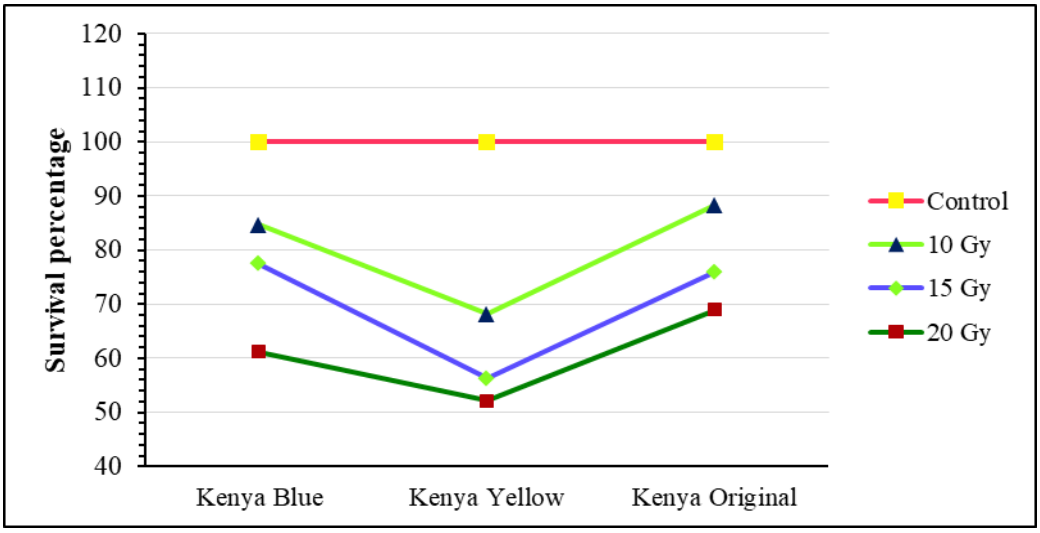

Fig 2: Effect of gamma radiations on survival percentage in dahlia cultivars

Abnormal plant percentage

It is clear from the data (Table 1 and Fig. 3) that percent abnormal plants increased with the increase in dose of gamma radiations. Among the gamma radiation doses, treatment of 20 Gy recorded significantly higher percentage of abnormal plants (15.88%) as compared to the rest of the treatments. Cultivar Kenya Yellow exhibited significantly maximum percentage of abnormal plants (10.06%), whereas, minimum abnormal plants percentage (8.01%) was recorded in cultivar Kenya Original. The interaction between cultivar Kenya Yellow and 20 Gy gamma rays treatment recorded significantly higher abnormal plants percentage (18.32%) as compared to rest of the interactions. However, minimum abnormal plant percentage (0%) was noted in untreated plants. These results are in accordance with earlier findings of Misra (1990) [10] and Dwivedi and Banerji (2008) [4], who recorded morphological abnormalities elevated with increased exposure to gamma rays.

