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IMPACT OF IONIZING RADIATION ON BIOLOGICAL PARAMETERS OF FRENCH MARIGOLD (*TAGETES PATULA* L.)

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ABSTRACT
To shorten the time required for breeding new cultivars of *Tagetes patula* L., a better understanding of radiation mutagenesis by heavy ions is required. The present investigation aimed at estimating the influence of gamma rays on germination of different varieties (Bonanza, Safari Red, Guljafri Yellow, Nana Patula Yellow and Guljafri Orange) of *Tagetes patula* L. (French marigold). Their seeds were exposed to gamma rays ranging from 2.5 KR to 25 KR using ^{60}CO gamma radiations at National Botanical Research Institute (NBRI), Lucknow. The seed germination percentage was decreased with increased in the concentration/doses when compared to control. The LD_{50} (Lethal dose) value was determined based upon the seed germination percentage. The 50 percentage of seed germination and reduction was observed in 20 kR of gamma rays. The statistic results revealed that the percentage of germination had decreased after irradiation and the effect becomes stronger with increase of gamma doses except nana patula yellow (94.57 %) followed by safari red (85.37 %) at 25 kR. Parameters such as germination percentage, speed of germination, germination value had significantly decreased with increased irradiation doses. The study clearly indicated increase in the deleterious effects of gamma irradiation at regular intervals, with attainment of LD_{50} at a dose 15 KR.

KEYWORDS: Gamma irradiation, French marigold, Seed germination, Mutation, variety.

INTRODUCTION

In India, marigold is one of the most commonly grown flowers and used extensively on religious and social functions in different forms. Because of their ease in cultivation, wide adaptability to varying soil and climatic conditions, long duration of flowering and attractively coloured flowers which have good shelf life. Due to its variable height and colour marigold is especially use for decoration and included in landscape plans. Today, it is one of the most important commercial flowers grown worldwide and in India it accounts for more than half of the nation's loose flower production. Major marigold growing states are Karnataka, Gujarat, Maharashtra, Haryana, Andhra Pradesh, Uttar Pradesh, Chattisgarh, Odisha, Jammu and Kashmir, Puducherry, Andaman Nicobar, Arunachal Pradesh, West Bengal, Tamil Nadu, *etc*. It occupies an area of 42,880 hectares with production of 3, 60, 210 metric tons loose flower (NHB database, 2012-13). Marigold (Tagetes spp.) a member of family Asteraceae, is native of central and South America, especially Mexico. Marigold is broadly divided into two groups, *viz*., *African marigold* (*Tagetes erecta* Linn.) and *French marigold* (*Tagetes patula* Linn). The French marigold is a hardy annual, about 30 cm tall, forming a bushy plant. Foliage is dark green with reddish stem. Leaves are pinnately divided and leaflets are linear lanceolate and serrated. Flowers are small, either single or double borne on proportionately long peduncles. The flower colour varies from yellow to mahogany red. Gamma irradiation has been widely applied in medicine and biology in terms of biological effects induced by a counter intuitive switch-over from low doses stimulation to high-doses inhibition (Charbaji and Nabulsi, 1999). Previous studies have shown that relatively low-doses ionizing irradiation on plants and photosynthetic microorganisms are manifested as accelerated cell proliferation, germination rate, cell growth, enzyme activity, stress resistance and crop yields (Chakravarty and Sen, 2001). To date there is no major report stating the use of gamma irradiation as a physical mutagen to alter the physiological characteristics of *T. patula.* Thus, the aim of the present investigation was conducted to tackle this issue by performing the physiological studies on *T. patula*, after exposure to different doses of gamma rays. Plant height of the seedlings (irradiated and non-irradiated) was measured from base of the plant to tip of flag leaf. The data was collected from 7 day to 90 days after irradiation at an interval of 7 days. Earlier experiments in this field have indicated that ionizing radiation could cause permanent genetical effects, lethal or beneficial mutations, morphological modifications and other effects in plants. Several factors may be involved in the inhibition of germination and the growth of the plants from seeds following their exposure to high irradiation doses. A number of radiobiological parameters are commonly used in early assessment of effectiveness of

radiation. Therefore, in present study the response varieties of different French marigold seed to gamma radiation stress on germination and seedling parameters was investigated compared to non irradiated seed.

