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A STUDY ON THE EFFECT OF X-RAY IRRADIATION ON THE FLORAL ATTRIBUTES OF AFRICAN MARIGOLD (TAGETES ERECTA L.) PLANT.

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ABSTRACT
This study was carried out to investigate the effect of different X-ray irradiation doses on the floral and horticultural attributes of African marigold (Tagetes erecta L.) plant with the aim of identifying any genetic effects which exposure to some mild doses of x-ray may have on the floral and ornamental qualities of this plant. The seeds were subjected to various X-ray doses using the Dongman X-ray machine of capacity 125kV, 250MA and rated line voltage of 220VAC). Seven treatment doses applied were as follows: (0mGy, 5mGy, 10mGy, 15mGy, 20mGy, 25mGy, 30mGy and 35mGy). Treated seeds were planted on sand filled pots arranged under shade house condition in randomized complete block design (RCBD) with three replications of ten(10) seeds for each treatment.. LD50 was determined above 20mGy of X-ray irradiation. Higher doses above 20mGy proved to be lethal as no seedling emergence was observe. The stimulatory effect of X-ray irradiation was observed at 10mGy and 15mGy in almost all the floral characters studied. It was also observed that lowest X-ray dose of 5mGy was effective in inducing early flowering of Tagetes eracta plant. Contrastingly, the higher mutagenic dose of 20mGy substantially decreased all the floral characters as compared to the control. On the basis of the present observation, it may be concluded that X-ray irradiation of 10mGy and 15mGy could induce variability and enhance flowering of African marigold (Tagetes erecta). Thus, it can be recommended that the treatments with lower X-ray doses of10mGy and 15mGy be adopted for improving flowering attributes of African marigold (Tagetes ereta) plants and lowest X-ray dose of 5mGy for inducing early flowering.

Keywords: Targetes floral, ornamental, irradiation, petals , mutagenesis

INTRODUCTION

African marigold (Tagetes erecta L.) belongs to the family Asteraceae and is one of the most important commercially exploited flower crops (Amit et al, 2018). The Genus Tagetes consists of 50 species, of which Tagetes erecta L. is commonly grown for their exquisite blooms (Soule, 1994). Marigold is native to Central and South America, especially Mexico, but it is naturalized in other countries in Africa, Asia, and Europe (Babu and Kaul, 2007). They are rapid-growing annual flowering plants in height ranging from dwarfs of 6-8 inch, to medium and taller and erect-growing plants, bearing globular-shaped flowers and has a shorter flowering period from mid-summer to frost (Dixit et al., 2013). It is very popular as a garden plant and yields a strongly aromatic essential oil (Tagetes oil), which is mainly used for the compounding of high-grade perfumes. Marigold occupies the top most position in ornamental horticulture and is highly valued for its spectacular flower, brilliant colour, delightful appearance, myriads of sizes, shapes, forms, fragrance, keeping quality and is endowed with large spectrum of commercial potentialities in medicinal and industrial sector (Mehra, 1966). African marigold (Tagetes erecta L.) is extensively used in religious and social functions. It is gaining popularity on account of its easy culture, wide adaptability, and increasing demand in the Asian subcontinent and other parts of the world (Suvija et al., 2019). Sometimes, the whole plant is used for decorations. It can be planted in beds for mass display, in mixed borders and can also be grown in pots. Different varieties of African marigold vary in plant height and spread, flower size, quality and yield. Colour shades vary from light yellow to creamy yellow, bright yellow, cadmium orange, deep orange, sulphur yellow and white. It is now a days gaining commercial importance as a source of carotenoid pigments (Suvija et al., 2019).

Radiation-induced mutation breeding is a remarkable method of breeding that presents superior mutant cultivars in contrast to conventional breeding which is time-consuming and laborious (Beyaz and Yildiz 2017; Hanafiah et al., 2010). Ornamental plant mutation breeding has become more successful owing to additional changes in phenotypic characteristics, heterozygous nature, and high mutation frequency produced a large number of new varieties (Datta 2001; Maluszynski et al., 1995). Within the ornamental trade circuit, there has always been a demand for new cultivars because of frequent changes in the sense of flavor and pattern (Yan et al., 2019). Also, the aesthetic disposition of individuals changes from time to timw.