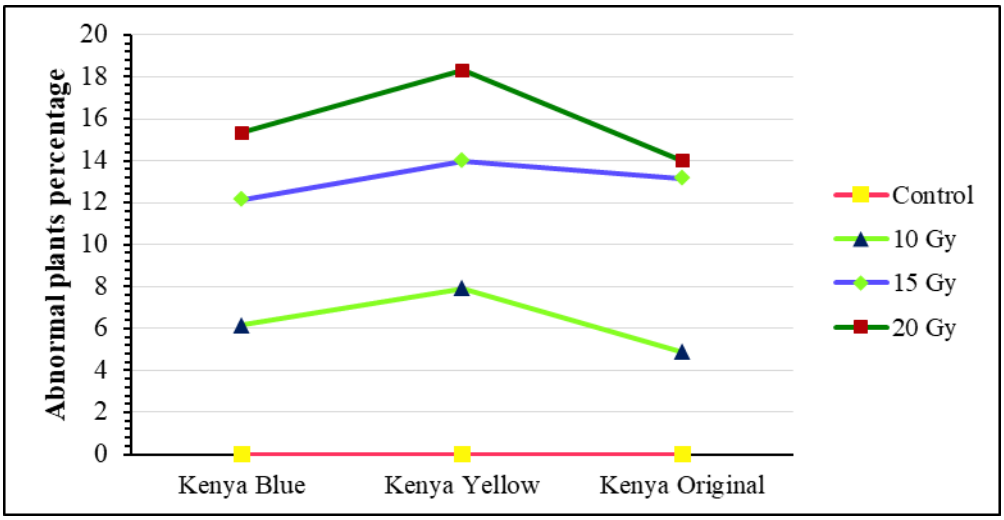

Fig 3: Effect of gamma radiations on abnormal plants percentage (%) in dahlia cultivar

The probit analysis of LD_{50} dose for individual cultivars was carried out separately and presented in Table 2 and illustrated through Fig. 4, 5 and 6. The probit analysis indicated the extrapolated LD_{50} value based on mortality percent for dahlia cultivar of Kenya Blue (27.54 Gy), Kenya Yellow (20.89 Gy) and for Kenya Original (33.11 Gy). This indicated the significantly higher sensitivity of cultivar Kenya Yellow thus LD_{50} could be beyond this dose. Determination of radio sensitivity and LD_{50} dose of gamma rays are prerequisites for a mutation breeding programme (Sadhukhan *et al.*, 2015) [11]. The LD_{50} value was estimated on the basis of percent plant survival. Broertjes and Harten (1988) [2] reported varietal differences for radiation sensitivity LD_{50} for different vegetatively propagated crops such as gladiolus, chrysanthemum and others varied from 0.5-15 kR.

The effect of gamma radiation on mutational characters of different cultivars revealed that increase in radiation dose increased the mortality and abnormal plant percentage. Enhanced survival percentage and higher LD value 50 was found with unrooted cuttings. This study indicated that cultivar Kenya Original exhibited low mortality and abnormal plant percentage but high survival and LD_{50} value.

Table 2: Probit analysis for extrapolated LD_{50} of gamma radiations in different cultivar for mortality percentage

Cultivars	LD_{50} (Gy)	Regression equation	R_2
Kenya Blue	27.54	Y= 2.46X + 1.45	0.932
Kenya Yellow	20.89	Y= 1.42X + 3.13	0.962
Kenya Original	33.11	Y= 2.21X + 1.62	0.994

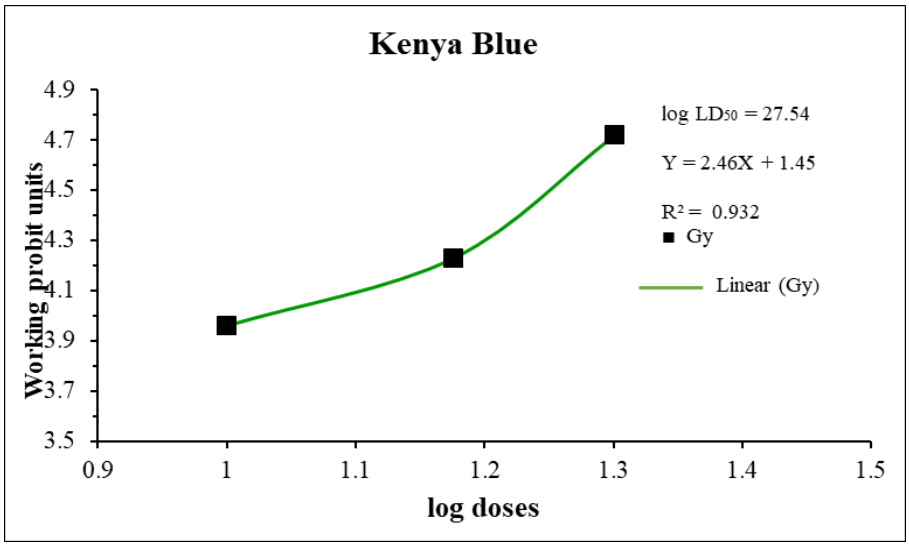

Fig 4: Probit analysis for extrapolated LD_{50} of gamma radiations in cultivar Kenya Blue for mortality percentage