MATERIALS & METHODS

The material for the present study comprised of seeds of different varieties of *T. patula*. The bags with 100 seeds were exposed to gamma irradiation with doses of 2.5, 10, 15, 20 and 25 KR. Samples were irradiated with gamma radiation at National Botanical research Institute, Lucknow and were compared with the observations made on untreated control. The material for irradiation was placed in an irradiation chamber located in vertical drawer inside the Lead flask. Radiation field was provided by a set of stationary Cobalt source placed in a cylindrical cage. Mechanism for rotating/stirring samples during irradiation is also incorporated. The quantity of absorbed dose (KR) can be defined as the amount of energy absorbed per unit mass of the matter at the point of interest. The experiment was carried out as per Randomized Block Design (RBD). The irradiated seed along with non-irradiated control were sown in field. Data on germination and seedling parameters were recorded seven days after sowing under ambient condition. Germination percentage was calculated using the formula as per ISTA, 1985. Speed of germination of the given sample was calculated according to the formula given by (Maguire, 1962). Similarly, other germination parameters *viz*., Mean daily germination, Peak value (Edwards, 1934) and Germination value (Czebator, 1962) were calculated. Seedling parameters like Shoot and Root length were measured using plantlets from different varieties collected at random from each sample. The shoot and root length were measured in centimeters (cm) using a scale and root/shoot length ratio was calculated using the estimates of seedling length.

Germination study at different dosage of Gamma Radiation

Germination study of *T. patula* varieties in different dosage was conducted. Daily observations were made on radicle emergence. Seed germination percentage was calculated using the following formula (ISTA, 1999).

$$\text{Germination \%} = \frac{\text{Number of germinated seeds}}{\text{Total number of seeds}} \times 100$$

Germination associate parameters were calculated by using following formulas:

a. Speed of germination

Speed of germination was calculated by the following formula given by (Czebator, 1962).

$$\text{Speed of germination} = -\frac{n1+n2+n3+---}{d1+d2+d3+---}$$

Where, n = number of germinated seeds, d= number of days.

b. Mean germination Time (MGT)

Mean germination time was calculated by the formula given by (Ellis and Roberts, 1981).

$$\text{MGT} = \frac{\text{n1} \times \text{d1}+\text{n2} \times \text{d2}+\text{n3} \times \text{d3}+----}{\text{Total number of days}}$$

Where, n= number of germinated seed
d = number of days

c. Mean daily germination (MDG)

Mean daily germination can be calculated by the following formula given by (Czebator, 1962).

$$\text{MDG} = \frac{\text{Total number of germinated seeds}}{\text{Totalnumber of days}}$$

d. Peak Value (PV)

Peak value was calculated by the following formula given by (Czebator, 1962).

$$\text{PV} = \frac{\text{Highest seed germinated}}{\text{Number of Days}}$$

e. Germination Value (GV)

Germination value was calculated by the following formula given by (Czebator, 1962).

$$\text{GV} = \text{PV X MDG}$$

RESULTS & DISCUSSION

Percent germination in different varieties of *Tagetes patula* seeds with five different doses of gamma radiation has been presented in Table 1. The percent seed germination in different varieties of *Tagetes patula* under control was maximum 100 in Nana patula yellow and minimum 96.30 in Guljagri Orange. When treated with different doses of gamma radiations (treatments) percent. Seed germination was delayed and reduced significantly in all the marigold varieties except Nana Patula yellow followed by Safari Red (Table 1) at 25 KR where it has increased. The % reduction (percentage of control) was maximum in Guljafri Yellow (53.00 %) and minimum in nana patula yellow (1.6 %) at 25 KR. (Fig.)

Speed of germination under control was recorded highest in Nana Patula yellow (34.10) and lowest 31.40 in Guljafri Orange (Table 2). When treated with different doses of gamma radiation (treatment), speed of germination was delayed and reduced significantly in all the weed species except Nana Patula Yellow (31.20 ±0.32) and Safari Red (28.03 ±0.13) with 25 KR (Table 2) Similarly, the mean daily germination was recorded maximum (3.20±0.62) in Guljafri Orange and minimum (3.12±0.10) in Safari Red under control (Table 3). With different treatments, mean daily germination and Peak value was significantly decreased (Table 3 & 4). Germination value was recorded maximum in Nana Patula yellow (11.38 ±5.80) and minimum in Bonanza (10.20 ±0.02) under control. Present study revealed that the nana patula yellow and safari red varieties has maximum % germination and rate of germination in comparison to other varieties of French marigold (*Tagetes patula*).