Physical mutagens are generally preferred by reason of being convenient, easy reproducibility, and user-/environment-friendly method. Ionizing radiation is used as a physical mutagen in mutation breeding. Ionizing radiation (IR) is categorized by the nature of the particles or electromagnetic waves that create the ionizing effect. Ionizing radiation (IR) is known to have great effect on plants. Their effects are classified as direct and indirect. Stimulatory, intermediate, and detrimental effects on plant growth and development are based on dose of ionizing radiation applied to the plant tissues. The severity of the impacts of radiation is in relation with the species, cultivars, plant age, physiology, and morphology of the plants besides their genetic organizations. Ionizing radiation such as X-rays and gamma rays have been used for improvement of several crops such as wheat, rice, barley, cotton, tobacco, beans, etc (Ahloowalia and Maluszynki, 2001).

MATERIALS AND METHODS

Collection of plant materials

Dry and healthy seeds of African marigold were procured and certified from the horticultural Department of the National root crop research institute Umudike, Umuahia Abia State.

Irradiation of plant materials

African marigold seeds were divided into eight groups each in brown labeled envelops. Each envelope contained 30 seeds of the African marigold. The seeds were taken to the X-ray department of Federal Medical Centre (F.M.C.) Umuahia, Abia State, Nigeria, where it was exposed to X-ray irradiation. The first group was not given any treatment to serve as control while the remaining seven groups were bombarded at different X-ray doses in Milligray; 5MGy, 10 MGy, 15 MGy, 20 MGy, 25 MGy, 30 MGy and 35 MGy respectively (using a therapeutic Medical X-ray device ;The Dongman X-ray machine of capacity 125kV, 250MA and rated line voltage of 220VAC)

Sowing of irradiated seeds

Treated seeds were planted on sand filled pots arranged under shade house condition in randomized complete block design (RCBD) with three replications for each treatment and each replication contained 10 seeds. After close examination of the sown seeds, it was observed that X-ray doses above 20MGy proved lethal to the seeds, hence seeds treated with such higher doses (25MGy, 30MGy and 35MGy) recorded no seedling emergence. Transplanting of the growing seedlings was done at thirty days from sowing. The field experiment was conducted at the Teaching and Research Farm of Michael Okpara University of Agriculture Umudike in the rainforest zone of Nigeria (50.29'N, 70.33'E).

Data collection and recording of floral parameters

Observation and measurement on floral parameters recorded are: days to bud-initiation, days for flower opening, number of flowers per plant, flower head height, flower diameter, number of ray petals, ray petal length, ray petal width). The data collected were statistically subjected to analysis of variance (ANOVA).

RESULTS

Effect of X-ray irradiation on number of days for flower bud initiation of Tagetes erecta plant.

The data regarding the effect of the x-ray doses on number of days required for first flower bud initiation is presented in Table 1 and Fig. 1. From the data, it could be revealed that lower doses of mutagens caused a stimulatory effect on the number of days required for first flower bud initiation. Earlier flower bud initiation was observed at 5MGy recording 30.00 days. 15MGy was at par with the control. The maximum number of days required for flower bud initiation was recorded with irradiation dose of 20MGy recording 32.000 days.

According to the analysis of variance, number of days required for flower bud initiation was significantly influenced ($p<0.01$) in plants treated with 5mGy irradiation dose which recorded the least number of days required for flower bud initiation (30 days). Irradiation dose of 15mGy recorded non-significant ($p>0.01$) difference in comparison with control. At 10mGy and 20Mgy irradiation doses, there was significant increase in number of days for flower bud initiation.

Table 1: Effect of X-ray irradiation on number of days for flower bud initiation of Tagetes erecta plant.

Treatment	Number of days for flower bud initiation
0	31.000
5	30.000
10	31.667
15	31.333
20 Mean = 31.200 LSD = 0.6431 p<0.01	32.000