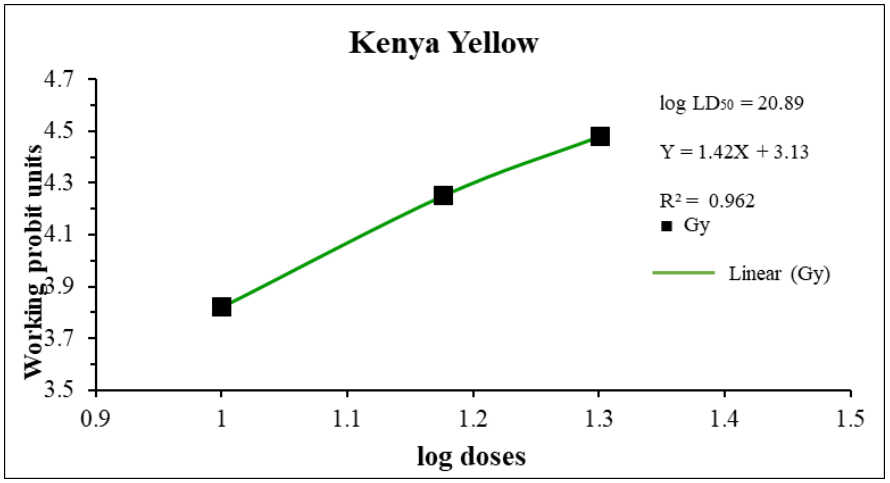

Fig 5: Probit analysis for extrapolated LD_{50} of gamma radiations in cultivar Kenya Yellow for mortality percentage

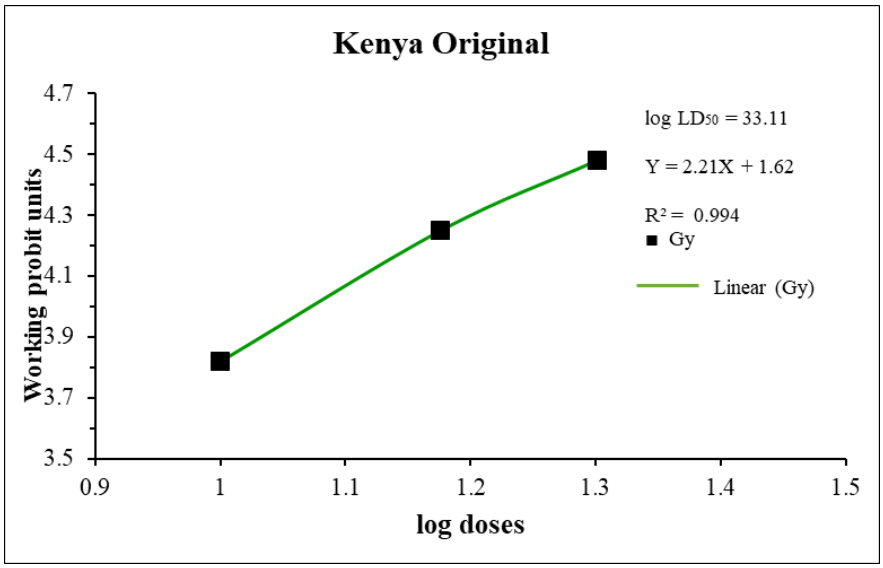

Fig 6: Probit analysis for extrapolated LD_{50} of gamma radiations in cultivar Kenya Original for mortality percentage

Acknowledgement
Authors are thankful to Department of Floriculture and Landscape Architecture, IGKV, Raipur (C.G.) for providing the financial assistance and also Regional Nuclear Agriculture Research Center under the BARC's Nuclear Intervened Agriculture project, Bidhan Chandra Krishi Vishwavidyalaya (BCKV) Mohanpur, Nadia (WB), for providing the radiation source.

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