TABLE 1: Germination percentage after 30 days

	Bonanza	Guljafri O.	Guljafri Y.	Nana Pat. Y	Safari R.	Mean
Control	98.10a	96.30a	97.37a	100.00a	98.57a	98.07a
2.5 KR	87.20b	90.07b	84.40b	98.40b	95.37a	91.09b
10 KR	84.00b	73.40c	72.43c	88.37d	87.33b	81.11c
15 KR	76.27c	62.30d	60.23d	76.23e	79.40c	70.89d
20 KR	74.97c	54.53e	57.60d	73.27e	75.50e	67.17e
25 KR	74.23c	44.57f	44.37e	94.57c	85.37b	68.62e
Mean	82.46c	70.19d	69.40d	88.47a	86.92b	
	Variety		Treatment		Variety × Treatment	
S.Em.±	0.55		0.60		1.35	
CD at 5%	1.56		1.71		3.83	

TABLE 2: Speed of germination

	Bonanza	Guljafri O.	Guljafri Y.	Nana Pat. Y	Safari R.	Mean
Control	32.60a	31.40a	32.30a	34.10a	32.30a	32.54a
2.5 KR	28.37b	31.27a	31.20a	32.63a	31.40a	31.17b
10 KR	27.27b	30.33a	24.37c	29.23b	30.10b	28.26c
15 KR	28.43b	28.20b	29.23b	25.27c	26.33d	27.49c
20 KR	25.37c	27.50b	28.60b	24.53c	25.23d	26.25d
25 KR	25.27c	14.20c	14.30d	31.20ab	28.03c	22.60e
Mean	27.88b	27.15b	26.67c	29.49a	29.07a	
	Variety		Treatment		Variety × Treatment	
S.Em.±	0.27		0.30		0.67	
CD at 5%	0.78		0.85		1.92	

TABLE 3: Mean daily germination

	Bonanza	Guljafri O.	Guljafri Y.	Nana Pat. Y	Safari R.	Mean
Control	3.17a	3.20a	3.17a	3.12a	3.13a	3.16a
2.5 KR	2.30c	3.03a	3.10a	3.13a	3.07a	2.93b
10 KR	2.43b	3.00a	3.03a	3.17a	3.03a	2.93b
15 KR	2.30c	2.30b	2.33b	2.43c	2.47b	2.36d
20 KR	2.33c	2.37b	2.30b	2.30c	2.43b	2.35d
25 KR	2.31b	2.43b	2.30b	2.23b	2.37b	2.33c
Mean	2.49c	2.72b	2.71b	2.83a	2.75a	
	Variety		Treatment		Variety × Treatment	
S.Em.±	0.03		0.03		0.08	
CD at 5%	0.09		0.10		0.23	

TABLE 4: Peak value

	Bonanza	Guljafri O.	Guljafri Y.	Nana Pat. Y	Safari R.	Mean
Control	3.17a	3.10a	3.07a	3.10a	3.07a	3.10a
2.5 KR	2.27c	3.03a	3.07a	2.97a	3.17a	2.90b
10 KR	2.27c	3.00a	2.97a	3.03a	3.10a	2.87b
15 KR	2.50b	2.27ab	2.30b	2.30b	2.30b	2.33c
20 KR	2.28c	2.23b	2.43b	2.23b	2.27b	2.29c
25 KR	2.27c	2.20b	2.17bc	3.20a	2.13b	2.39c
Mean	2.46c	2.64b	2.67b	2.81a	2.67b	
	Variety		Treatment		Variety × Treatment	
S.Em.±	0.03		0.03		0.08	
CD at 5%	0.09		0.10		0.23	

TABLE 5: Germination value

	Bonanza	Guljafri O.	Guljafri Y.	Nana Pat. Y	Safari R.	Mean
Control	10.20a	11.37a	11.37a	11.38a	11.30a	11.12a
2.5 KR	7.33b	9.33b	10.27b	10.43a	10.43a	9.56b
10 KR	7.57b	6.33c	9.30b	9.00b	9.27ab	8.29c
15 KR	8.33b	7.43c	8.37bc	8.37b	8.37b	8.17c
20 KR	6.37d	7.30c	7.27d	7.23bc	7.33c	7.10d
25 KR	7.23bc	6.43c	6.37d	9.37b	6.33c	7.15d
Mean	7.84c	8.03c	8.82b	9.29a	8.84b	
	Variety		Treatment		Variety × Treatment	
S.Em.±	0.14		0.15		0.35	
CD at 5%	0.41		0.45		1.01	

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