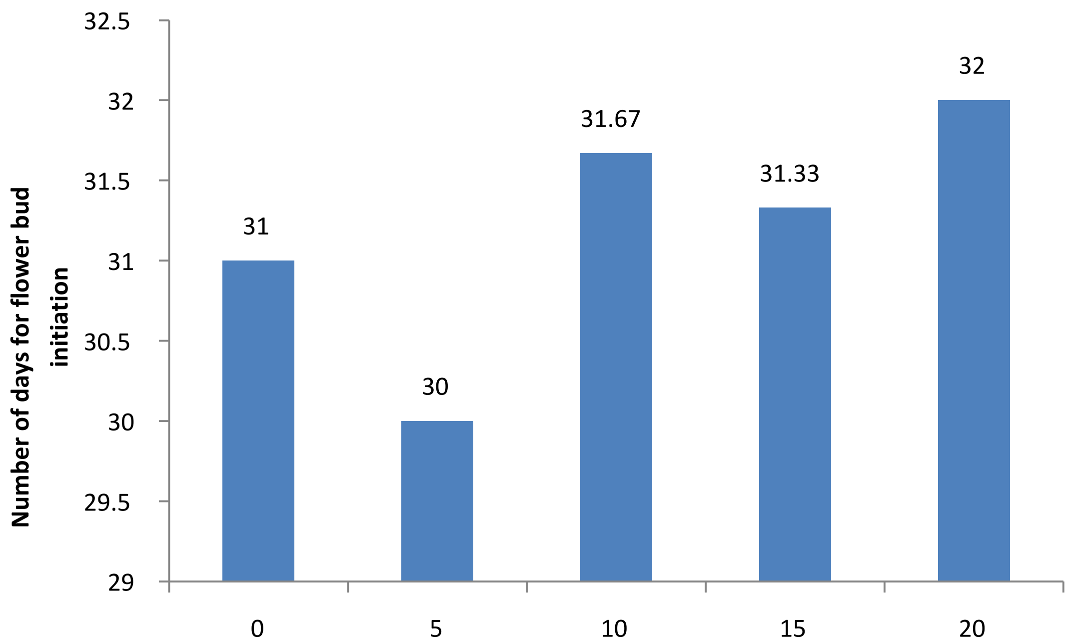

Fig. 1: Number of days for flower bud initiation of Tagetes erecta plant.

Effect of X-ray irradiation on number of days for flower opening (from the first day of flower bud initiation) of Tagetes erecta plant.

Concerning the effect of the treatment on number of days required for flower opening , it was observed that number of days for flower opening was not significantly influenced ($p<0.01$) by the irradiation doses. However, first flower opening was observed at 10 days from the first day of bud initiation in 5mGy population which is at par with the control and was delayed with 10mGy, 15mGy and 20mGy treatment. The maximum number of days required for flower opening was recorded with treatment of 20mGy (11.67 days).

Table 2: Effect of X-ray irradiation on number of days for flower opening (from the first day of flower bud initiation) of Tagetes erecta plant.

Treatment	Number of days for flower opening
0	10.33
5	10.00
10	11.33
15	11.00
20 Mean = 10.87 LSD = 0.909 p<0.01	11.67

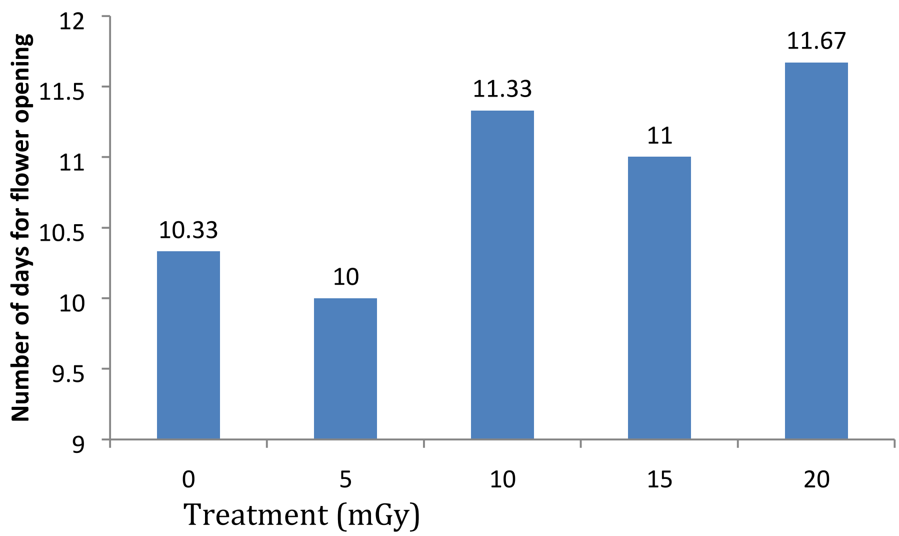

Fig. 2: Number of days for flower opening (from the first day of flower bud initiation) of Tagetes erecta plant.

Effect of X-ray irradiation on number of flowers of Tagetes erecta plant

The effect of X-ray irradiation on number of flowers per plant is shown in Table 3 and Fig. 3. The result showed that treated plants at 10mGy and 15mGy increased the number of flowers significantly ($p<0.01$), recording 34.00 and 33.67 flowers per plant, respectively as compared to the control samples (27.67). 5mGy recorded 27.00 flowers per plant which was at par with the control sample. Maximum significant reduction ($p<0.01$) in flower number was observed at 20MGy recording 19.00 flowers.

Table 3: Effect of X-ray irradiation on number of flowers of Tagetes erecta plant

Treatment	Number of flowers
0	27.67
5	27.00
10	34.00
15	33.67
20 Mean = 28.27 LSD = 0.729 p<0.01	19.00

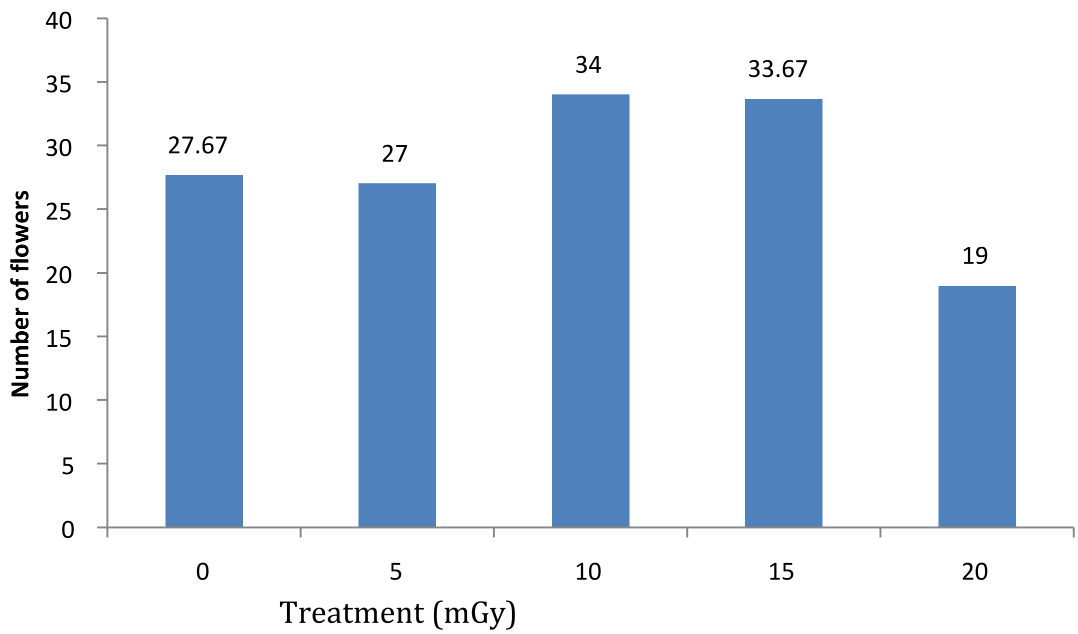

Fig. 3: Number of flowers of Tagetes erecta plant

Effect of X-ray irradiation on flower head height of Tagetes erecta plant.
Concerning the effect of the treatment on flower head height , significant increase in flower head height was observed at 10mGy (10.93cm). Irradiation dose of 15mGy recorded non-significant ($p>0.01$) difference in flower head height in comparison with control. Flower-head height decreased significantly ($p<0.01$) at irradiation doses of 5mGy and 20MGy recording a flower head height of 8.13cm and 6.50cm respectively.

Table 4: Effect of X-ray irradiation on flower head height of Tagetes erecta plant.

Treatment	Flower head height (cm)
0	9.63
5	8.13
10	10.93
15	9.03
20 Mean = 8.85 LSD = 0.860 p<0.01	6.50

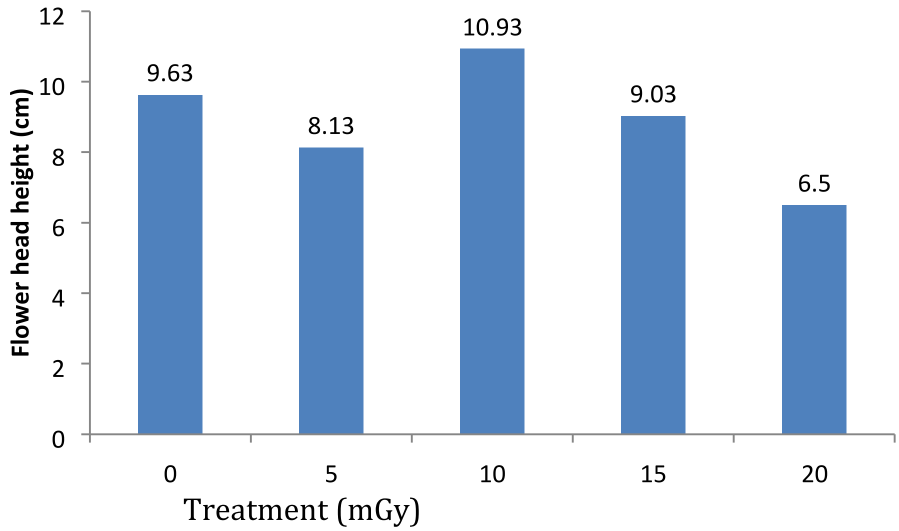

Fig. 4: Flower head height of Tagetes erecta plant.

Effect of X-ray irradiation on flower diameter of Tagetes erecta plant.

As for the effect of application of X-ray irradiation on the flower diameter, data obtained showed that plants treated with 10MGy recorded maximum diameter of flower (5.167cm) which was significantly different ($p<0.01$) from the other treatments. Irradiation dose of 5mGy and 15mGy recorded non-significant ($p>0.01$) difference in flower diameter in comparison with control. At higher irradiation dose of 20mGy, there was a significant reduction ($p<0.01$) in flower diameter which recorded a flower diameter of 4.033cm in comparison with the control (4.433cm).

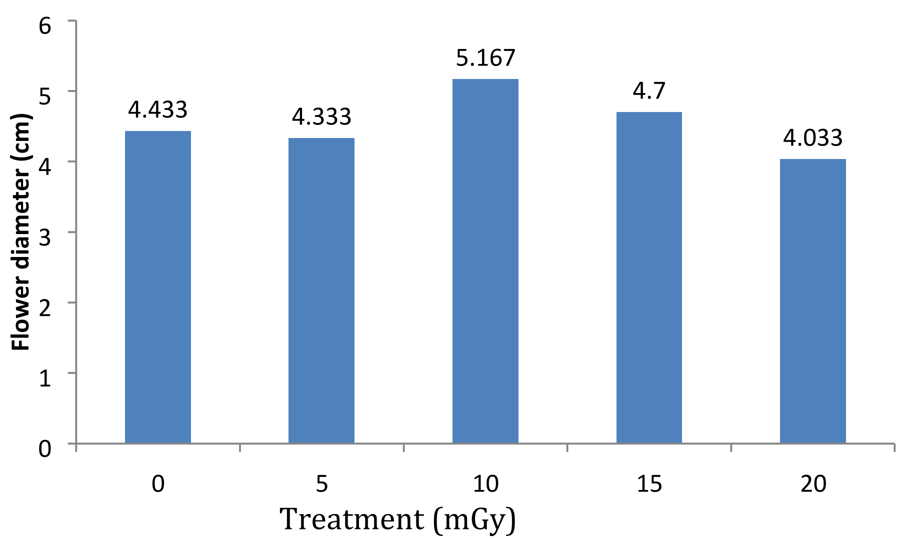

Fig. 5: Flower diameter of Tagetes erecta plant.

Table 5: Effect of X-ray irradiation on flower diameter of *Tagetes erecta* plant.

Treatment	Flower diameter(cm)
0	4.433
5	4.333
10	5.167
15	4.700
20	4.033

Mean = 4.533
LSD = 0.3403
$p<0.01$

Effect of X-ray irradiation on number of ray petals per flower of Tagetes erecta plant.

It was observed that the number of ray petals per flower was not significantly increased ($p>0.01$) by the irradiation doses in comparison with the control. However, the highest number of ray petals per flower was obtained from plants treated with 10mGy which recorded 133.67 number of ray petals per flower, whereas 5mGy, 15mGy and 20mGy recorded a significant reduction ($p<0.01$) in number of ray petals per flower recording 127.33, 128.67 and 108.67 number of ray petals respectively.

Table 6: Effect of X-ray irradiation on number of ray petals of *Tagetes erecta* plant.

Treatment	Number of ray petals
0	131.33
5	127.33
10	133.67
15	128.67
20	108.67

Mean = 125.93
LSD = 2.419
$p<0.01$

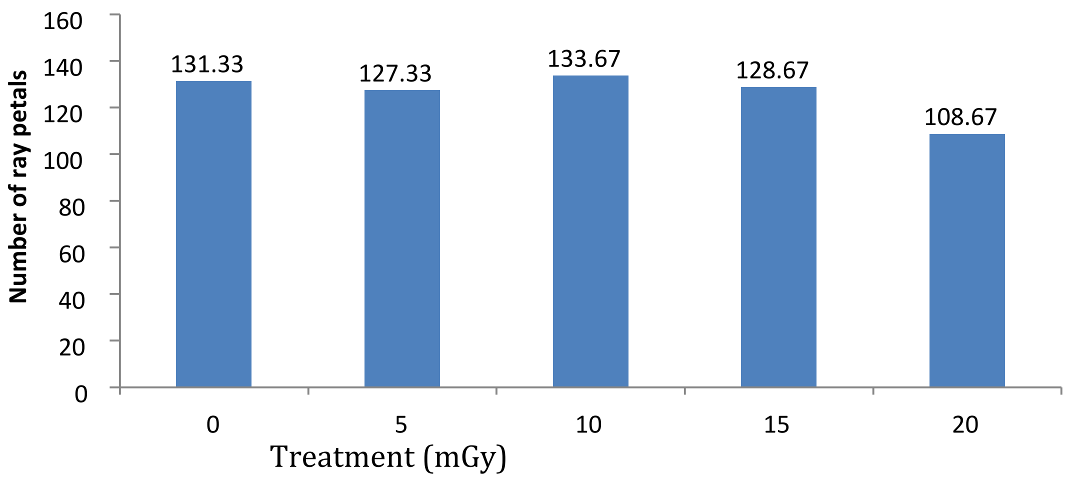

Fig. 6: Number of ray petals of Tagetes erecta plant.

Effect of X-ray irradiation on length of ray petal of Tagetes erecta plant.
The data regarding the effect of the X-ray doses on length of ray petal is presented on Table 7 and Fig. 7. It was observed that the length of ray petal was not significantly increased (p>0.01) by the irradiation doses in comparison with the control. However, irradiation dose of 15MGy recorded highest length of ray petal (1.800cm). This was followed by 10MGy (1.733cm) which was at par with the control sample (1.700cm). Maximum decrease in length of ray petal was observed at 20MGy (1.533cm).

Table 7: Effect of X-ray irradiation on length of ray petal of *Tagetes erecta* plant.

Treatment	Length of ray petal (cm)
0	1.700
5	1.500
10	1.733
15	1.800
20	1.533

Mean = 1.653
LSD = 0.2696
p<0.01

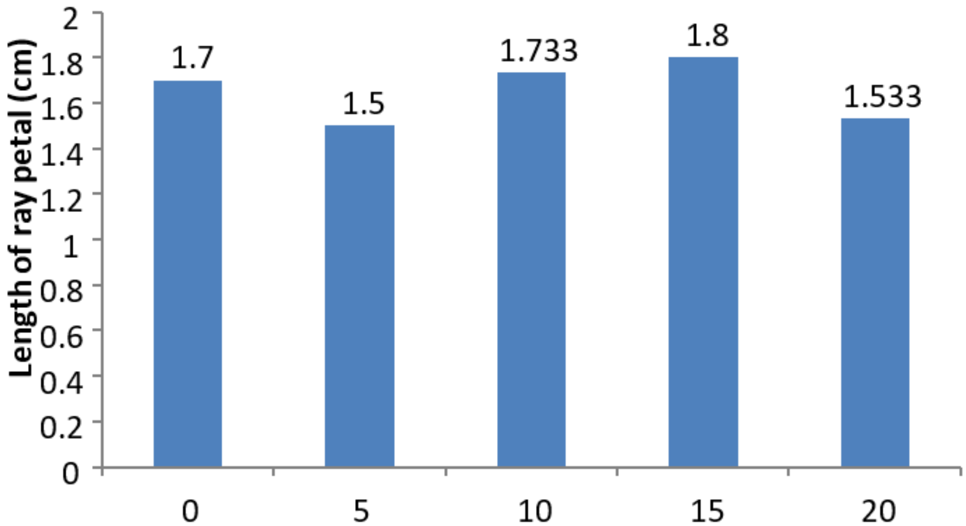

Fig. 7: Length of ray petal of Tagetes erecta plant.

Effect of X-ray irradiation on width of ray petal of Tagetes erecta plant.

Table 8 and Fig. 8 showed the effect of X-ray irradiation on width of ray petal of Tagetes erecta plant. It was observed that width of ray petal was not significantly increased (p>0.01) by the irradiation doses. However, width of ray petal performed best at 10mGy recording 1.267cm. This was followed by control (1.167cm), whereas 5mGy, 15mGy and 20mGy recorded a significant reduction (p<0.01) in width of ray petal recording 0.767cm, 0.967cm and 0.733cm respectively.

Table 8: Effect of X-ray irradiation on width of ray petal of *Tagetes erecta* plant.

Treatment	Width of ray petal (cm)
0	1.167
5	0.767
10	1.267
15	0.967
20	0.733

Mean = 0.980
LSD = 0.1851
p<0.01

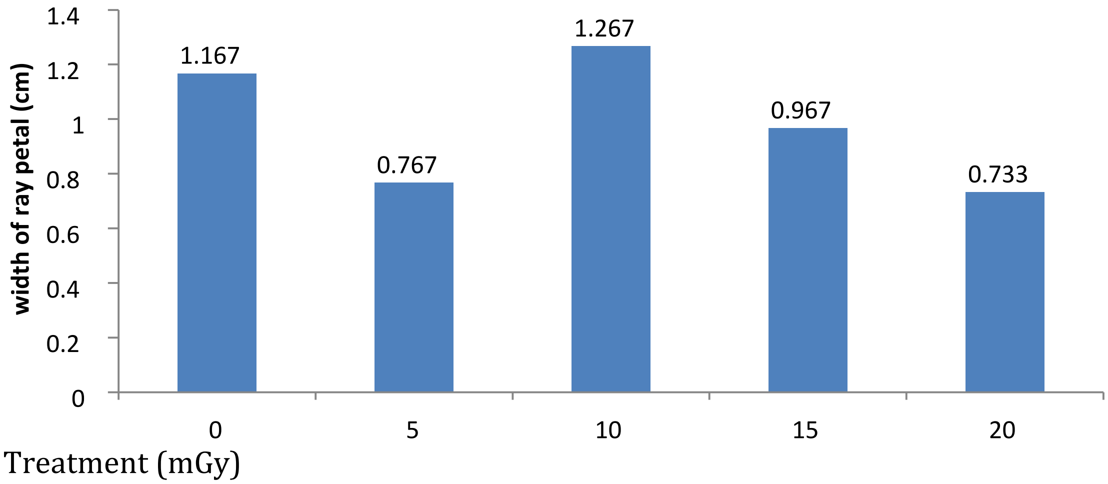

Fig. 8: Width of ray petal of Tagetes erecta plant.

Plate 1: Treated African marigold samples harvested after 60 days

DISCUSSION

Stimulatory effect has been recorded at lower doses (10MGy and 15MGy) where number of flowers per plant, flower head height, flower diameter, and length of ray petal increased. Lowest irradiation dose of 5mGy was effective in inducing early flower bud initiation and early flower opening. The higher dose of 20MGy might have affected the physiological process leading to flowering. But the lower doses of mutagens might have caused a stimulated effect on physiological process of flowering and thus induced early flowering. This is in line with the findings of Singh et al., (2009) in Marigold, Mostafa et al. (2014) in Celosia argentea, Patil (2014) in gladiouls and Singh et al., (2015) in tuberose. The results indicate that flower bud initiation was earlier in 5MGy (30.000 days) while those irradiated with 20MGy took longer time (32.000days) for bud initiation. These results corroborate the findings of Datta and Gupta (1981) and Singh et al., (2009). As a result of irradiation many biosynthetic pathways are altered, which are directly and indirectly associated with the flowering physiology (Mahure et al., 2010).

With respect to number of flowers per plant, lower X-ray radiation treatments (10 mGy and 15 mGy) had stimulatory effect in comparison with the control. At higher dose of 20MGy, a sudden decrease in number of flowers per plant was found compared to control. It might be due to the reduced vegetative growth as a result of X-ray treatments. Similar findings were reported by Puneet et al., (2007) in gladiolus, Singh et al., (2009) in marigold and Rather et al., 2011 in pot marigold.

The diameter of the flower was also influenced significantly by irradiation. Flower diameter decreased with increase in X-ray at 20MGy. Highest flower diameter (5.167cm) was recorded at 10mGy of X-ray irradiation.

In general, flowering was delayed upon exposure at 20MGy irradiation. Banerji and Datta (1993 and 2002) reported similar results in Chrysanthemum.

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